Grafting: An Approach to Exploring Crossovers Between Craft and Gaming

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_Abstract

This thesis investigates the crossovers between craft practices and the play of video games by utilising innovative design and making approaches. The study challenges assumptions about craft and gaming by exploring their intersections and sheds light on the potential value for contexts beyond individual practices. Through an analysis of skilled amateur craft and gaming, the research explored an emerging field by considering the embodied nature of video gaming and its theoretical relationship with craft. Specifically, this study contributes new knowledge through the development of 'graft-games' that reveal potential to improve production efficiency by directly connecting craft and gaming.

The study combines theoretical investigation with creative practice, employing a mixed-methods approach that spans the fields of craft and gaming. This study establishes new ways of thinking about embodiment and practice in both fields by drawing upon craft theory and games studies. Indeed, through an analysis of autoethnographic observations of amateur craft and gaming case studies, this study also develops a conceptual model that articulates areas of crossover between them. The conceptual model is evaluated through a progressive series of applications and prototypes. Firstly, the graft-game, *Hazuki Knit*, is informed through a series of public participatory events. A second prototype graft-game, *Pocket Racer*, is developed through observations of skilled practices within the Blackburn based garment manufacturer *Cookson & Clegg*, tested at a festival site through public interaction and deployed as an intervention into a small-scale production process. The evaluation and analysis of graft-game prototypes indicate the value of introducing craft-game hybrids into manufacturing contexts.

The study contributes new knowledge through the concept of grafting, positing that creating new or merged goals for users supports the development of individual strategies for improving efficiency and reducing risk. New hybrid forms of knowledge emerge through cross-fertilisation and conjoined experiences between craft and gaming. By utilising creative practice this research contributes to our theoretical understanding of the relationship between craft and games, adding new understanding in the form of 'graft-games' and the value these generate.

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_1 Introduction

1.1 Overview

This thesis presents an exploration into the crossovers between craft practice and the play of video games. Its purpose is to identify the insights that can be brought about by examining the relationship between the two areas through my own creative practice.

The study contributes to the related fields of design practice and craft theory through an analysis of gameplay and the field of games research through innovative methods and creative practices. Specifically, this study contributes new knowledge through the development of custom 'graft-games' that explore the crossovers between craft and play.

This research is concerned with the embodied nature of video gameplay and its linked conversations with skills associated with craft practice. In doing so it considers craft both as a practice and as an approach: discursive, collaborative, and generative. There is much existing research and practice that investigates the collaborative nature of craft (Felcey et al., 2017; Adamson, 2007), its ability to connect people (Gauntlett, 2018) and transcend traditional boundaries, especially in relation to digital technologies (Rosner, 2010; Golsteijn et al., 2014). Likewise, there exists an extensive amount of work on the relationship between work and play (Sennett, 2008; Crawford, 2009). There is, however, little research that directly explores links between craft and gaming, especially from the perspective of creative practice. Authors within the field of game studies, such as Brock & Johnson (2021), Brock & Fraser (2018), Nørgård (2012) and Reeves et al (2009), have begun to examine the relationship between the skilled hand and video game play from a theoretical perspective but few conclusions have been drawn as to what value these similarities with craft skill could provide beyond academia other than to perhaps challenge perceptions of gaming. In contrast, this study embraces a mixed methods approach, in which craft and gaming are explored in direct relation to one another through a process which I will refer to as ‘grafting’, and consider the potential new spaces and terrains brought about through a collaborative relationship between the two disciplines.

The aims of this research are:

- to identify existing crossovers between craft and gaming
- to investigate the relationship brought about through directly connecting craft and gaming
- to highlight the potential value that a direct relationship between craft and gaming could have in contexts beyond the individual disciplines

My Background

I undertook this research as a designer, maker and participatory artist exploring linked conversations between digital and physical forms of making. My practice has previously focused upon magnifying textile processes, progressing to the inclusion of a variety of digital technologies including videogames such as Minecraft, in order to engage the public. Much of this work has taken place within artistic and creative settings such as museums and galleries, whilst using accessible materials and tools (including the digital) to engage members of the public with archives and collections. One notable project that combined this approach with a game was *Patterncraft*: a punchcard reader that translates the holes that are punched into a physical card, into digital builds within the virtual world of the game Minecraft. My practice has never involved a solitary studio practice. Instead, members of the public are invited not just to contribute to what are often temporary works but their participation feeds into a dialogue which enables the work to further develop over time through multiple iterations. This approach has remained at the core of this research with reflective practice and participation playing a vital role across the multi-method study.

Within this research I have chosen to focus upon textiles as indicative of craft practices in part, due to the role textiles have played within my practice to date. Through digital and analogous explorations of textile processes in participatory settings, I have found textile practices to open-up conversations with broad audiences. I thus felt confident that textile processes would provide a suitable medium for exploring further within participatory contexts within this research whilst also prompting reflective thought based on my own experiences.

Throughout this study I also drew on my previous experience as a Garment Technologist and Product Developer working within the outdoor clothing industry for eight years following completion of a bachelor's degree in Fashion Design with Technology. This experience provided valuable insight into the garment construction setting and knowledge of specialist machines within manufacturing which became useful when working with industry as part of this research.

Transformation North West

This PhD is one of twelve studentships as part of a program called Transformation North West (TNW), funded by the AHRC as part of the National Productivity Investment Fund (NPIF), tasked with unlocking creative intelligence within the region and carrying out research in response to Theresa May's Government's Industrial Strategy[1]. With much analysis in current policy and government strategy on the skills required for the changing demands of a technologically driven future (BEIS, 2017; Bughin et al, 2018; Djumalieva & Sleeman, 2018), this research explores linked conversations between the play of video games (gaming) and craft expertise in traditional making, investigating how these could inform business growth, specifically in manufacturing. The North West of the UK is a region which boasts the "largest manufacturing base of any region in the country accounting for 13 per cent of the UK's manufacturing GVA (Young and Sly, 2010/11)" (Transformation North West Cohort, 2018). Despite the current drive for technological advancement, many manufacturers within the North West rely on highly dextrous craft skills as a vital part of their production. Luxury car manufacturer Bentley[2] for example, based in Cheshire East, consider "craftsmanship as fundamental" (KPMG, 2016) to its proposition in a global market. This study features a case study with garment manufacturer *Cookson & Clegg*, based in Blackburn, which employs the same highly dextrous skills today that is has since

[1] The Industrial Strategy was archived in 2020/2021 and replaced with a new Build Back Better policy document but many of the aims of the original document remain in place.
[2] This one company "generates significant revenue" (Crafts council - innovation report, p.25) to the UK economy (£1.1 billion of GVA) with 3 out of 4 production line staff using innovative applications of traditional craft skills.

its beginnings as a leather currier when it was founded in 1860. The skilled actions of workers in manufacturing settings such as this are difficult to automate unlike lower skilled tasks which are in some instances beginning to be replaced by machines and technology in order to compete with lower labour costs of production in other countries. There is, therefore, a significant challenge presented by the desire for manufacturing that employs craft skills to find ways that enable business growth through increasing productivity and efficiency of such tasks when they rely so heavily on skilled human action. Taking an investigative designing approach (Durling & Niedderer, 2007) in which craft is seen as an explorative tool that enables cross-disciplinary collaborations, this research will consider the potential value of crossovers between craft and the play of video games for contexts beyond the individual practices. This research is interested in what new hybrid forms, be that hybrid practices, or experiences, could result from the creation of a direct relationship between craft and gaming. Working within the aims of Transformation North West, this study uses a case study within manufacturing as a means of exploring one aspect of such potential value.

1.2 Research Context

The following section outlines the underlying themes of this research including the collaborative nature of craft and the link between work and play in the context of embodied action. I will explore these themes in detail in order to establish some firm foundations.

The collaborative nature of craft

As stated in the opening introduction, this research considers how collaboration can open up the capacities of both craft and gaming. In *Collaboration Through Craft,* Felcey, Ravetz and Kettle (2017) discuss the generative and supplemental capacity of craft as a practice that has the ability to open situations up “to the ‘rule-finding’ capabilities and the plural skills of willing participants” (2017:1). The authors state that despite being a term that is generally perceived as being different from other modes of production, “craft’s association with practical knowledge has always lent it a significance that goes beyond this apparently bounded self” (2017:2). In challenging the conflation of ‘craft’ with ‘the crafts’, the authors draw upon Adamson who sets out that "'craft' might be conceived not only as a horizon but as a constellation of stars - useful for purposes of navigation, but impossible to inhabit" (Adamson, 2007, as cited in Felcey et al., 2017:6). In this sense 'craft' (as opposed to 'the crafts') not only transcends disciplines but should be conceived not as a classification of objects of people but as a process, an approach that "only exists in motion" (Adamson, 2007:4). This research will consider craft as a process and a field of knowledge that gives those involved "access to a number of crucial tools when it comes to challenging retrospective and static forms of knowledge" (Felcey et al., 2017). In doing so, this research uses craft as a navigational aid and exploratory tool through which the relationship between the skilled practices of craft and gaming can be explored. It also acknowledges the work of Fiona Hackney and colleagues on the *CARE* project (Hackney, 2013a; Hackney, 2013b; Hackney, Saunders et al., 2020; Hackney, Maughan & Desmarais, 2016) that draws on Sennett's thinking to explore the value of collaborative making:

> In his recent book *Together, the Rituals, Pleasures and Politics of Cooperation,* sociologist Richard Sennett argues that the skills involved in material craftsmanship and in social cooperation are analogous and linked. (Hackney, 2013a:23)

Hackney "proposes that craft has a unique potential" (2013a: 23) to build community and social capital, whilst highlighting that "collaboration might promote positive or negative experiences" (2013a:25). This research is interested in the notion that interrupting familiar practices or processes, opens up an intermediate zone where unexpected things can happen (Hackney, 2013a; Hackney. Maughan & Desmarais, 2016).

Digital Technologies

It would be neglectful to open a discussion around crossovers between craft, that engages with physical material, and the embodied skill within gaming without acknowledging the existence of a growing area of craft made up of digital craftspeople. The expansion of craft through the use of digital technologies demonstrates how craft has developed and evolved. Nimkulrat, Kane and Walton, in *Crafting Textiles in the Digital Age,* talk specifically of the growing number of textile designers exploring digital technologies:

> In an era of digital technology, many textile designers and makers find themselves at an interesting juncture. Knowledge and experience of traditional craft processes have, within the current generation, been supplemented by opportunities offered by digital technologies (2016:18).

In her 2017 book 'Digital Handmade', Lucy Johnston "brings together a collection of the work of eighty pioneering designers, artists and craftsmen" (2017:9) each challenging the possibilities offered by digital technologies. With digital-fabrication technologies “such as ‘CAD-modelling’, ‘sintering’ and ‘CNC-milling’” (Johnston, 2017:9) being highly democratized and no longer the “sole domain of large-scale manufacture” (Johnston, 2017:7), these digital craftspeople are challenging these new tools to create a new aesthetic, in that digital technologies provide capacities to create finishes and effects that would not be possible through handwork alone.

> Through disassembling, manipulating and reassembling the building blocks of material and form, these artisans reveal a certain beauty that would have been impossible to conceive in the age of analogue alone (Johnston, 2017:8).

In choosing to incorporate digital processes, however, these designers and makers do not abandon their craft skills but apply and combine them into this new medium, transferring and integrating “textile knowledge within digital design and production” (Nimkulrat et al, 2016:19). Despite the widely argued “perceptions of the computer as a creative tool” the “quality of the outputs realized rely upon the prior knowledge and expertise of the maker.” (Nimkulrat et al., 2016:21). Although this research is not concerned with the creation of artefacts with digital technologies, this emerging field demonstrates the hybrid potential of craft, making the ‘gap’ between craft and gaming more ‘porous’ and open to exploration.

Work and play

Making, and more specifically craft labour, raises questions of the relationship between work and play with key authors such as Sennett arguing that “aspects of craft can be found in all walks of life, from computer programming, to nursing, artistry, parenting, and citizenship” (Sennett, 2008 cited in Brock and Fraser, 2018: 1219). Brock and Fraser (2018) posit that within the play of video games, it is the aspiration for quality within rewarding work that aligns gaming with craft labour. This research builds upon this proposition by considering theories of play in which play is an embodied form of pleasure. Brock and Fraser's paper, *Is computer gaming a craft? Prehension, practice and puzzle-solving in gaming labour,* sets out to contrast perceptions of gaming as a passive act that is suggested by authors such as Crawford (2015) "by arguing that computer games offer a viable source of craft-like experiences" (2018:1220). In doing so the authors propose that there are many commonalities between practices of work and play. Discussing Sennett's interpretation of Schiller's theory of play, Brock and Fraser highlight that play in early childhood establishes the foundations for craftmanship through creative exploration and problem solving:

> Sennett argues that play teaches us some of the earliest attitudes needed for 'good work'. It was a playful attitude, Schiller believed, which helped humans to develop a sense of discovery and creativity alongside rigorous and repetitive working practices (Sennett, 2008 cited in Brock and Fraser, 2018:1220).

Liboriussen (2013) draws similar parallels between the play of computer games and Sennett's broad definition of craftsmanship stating that computer games are cultural objects that "allow playful desires identified by Calliois to be fused with *craftmanship,* the desire to do a job well for its own sake" (2001:273). According to Liboriussen, Callois adopts Huizinga's position in which "professional sportsmen and actors" (Liboriussen, 2013:276) are considered not as "players but workers" (Caillois, 2001:6) "because they are motivated to play by something outside of the game" (Liboriussen, 2013:276). Play, Caillois claims, "must be defined as a free and voluntary activity, a source of joy and amusement" (2001:6) and differs from work in that it is intrinsically motivated. Liboriussen argues it is this intrinsic motivation and "the desire to do a job well for its own sake" (Sennett, 2008:9) that highlights "craftsmanship's relevance for understanding the motivation behind playing computer games" (Liboriussen, 2013:274). Brock and Fraser also cite Sennett's claim that it is the "aspiration for quality" and "an understanding of the rules by which objects operate, such that, within this process, an enduring impulse towards quality work ('craft') emerges" (2018:1220). Using this as a departure point, this study focuses on play as an embodied form of pleasure that links with the aspiration for good work upon which the craftsmanship is founded. By considering the skilled aspects of video game play this research acknowledges and further explores the commonalities between work, play and craft labour.

In his 2018 book *A Play of Bodies*, Keogh examines the embodied engagement between the playing body and video games and how the two incorporate each other. In it, Keogh describes how when playing video games, we interact with them through what he deems as corporeal engagement in which “[w]e poke them, and they in turn poke us back” (2018:4). Keogh outlines that through the book he wishes to explore:

> how it is I come to feel some sense of embodied presence in the projected world of videogames, even as I am always aware that I remain present in this world alongside the videogame (2018:4).

Challenging comments on the ‘newness’ of games as a medium, Keogh claims that gaming is not “radically different from all other ways human bodies have engaged with and experienced creative works in different media over the previous centuries and millenia” (2018:5). In an earlier critique of a single game, Atari’s *Breakout*, Sudnow’s *Pilgrim in the Microworld* (1983) talks about the seductive nature of the videogame in a time that pre-dated game studies. His work forms an account of the body’s interaction with the video game via the computer which he describes as “[o]ur organically perfect tool” (Sudnow, 1983:22). Building on these studies this research is concerned with the embodied practice of players and the highly dextrous skills acquired through engagement with video games.

Value

Core to this research is not only to explore crossovers between craft and gaming but to seek out potential value that could result from directly connecting the two practices through a process I will refer to as ‘grafting’. In this section I wish to briefly set out what I mean by ‘value’ in the context of this research, and its aims. Primarily I use ‘value’ to refer to an outcome that is of benefit to one or more parties in the same way that Felcey et al., define collaboration as a “joint endeavour” that “leaves(s) one or both sides significantly changed” (2017:1). The impacts of grafting on the individual elements are discussed within

Chapters 5 and 7 of this thesis through an analysis of interactions with graft-game prototypes. The research also seeks to find potential value for spaces or contexts where these craft or gaming practices may exist in some form, for which a case study that employs craft skills is used as an example. Here, the research considers whether the outcomes of an exchange between craft and gaming could be of benefit within this setting, specifically productivity and efficiency of craft processes within production. Value here is assessed against specific challenges that are faced within the manufacturing setting of partner factory, *Cookson & Clegg*, which are discussed in Chapter 6. This sits within the context of the funding of this research, which seeks to inform growth of industry in the North West in response to the *Industrial Strategy* (as outlined in section 1.1). Beyond the aims of Transformation North West, there is the consideration of value for participants. At times within the research the two are in tension.

1.3 Key Territories

This research considers craft in its broadest sense, as both a skilled practice and as an approach that is both collaborative and useful for navigation (Adamson, 2007). When considering crossovers with gaming, the research focuses on the embodied and skilled actions, with both being 'active' terms. Craft, for example only comes into existence as a process when a craftsperson engages with a material and digital games only "exist when enacted" (Galloway, 2006:2). Before opening up discussions around crossovers, it is important to first set out what I mean when using the terms 'craft' and 'gaming'.

Craft

Many authors and indeed makers agree that the definition of craft, in reality, is difficult to pin down (McCullough, 1996; Frayling, 2011). For example, Frayling states:

> The commonsense definition of the word 'craft' seems clear enough: an activity which involves skill in making things by hand (Frayling, 2011:9).

The term derives from the old English *craeft* (McCullough, 1996)) meaning strength or skill which at one time may have been regarded with suspicion due to implications of "political cunning and a sly, jocular, tricksy approach to social issues" (Gauntlett, 2018:57). "In later meanings the word referred to a more specific power, namely specialized skill or dexterity in the manual arts" (McCullough, 1996:20). More recently 'craft' has been a "word that has been stretched [...] almost to breaking point" (Frayling, 2011:9) for example in its use to promote luxury goods with ad agencies using phrases like 'hand finished' and 'made by craftsmen' (Frayling, 2011). This comes from an assumption that the public associates craft with "values of the recent past rather than the present" (Frayling, 2011:9), a response that Frayling attributes to a feeling that crafts are perhaps endangered. Greenhalgh claims that the main problem with the term 'craft' is that it is "used to collectively describe genres and ideas that formerly were not grouped together and that grew from quite separate circumstances" (1997:21). He expands upon this to claim that more recently 'craft' is used either to refer to 'studio craft' covering anyone working with a craft medium including both "producers of functional ware as well as abstractionist sculptures working in textiles, clay, or glass" (Dormer, 1997:6), or it refers to the "process over which a person has detailed control, control that is a consequence of craft knowledge" (Dormer, 1997:6). The latter of these two is the definition that this research aligns with.

I am particularly interested in the work of Richard Sennett. In his seminal work, *The Craftsman,* Sennett "argues that aspects of craft can be found in all walks of life, from computer programming, to nursing, artistry, and citizenship" (Sennett, 2008 cited in Brock and Fraser, 2018:1219). Brock and Fraser's article, *Is computer gaming a craft?* (2018)*,* which begins to examine aspects of craft within gaming, also considers sociological theories of craft, including the work of Sennett. As Frayling suggests "[t]o a sociologist, the word 'craft' is associated with 'skilled manual labour'" (Frayling, 2011:10). Sennett forcefully argues the meaning of craft in its broadest sense as the basic human impulse of "the desire to do a job well for its own sake" (Sennett, 2008:9), "where doing a job well involves as well as physical activity submerged processes and reflection and feeling" (Frayling, 2011:15). In his broad definition, Sennett suggests that craft is not about looking backwards to tradition but instead is forward thinking process which still "involves hard work and dedication" (Sennett, 2008 cited in Frayling, 2011:15). Whilst recognising the drive for quality and dedication that exists within craft, this research acknowledges Sennett's broad view of the term and aligns with the view put forward by Brock and Fraser (2018) that overlaps exist between the act of computer gaming and experiences of craft labour. This research does not, however, seek to ask if the play of video games *is* a craft but instead sets out to explore crossovers between the two domains. Within this thesis, I will use the term 'craft' to refer to the skilled act of *'making'* which: requires detailed control (skilled work); utilises particular tools and materials; is developed and refined over time, and ordinarily produces artefacts. McCullough offers a comprehensive definition that encompasses these key attributes:

> Craft remains skilled work applied toward practical ends. It is indescribable talent with describable aims. It is habitual skilled practice with particular tools, materials, or media, for the purpose of making increasingly well-executed artifacts. Craft is the application of personal knowledge to the giving of form (1996:22).

This research acknowledges that all craft practices require a varied sets of tools and expertise. The study tries to address this through the exploration of textile crafts and its associated tools and materials, as indicative of broader craft.

Games and gaming

In order to explore crossovers with craft, I will also outline the meaning of the terms 'games' and 'gaming'. For the purpose of this study, I will focus on digital games, otherwise referred to as 'video games'. Many definitions of 'games' offered within game literature often take into account broader categories that include board games and it is useful to consider the broader meaning of games before focusing on experiences of playing digital games.

In her book *Reality is Broken* (2011), Jane McGonigal refers to a definition of games by Bernard Suits (1978) which she deems to be the most convincing: "[p]laying a game is the voluntary attempt to overcome unnecessary obstacles" (2011:22). Alongside this, McGonigal acknowledges that core to our understanding of something being a game is the player's experience of it, “when we’re playing a game, we just know it” (2011:20). This suggests that like craft a definition of games is difficult to pin down but McGonigal does go on to provide deeper clarification outlining four key traits that all games contain:

Goals: games contain specific outcomes that players work towards, offering them a “sense of purpose” (McGonigal, 2011:21).

Rules: games pose “limitations of how players can achieve the goal” (McGonigal, 2011:21) through the application of rules.

Feedback systems: mechanisms such as points, levels, scores or progress bars tell “players how close they are to achieving the goal” (McGonigal, 2011:21).

Voluntary participation: everyone playing a game “knowingly and wittingly accepts the goal, the rules, and the feedback” (McGonigal, 2011:21).

In the next Chapter, I will outline four key thematic areas of crossover between craft and games that, to some extent, echo these key traits whilst considering key aspects of craft also.

In *Half Real* (2011), Jesper Juul discusses seven definitions of games offered by earlier authors. These definitions range from Caillois (2001) and Huizinga (1955) who consider games to be “unproductive” with “no material interest” (2011:23) to more prescriptive definitions, for example, Salen and Zimmerman (2004), in which all games are considered to contain certain attributes. These bear some similarities to those listed by McGonigal (2011) but include the addition of ‘variable and quantifiable outcomes’. Through his analysis of these existing definitions, Juul proposes his own definition that contains six features of games:

> A game is a rule-based system with a variable and quantifiable outcome, where different outcomes are assigned different values, the player exerts effort in order to influence the outcome, the player feels emotionally attached to the outcome, and the consequences of the activity are negotiable (Juul, 2011:36).

Although these definitions acknowledge player effort, motivation and experience of playing games, they do not consider the skilled aspect of gameplay. As discussed previously, some authors have begun to highlight this (Brock and Fraser, 2018; Reeves, Brown & Larier, 2009) identifying dexterous skill as an important aspect of gaming, specifically concerning the play of video games.

It is important at this stage to make a distinction between digital (video games) and non-digital games, something which Salen and Zimmerman (2004) state that many definitions of games fail to do. This is in part because many key thinkers discussing play and games, such as Huizinga and Caillois, "were writing before the invention of computer games, let alone before the recent explosion of the video game industry" (Salen and Zimmerman, 2004:104). Salen and Zimmerman offer a list of four traits of "digital media that can support gaming experiences" (2004: 106) that are not possible in non-digital games:

Trait 1 Digital games offer immediate and narrow interactivity, with feedback that "responds seamlessly to the player's input" (2004:106). In this sense digital games offer a form of dynamic real-time game play.

Trait 2 Digital games' ability to store and manipulate complex information makes it possible "to learn the rules of the game as it is being played" (Salen and Zimmerman, 2004:107) unlike players of non-digital games who are generally required to learn and understand the rules of a game before play begins.

Trait 3 Digital games "can automate complicated procedures" (Salen and Zimmerman, 2004:107) resulting in something akin to a 'black box' system that does not reveal its inner workings, where players may then not know why things in the game happen in particular ways.

Trait 4 Many digital games offer forms of digitally mediated communication such as in-game text chat, video and/or audio communication, offering the ability for players to communicate both locally and over long distances (Salen and Zimmerman, 2004).

These traits are useful within the context of this research for framing aspects of digital games that align with craft practices. In particular, when exploring crossovers with craft, this research focuses on digital games encompassing those which can be played on electronic platforms including personal computers (PC), consoles that are attached to a television, and handheld game devices. In their analysis of the overlap between the play of digital games and craft labour, Brock & Fraser stress the importance of recognising that their "approach may not apply to all computer games in a uniform way – as computer games are exceptionally diverse" (2018:1220). This research acknowledges this diversity and focuses on digital games (video games) in which unfolding narratives are mediated by physical interfaces (da Luz, 2014) as expressed by Salen and Zimmerman:

> Playing a game means interacting with and within a representational universe, a space of possibility with narrative dimensions. [...] Formed by rules and experienced through play, a game is a space of possible action that players activate, manipulate, explore, and transform. (Salen & Zimmerman, 2004:425)

It is these qualities that this research considers to be aligned with craft expertise, requiring the acquisition and embodiment of skill in order to achieve mastery of the interface, themes that will be explored in further depth in Chapter 2.

Having outlined definitions of craft and gaming that will be used throughout this thesis, I will now briefly discuss the motivations of players and crafts people (makers).

Motivations

As stated previously, "the desire to do a job well for its own sake" (Sennett, 2008:9) is a core aspect of craft, and it is Sennett's analysis of craft labour that Brock and Fraser (2018) apply to, and align with, the act of computer gaming. As outlined in the definitions above, ‘voluntary participation’ is also key to games and gaming (McGonigal, 2011). According to Jesse Schell:

> doing something ‘for its own sake’ […] is an important characteristic of play. If we don’t like to do it, it probably isn’t play. That is, an activity cannot be classified as a “work activity” or “play activity.” Instead, what matters is one’s attitude about the activity. (Schell, 2020:39)

To this end, gaming could be classified as an intrinsically motivated activity (without external reward). Schell (2020) considers playing a game as a ‘pleasure seeking’ activity, something that the player ‘wants to do’ rather than ‘has to’ do. Unlike extrinsically motivated activities like work that are rewarded with pay, doing things that we ‘hafta’ do, like our taxes, are driven by a desire to avoid pain or to avoid punishment (Schell, 2020). Just as extrinsic and intrinsic motivations are not binary in nature, with potential for them to interact in different ways, some games can “slide from pleasure seeking” to “pain avoidance” (Schell, 2020:159) with the addition of increasing obligations to play or penalties for not completing certain tasks.

Many game designers seek to tap into these different forms of player motivation when designing digital games, considering the aesthetic components that create player experiences as opposed to a feature-driven approach (Hunicke et al., 2004). In recent years an emerging trend within business and marketing sectors (Seaborn and Fels, 2015) has seen “t*he use of game design elements in non-game contexts”* (Deterding, Dixon, et al., 2011: 9; Deterding, Khaled, et al., 2011: 1) become remarkably popular (Woodcock and Johnson, 2018). It is not difficult to see why video games that “can demonstrably motivate users to engage with them with unparalleled intensity and duration” (Deterding, Dixon, et al., 2011: 10) may be seen to be to provide an inviting level of potential for use in non-game contexts. A term first coined in 2008[3], this phenomenon is now widely accepted and referred to as ‘gamification’. With applications across education, training, health, self-management,

[3] The term gamification was first documented in 2008 but not popularised until the latter half of 2010 (Deterding, Khaled, et al., 2011)

employee engagement, crowdsourcing and marketing, gamification is generally utilised for the purpose of motivating and increasing user activity and retention, whether those users be customers or employees (Deterding, Dixon, et al., 2011). This is an appealing concept and is why gamification has rapidly gained traction in recent years. However, game designers and academics alike have widely criticised gamification for its ‘stock’ approach with “pointisfication, or gamification that exclusively relies on points, badges and leaderboards (Bogost, 2011a; Kapp, 2012; e.g. Lawley, 2012; Robertson, 2010)” (Seaborn and Fels, 2015: 18). Game designer and academic Ian Bogost is cited by some as gamification’s most vocal critic (Seaborn & Fels, 2015), referring to it as ‘exploitationware’. In Bogost’s view ‘gamifiers’ (the likes of business “Vice Presidents” and “Brand Managers”) are seeking only “to capitalize on a cultural moment” (2011: online) by applying games strategy enthusiastically despite having little expertise in the area. Bogost believes this view to be shared by game designers and players who “have critiqued gamification on the grounds that it gets games wrong, mistaking incidental properties like points and levels for primary features like interactions with behavioural complexity” (Bogost, 2011: online).

Similarly, in a more recent paper, ‘*Gamification: What it is, and how to fight it’,* Woodcock and Johnson describe "the application of game systems [...] into non-game domains" as being deeply problematic (2018: 542). Whereas early advocates "dreamt of bringing play and fun into the banal activities of our lives" (2018: 544) Woodcock and Johnson suggest that gamification "ignores the power dynamics in both the workplace and society", replacing "older forms of labour surveillance and oversight with equivalent seemingly 'playful' forms that workers engage with" (2018: 544). The goals for employing gamification in actuality have "decidedly *un-playful* motivations" and are not about "'gamifying' user experiences" at all (Woodcock & Johnson, 2018: 546). Instead, gamification has been "transformed into a management tool" (Woodcock & Johnson, 2018: 546) where gamification appears as a ‘magic’ solution to worker motivation and the productivity that is central to functioning capitalism.

As this research progresses through amateur and participatory settings to the observation of and intervention within craft skill in an industrial setting, it is important to acknowledge the potential links with gamification. Significantly, this research is mindful of the exploitative potential and problematic power relations that the application of gamified systems could pose within a setting where external rewards will impact upon individual motivation. Craft may provide a way of mediating these power dynamics so that productivity is co-created.

Endogenous value

A key aspect that may be seen to be misaligned between definitions of gaming and craft, is the production of artefacts in craft and the variable outputs of gaming. As suggested in the definition of craft, the term is generally seen as synonymous with the production of a craft object. More recently, though, craft has come to be seen more as an approach or a way of thinking (Adamson, 2007). Through the definitions of games discussed it is evident that a variable outcome plays a key role in the experience of playing a game with players developing an emotional attachment to the output. These outputs, varying from quantitative to qualitative, are generally intangible, not being manifested in the physical world, often taking the form of a score or specific achievement which are set as the goal of the game from the outset. In *The Art of Game Design*, Schell invites game designers to view their game from the perspective of 'Endogenous Value'; a term borrowed from the field of Biology, that refers to something that is 'internally generated'. Within games this term is used to describe how "things that have value inside the game have value only inside the game" (Schell, 2020:43). Indeed "the more compelling a game is, the greater the endogenous value that is created within the game" (Schell, 2020:43). The value items within the game "is a direct reflection of how much players care about succeeding in your game" (Schell, 2020:43).

Within video games, virtual items may be produced and may even be traded in-game or for real currency (Bartle, 2004; Hamari & Lehdonvirta, 2010), but the items remain predominantly in the virtual space. Variable outcomes be they scores, or items created, are what makes a game desirable to play (Juul, 2011) and in this sense, match the goal of craft to produce an object or artefact. According to Sennett, it is the "aspiration for quality" that drives a craftsman "to improve, rather than get by" (2008:24). The key difference is that the output of a video game tends to remain virtual. It is important to recognise, however, that both outcomes, hold value to the player and the craftsperson alike. Both act as evidence of their actions and both player and maker exert effort in the production or achievement of their outcome and in doing so develop a personal connection to it seeking to improve the quality of these through practice.

1.4 Methodological Approach

This research aims to investigate the potential impacts and outcomes created through developing a direct relationship between craft and gaming, using both myself as a research subject and embracing an experimental approach to prototyping through participatory activities at public events and industry intervention. To answer the research aims, the study combines theoretical investigation with creative practice. In the first instance, the literature review focuses on establishing crossovers that already exist between the embodied practices of craft and gaming which serve as a conceptual model for further investigation throughout the thesis. These include material affordances; feedback systems; habitual practice; and minimising risk.

The empirical aspect of this research follows a multi-stranded, bricolage approach that incorporates ‘methods braiding’ (Watson, 2020) underpinned by reflective practice (Schön, 1983; Cowan, 1998) and investigative designing (Durling & Niedderer, 2007). Three strands of the research were carried out, often concurrently and overlapping. The first strand focuses on autoethnographic observations of amateur craft and gaming before broadening the study to engage with members of the public alongside detailed observations of skilled factory workers. Each setting was used as a test bed for the creative practice and acted as an area for direct observation of the potential for the hybridity that results from a direct relationship between craft and gaming.

Amateur making

In the first setting, the thematic crossovers are further examined and explored in depth through reflective practice that engages directly with amateur craft and gaming practices. The phenomenon of video games "has only been relevant socially speaking, since the 1980s (Kirkpatrick, 2015)" (Muriel and Crawford, 2018:3). Since then, the playing of video games has grown exponentially, and it is now "evident that playing a video game can be, and is increasingly becoming, a mainstream, ordinary and everyday activity for many" (Crawford, 2012:159). The proliferation of personal computers, video game consoles and mobile devices has enabled video games to be located within people's lives "both physically and socially" (Crawford, 2012:155). Craft practice has a much longer history as an amateur activity, specifically textiles, upon which this study concentrates. As stated by Twigger Holroyd "knitting, sewing, and mending having been carried out in the home, whether through necessity or as a hobby (Black 2012; Burnam 1999)" (Twigger Holroyd, 2018:292), for generations. Long “presumed superfluous and opposite to valorised ‘professional’ practice” (Knott, 2011:abstract), amateur practice is typically disregarded by craft historians such as Greenhalgh (Hackney, 2013b). Stephen Knott, in his more recent writing on amateur craft on the other hand argues “the constrained freedom of amateur craft practice fulfils an essential role within modern life, providing a temporary moment of autonomous control over labour-power in which the world can be shaped anew” (Knott, 2011: abstract). Furthermore, “interest in amateur creativity” (Hackney, Saunders, et al, 2020: 37) has seen a resurgence in popularity over the last 10-15 years as "the rise of digital technologies and social media" (Gauntlett, 2018:72) and the platforms they provide have enriched amateur activities. Digital technology now plays a significant role in amateur craft practice supporting the building of communities around making, and the sharing of resources and outcomes. “Terms such as crafting, craftivism (craft activism), manbroidery, counterfeit crochet, net craft, ‘stitch ‘n’ bitch’, guerrilla knitting, yarn bombing, Punk DIY, subcultural and indie craft, signal a new energy” (Hackney, 2013a:25-26) and “the emergence of a new super-connected” (Hackney, 2013b:170) amateur. This new amateur is both technologically and historically savvy re-engaging with craft’s rich political heritage, informed by an array of on- and offline resources (Hackney 2013a, 2013b). These amateurs “are quietly active as they open up new channels of value and exchange by engaging in alternative craft economies and harnessing assets in often surprising, productive ways” (Hackney, 2013b: 171). The re-emergence of craft and interest in amateur creativity within a wider resurgence of community activism has led us to reassess the boundaries between professional and amateur (Hackney, Saunders, et al, 2020; Hackney, 2013b). This is especially the case in contexts where “untrained or self-educated crafters who make for fun are increasingly able to exhibit or sell their wares” (Hackney, Maughan & Desmarais, 2016: 40) through online forums and marketplaces. With calls amongst academics for greater inclusivity within interdisciplinary approaches (Hackney, 2013b) to include amateur practice. Twigger Holroyd calls for caution to not overlook activities that are undertaken for pleasure:

> The overwhelming focus on commercial endeavours can overshadow an important parallel strand of activity: amateur makers producing items for their own use and motivated by non-commercial concerns. (Twigger Holroyd, 2018: 291)

In line with researchers such as Hackney, Maughan & Desmarais (2016), for this strand of the research I chose to focus on textile activities "undertaken voluntarily and for pleasure" (2016: 34) so as to remove potential impacts from external factors such as commercial endeavours or paid work. This also enabled a direct comparison with gaming activities taking place within the home where the player "plays for pleasure, fun, and for the love of the game" (Mortensen, 2009:13). Amateur activities observed within this strand of the research included: PC game *Unravel, Mario Kart 8 Deluxe* on the *Nintendo Switch*, handknitting a *Mother of Pearl* Sweater using a kit from online retailer Wool and The Gang, following an online macramé course with Isabella Strambio. I approached these activities as an amateur myself, having some experience playing PC games such as *Minecraft*, including within my practice, and only casually engaged with console games (including previous versions of *Mario Kart*) in the past. As discussed in section 1.1, my practice has also drawn on textile making processes, including processes such as embroidery and the more complex mechanisms of jacquard weaving, with a special interest in its links with early computing. I had also previously attempted a small number of knitting projects, completing very few, and was familiar with the basic stitches, but was completely new to macramé as a practice. Accessing these activities as an amateur enabled new descriptions and potential spaces to form, including the ability to access reflections that may be inarticulable (Polanyi, 1983) to more experienced participants.

Participatory practice

As a participatory artist, making is at the heart of my practice and the second strand of this research was led by the development of collaborative prototypes that were tested and critiqued with members of the public at a series of events. ‘Participatory art’ is a complex term that this research does not seek to explore. Within this research I use the term ‘participatory’ to express an approach that I use within my practice as a means of engagement with and involvement of participants within public settings. This approach also builds upon a long history of collective textile making, which in recent years has demonstrated a shift into academic research. This has been highlighted through the work of Dr Emma Shercliff and Dr Amy Twigger Holroyd who have led the recent formation of research network, *Stitching Together*. With participatory textile making featuring “in recent activities as both the subject of inquiry and the means of investigation” (Shercliff & Twigger Holroyd, 2020: 10), the network “brings together researchers, professional textile practitioners, project commissioners and textile enthusiasts to foster critical dialogue” (Stitching Together, ND: online) around making textiles with others.

> The network has discovered participatory textile making activities being used in varied contexts across a range of disciplines, from occupational therapy and human-computer interaction to community building and sustainable development, to gain rich insights into questions of artistic, scientific, social, material and cultural value. (Shercliff & Twigger Holroyd, 2020: 10)

In this research members of the public were not co-producers or contributors to a collective works but were seen as active participants in testing and trialling a series of prototype graft-games. At these events these prototypes were not presented as ‘finished games’, or interactive art pieces but were framed within the context of ongoing research activity. In doing so invited participants engaged in conversations about crossovers and critiquing potential outcomes. This approach has many symmetries with standard participant observation methods, but it did not observe people within existing settings, creating instead, spaces for participants to collectively explore the research topic through direct engagement, including hands-on activity. The observations recorded focused on those physically interacting with the prototypes but, as within my art practice, the approach recognised all forms of participation including peripheral observers. This approach enabled reflection upon observations of interactions alongside less-central conversations adding to the investigation into the relationship between craft and games brought about through grafting.

Industry

Garment manufacturer *Cookson & Clegg*, in Blackburn, were chosen as a test environment during the third strand. Direct observation of processes being carried out by machinists in the factory alongside the development of creative prototypes and participatory practice drew attention to the way craft functions within such a setting and how games may contribute collaboratively. The aim here was not to directly solve production problems within the factory but to use my creative practice to raise questions and explore potential areas for new value, as discussed above. In 2020, plans for a creative intervention within the factory setting had to be adapted in response to COVID-19 restrictions in the region. As an alternative a group of domestic sewers working on a small batch production project, including myself, were used for the final stages instead. This has the additional benefit of providing direct access to the inarticulable processes involved and the ability to reflect on the impacts of the creative intervention, such as where the grafted game led to the development of strategies and changes in techniques to improve efficiency of processes. These insights were then aligned with observations made on the factory floor of *Cookson & Clegg*. Implications of these will be discussed in the conclusion, including potential development of application within the partner setting but also in respect of wider contributions within other manufacturing settings and other potential creative outputs.

As this research moves from amateur settings, through to wider participatory practices, and then into craft skills used in a factory setting, this research cannot ignore, and will be mindful of, the potential links with gamification which may pose ethical implications in terms of potential for exploitation.

1.5 Structure of the Thesis

This thesis is divided into eight chapters. This introductory Chapter frames the research by exploring the foundation themes of the collaborative nature of craft, work and play, digital technologies, and the meaning of value. I then set out the key territories of craft and gaming, and their motivational qualities, to establish where the research sits within these broad but overlapping fields. Chapter 2 begins to explore existing thematic crossovers between craft and gaming through an analysis of key craft and gaming literature establishing four key areas: material affordances, feedback systems, habitual practice, and minimising risk. I then set out existing approaches that combine the two fields before putting forward 'grafting' as an alternative creative approach.

Chapter 3 describes the research methodology, introducing the mixed methods approach that draws upon methods braiding underpinned by methodologies of reflective practice and investigative designing. The chapter sets out the research approach across three strands with a review of data collection methods and analysis.

Chapter 4 builds further on the thematic crossovers identified in Chapter 2 through an analysis of reflective observations of my own amateur craft and gaming activities, to develop a conceptual model of crossovers. The next three chapters present the empirical aspects of the research. Chapter 5 describes in detail the development of grafted game *Hazuki Knit* and provides an analysis of observations made during gameplay, before summarising potential positive and negative impacts grafting has upon the individual craft and game elements. Chapter 6 and 7 cover an analysis of observations made within the factory setting of garment manufacturer *Cookson & Clegg* and the subsequent development of second graft-game *Pocket Racer*, developed in response. Analysis of initial observations made of tasks and processes carried out by machinists in the factory setting aid the assessment of key challenges faced in the setting in relation to company's digital strategy in order to set out potential areas for growth within skilled production. Chapter 7 outlines the development of two iterations of graft-game *Pocket Racer* that responds to activities observed in the factory. I discuss outcomes of participatory engagement at a public event and as an intervention into a small-scale batch production process, aligning outcomes of the graft-game with potential areas for growth identified in the factory.

My conclusion assesses the outcomes of this research project, including a summary of the findings and identification of the contributions to knowledge. The Appendices contains copies of documents used for ethics purposes along with examples of data gathered (e.g. field notes, video transcripts, analysis spreadsheets and diagrams). Please note additional supporting material in the form of video content can be found via the One Drive file Appendix B5 Supporting videos (access provided separately), with links provided within the document.

1.6 Contribution to Knowledge

This research aims to bring craft and gaming together in a seamless method that generates a greater effect for contexts beyond the original individual components, hence providing potential value. By directly connecting the two elements new hybrid forms of knowledge can emerge through cross fertilisation and conjoined experiences. In doing so, this research contributes to the field of design practice whilst further progressing the convergence of the as yet separate fields of craft theory and game studies. Specifically, this study contributes new knowledge through the development of custom ‘graft-games’ that reveal potential value to contexts beyond the individual craft and game practices, such as manufacturing.

Through investigating the commonalities between the craft and gaming this research identifies four thematic crossovers: material affordances, feedback systems, habitual practice and minimising risk. Through an investigative designing approach that explores directly connecting craft and games this research reveals that ‘grafting’ can create additional or merged goals for participants that can lead to the development of new strategies to reach these goals. Working with project partner *Cookson & Clegg*, these outputs demonstrated potential value for improving efficiency of craft processes carried out within the manufacture of clothing. Grafting provides additional feedback which has potential to inform the development of new strategies and techniques within making through a desire to improve grafted goals without putting the quality of the craft output at risk. In doing so the study presents a new model that is adaptive and responsive to settings and contexts where existing craft or gaming practices may reside. Grafting is therefore presented as a model that can be transposed into and across settings, opening-up existing ways of doing things to reveal new hybrid possibilities.

This research adds to our understanding of the relationship between craft and games that contributes to emerging theoretical research through empirical research that utilises creative practice. This has implications for manufacturing but grafting as a method also has potential to be used in other contexts as a means of assessing the potential impacts of combining craft with other skilled and active processes.

In the exploration of aspects of gaming within non-gaming contexts, this study could be seen to be synonymous with gamification and thus have implications for this growing field. Gamification, however, a highly contested and debated field that has many political implications, especially in the contexts of work and labour. Although considered within the realms of this research, it was felt that the political elements would distract from the core aims and thus not considered as central to the research.

_2 Crossovers

This review is used to develop a conceptual model that forms the foundations for this study. As outlined in the introduction, this research investigates crossovers between craft and gaming and explores the potential value that might be brought about through directly connecting the two through a process I have chosen to refer to as ‘grafting’. This Chapter identifies existing crossovers through an analysis of craft and gaming literature and seeks to fully determine the fundamental meanings and approaches from where creative practice will be drawn. After identifying four thematic areas of crossover, I will then establish ‘grafting’ as both a term and an approach for exploring the possibilities of connecting craft processes directly with gaming.

2.1 Skill and Craft Expertise

As stated by Cheasley Paterson and Surette “[c]raft and skill have traditionally been conceptually aligned” (2015:6). Skill within gaming, on the other hand, is often overlooked, dismissed as a “repetitive, rhythmic and routine” experience that distracts “players into a ‘passive’ state of ‘absorbed automacity’” (Brock and Fraser, 2018:1220). Through an analysis of skill and, more specifically, craft expertise within craft literature, I will draw upon game studies research to argue that gaming involves comparable experiences of embodied skill.

Skill is a broad term that we could generalise as “the learned ability to do a process well” (McCullough, 1996:3), but what exactly is it? "No one can ever agree about what the components of 'skill' are because clearly, all skills are different" (Frayling, 2011:80), they take many forms and are domain specific. We might be skilled at listening to other people (interpersonal) or skilled at coming up with ideas (cognitive), or skilled at typing or fixing things (technical). For this research, I will consider skill within the context of craft expertise: being refined over time through continual engagement with material and using one’s hands.

> Most writings on craftsmanship […] make huge assumptions about the importance of skill, but there seems to be no general agreement about what the word means. Does it refer to manual dexterity, craft experience, conceptual activity, general know-how, or a shifting combination of these four? (Frayling, 2011:74).

A craftsperson is commonly considered to be someone who has acquired high levels of technical skill and practical proficiency (Figueiredo and Ipiranga, 2015) with craftsmanship being “founded on skill developed to a high degree” (Sennett, 2008:20). This high level of skill may have required some form of training, but most definitely will have been acquired systematically over a long time, a period that Sennett states is commonly measured as “about 10,000 hours” (2008: 201) if mastery is to be achieved. Mastery of a skill may otherwise be referred to as expertise. According to Risatti, expertise in craft is formed of two kinds of learning: specialized knowledge of how to prepare and finish materials and “a high degree of technical manual skill to readily and effectively work material into the requisite form” (2013:99). Craft expertise is thus a combination of technical knowledge and technical skill, with ‘technical’, or ‘technique’, is a term rooted in skill. Risatti explains the etymology of the term:

> ’Technique’ is a French word derived from the Greek ‘*technikos*’, which in turn, has its roots in the Greek ‘*technē*’. ‘Techn*ē*’ refers specifically ‘to the knowledge of *how* to do or make things (as opposed to why things are the way they are)’. But more generally ‘*technē’* denotes a body of procedures and skills (2013:143).

The specific skills of craft expertise, such as an understanding of how to work their material, may appear to be semi subconscious, but they are not purely mechanical. This will be discussed further in section 2.5. This knowledge, especially, is not imparted but acquired over time. Risatti, explains that a vast gulf lies between “intellectually knowing how to manipulate a material and being physically capable of doing so” (2013:146), a gulf that can only be traversed by learning through meticulous practice. This concept can be extended further with craft expertise categorised as a form of practical ‘inarticulable’ knowledge, otherwise referred to as *tacit knowledge*, first discussed by Polanyi in 1983.

> Psychologists and social scientists have studied this inarticulable knowledge extensively, and they have many names for it: operative, action centred, elective, reflection-in-action, know-how. The most common word is skill (McCullough, 1996:3).

Tacit knowledge (Polanyi, 1983), or *knowing how,* is a form of knowledge "that we cannot explicitly explain or verbalize"(Tanaka, 2013:50). As opposed to *knowing that*, a form of information-based knowledge that can be explained and acquired through language, *knowing how* is "training-based knowledge […] that cannot be reduced to a set of propositions" (Tanaka, 2013:50) expressed through the performance of skilful actions. Polanyi explains this simply as "we know more than we can tell" (1983:4) and is understood as being procedural and performance related. Actions of tacit knowledge in everyday life include basic bodily movements, such as walking, using a knife and fork, or playing the piano (Tanaka, 2013). These actions "are not necessarily experienced in a conscious way but are practiced in a prereflective way"(Tanaka, 2013:52). In other words, this knowledge is lived rather than being scientific knowledge that is externalised.

Craft expertise, as a form of tacit knowledge, is practical and is a process that is learned by the body (Figuierdo & Ipiranga, 2015), more specifically in craft, it is a skill that is considered as residing predominantly in the hands. McCullough tells us that "[l]ittle can surpass the hands in showing that we know more than we can say" (McCullough, 1996:3). In gaming, knowledge resides in the hands and is also inarticulable. Keogh (2018) recalls talking his housemate through a particular manoeuvre in the game *Crash Bandicoot* (Naughty Dog 1996) in which a particular sequence of button presses on the game controller were required to navigate a jump over a chasm in the game. He explained that the player must "move forward, then jump while continuing to move forward, then press Square while jumping forward to do a spin attack through the enemy so as not to lose momentum" (Keogh, 2018:75). In trying to replicate this set of actions his housemate, as *Crash* in the game, fell to his death. His housemate asked how he was to "press Square soon enough while still holding down X with the same thumb?"(Keogh, 2018:75). Keogh did not have the answer and needed to pick up an unused game controller from the floor and pretend to play the game so that he could observe the exact movements of his thumbs and fingers across the buttons.

> When I first explained to my housemate how to approach this challenge, I thought I 'knew' what to do: jump and spin. Looking at my hands as I reenacted the scene, however, it became apparent that 'I' consciously did not know what to do at all. The performance was somatic, proprioceptive. The knowledge was in my hands"(Keogh, 2018:77).

This phenomenon was described by Merleau-Ponty (1945) as ‘knowledge in our hands’, “a particular type of knowledge that is not a reflex but rather comes about through repeated bodily practice" (Tanaka, 2013:48) through which the body knows how to act. This demonstrates a direct crossover between craft and gaming that directly relates to the notion of embodied knowledge, derived from Merleau-Ponty’s phenomenology of perception in which the body knows how to act.

Summary

Having established that skill, specifically craft expertise, is a form of tacit knowledge that is embodied by both the gamer playing a video game and the maker engaged in craft practice, I am now able to carry out a deeper exploration into the crossovers between the two. I will use the rest of this Chapter to analyse and outline thematic crossovers between craft and gaming including material affordances, feedback, habitual practice (including the embodiment of tools), and minimising risk. In the final sections I will outline existing examples of craft within games and craft combined with games before putting forward my own approach that I will term as ‘grafting’.

2.2 Material

Risatti states that “material and process are essential to craft and must be understood together as the basis of craft technique” (2013:99). Having discussed craft expertise as a skill that is acquired through action becoming embodied over time, this section will consider material as an element to which craft is emphatically linked. I will then establish an argument for the consideration of video games as the material with which the gamer engages, interacting with rules posed by the game in the same way a craftsperson responds to the affordances and limitations of physical material.

The Oxford English Dictionary defines *material* as 'the matter from which a thing is or can be made'. We sense a material's "basic properties as physical matter and its 'willingness' to be formed so as to become a functional object" (Risatti, 2013:98). Material is thus essential to the production of craft objects and it is this which distinguishes craft expertise from other forms of everyday embodied knowledge, such as touch-typing or riding a bike (Tanaka, 2013). Greenhalgh states that "[i]n late modern culture the crafts are a consortium of genres" (2002:1) each with their own accompanying gestures, tools and materials that are specific to that practice yet "poised for radical change" (2002:1). For this aspect of the research, in identifying crossovers between craft and gaming, I consider craft in its genre-specific form that involves material specialism before later considering its potential to cross-fertilise with gaming.

Traditional crafts are generally defined and identified by their specific material with the "physical workability of a material" defining "its possibilities as a medium"(McCullough, 1996:212):

> This could be wood, glass, metal, clay, paper, plastic, paint, stone-anything-or more than one material in combination. In any case, though, craft involves direct engagement with specific material properties (Adamson, 2007:39).

McCullough (1996) tells us that every material has a set of qualities and according to Korn, the craftsman must adapt to the "character and quirks" (Korn, 2015:55) of their material to work it successfully. "Over time he learns to read his material through its response to hand and tool" (Korn, 2015:55). Although some qualities are made explicit such as grades of wood (McCullough, 1996), much understanding of material structure is implicit, sensed and understood "only in action" (McCullough: 1996:196). McCullough borrows from psychology, using the term *affordances* to describe the "workable capacities" (McCullough, 1996:198) of a material, and I shall do the same within this research. The "word affordances implies a finite budget of opportunities" (McCullough, 1996:199) which, according to McCullough is “complimented with the idea of ‘constraint’” (McCullough, 1996:199-200). The affordances of a material, therefore, pose both a set of possibilities and limitations or, put simply, what can or can’t be done with, or to, a material.

Pye puts forward two further ideas about the capacities and possibilities of material. The first, that the worker or craftsperson “feels obliged to respect his medium” (Pye, 1995:86), for example, a wood worker who desires to bring out the quality of grain in the wood they are shaping. The second is that any material can be made to take “certain shapes easily or directly” (Pye, 1995:86), lending itself to be manipulated in a particular way.

> Both ideas have in common the notion that every material has, a matter of objective fact, a specific nature, a fixed set of inherent properties, which can be expressed or suppressed when it is used. [..] a material shall not be shaped or otherwise treated to suppress the set of inherent properties which constitute its nature (Pye, 1995:86).

Expertise "involves deep familiarity with possibilities and practicalities of particular media" (McCullough, 1996:199). Just as wood can be carved easier than stone, the process and possibilities offered by two materials are different. In essence, the craftsperson works with a material’s properties rather than fighting against them. Working outside of the tolerances of a physical material will result in its breakdown (McCullough, 1996).

With the advent of digital processes as an extension of traditional crafts, discussions around the validity of digital tools and skill required when working within the digital space have come to the fore (McCullough, 1996; Sennett, 2008; Jorgensen, 2005; Johnston, 2017). McCullough asks, with the “physical workability of a material” being what defines its possibilities (1996:212), must a craft medium have a “material substance”. He suggests:

> the fundamental difference between digital and traditional media is rooted in microstructure: bits versus atoms. Processes that move physical atoms around are precisely the irreversible aspect of traditional work (McCullough, 1996:213).

Affordances in the digital space of a computer used for 'electronic craft' (McCullough, 1996), with "its *undo* and *save as* functions" (McCullough, 1996:212), however, may be less apparent and not appear to demand the same level of concentration that the irreversibility of a physical material does.

In *The Real Thing* (2015), Harrod discusses the work of American digital artist Casey Reas "who argues that softwares[sic] should be regarded as materials with different qualities, like oak as compared with walnut, or rigid as opposed to flexible" (Harrod, 2015:85). Raes claims that each "piece of software has different properties that combine an 'atmosphere' and a set of tools." (Harrod, 2015:85) suggesting a more nuanced engagement between maker and digital material, aligning with that of physical matter. The reversible properties of craft actions in comparison to the undo functions of digital work will be discussed in more detail in a later section of this Chapter. For now, I ask if a medium "signifies a class of tools and raw materials", as McCullough suggests (1996:193), should games not be considered a medium in which the game is the material and the controller, or keyboard and mouse, are the tools?

Game rules as material affordances

As one of the key traits of games defined by McGonigal (see section 1.4), "**rules** place limitations on how players can achieve the goal" (2011:21) of the game, "the specific outcome players will work" (2011:21) towards. It is rules and their implementation that begin to distinguish between digital and non-electronic games, and more significantly for this research, where digital games demonstrate a crossover with craft. Just as properties of physical matter pose a set of affordances and limitations, "[r]ules describe what players can and cannot do" (Juul, 2011:55). "[R]ules do not appear out of nowhere" (Juul, 2011:55) they are created by game designers who seek to make sure "the rules are unambiguous" (Juul, 2011:38). Non-electronic games, according to Juul (2011), require rules to be made explicit before play begins, otherwise, disagreements will result in gameplay being halted. Digital games, on the other hand, may have some rules set out prior to play but the player generally has to learn the possibilities and limitations of the material as a craftsperson would with physical matter. It is only through engagement that the rules, the limits of what can and can't be done, become truly understood. Just as the maker must work within the boundaries of a physical material to prevent it from breaking, the player must work within the constraints of the game (the rules). If they don't, the player is either punished or prevented from proceeding towards achieving the goal (Juul, 2013; Keogh, 2018).

> Game rules are designed to be easy to learn, to work without requiring any ingenuity from players, but they also provide challenges that *require* ingenuity to overcome (Juul, 2011:55).

It is in working with the game's affordances (determined by explicit and implicit rules) that the player learns to work with and make the most of their material. This demonstrates our first crossover between craft and gaming:

Material Affordances: **That both physical and digital materials (including games) pose a set of limitations and affordances.**

2.3 Feedback

Although not made explicit in the definitions of craft outlined in Chapter 1, "[c]raft is a process of continuous feedback in which the craftsman's working suppositions are subject to constant fact-checking by the real world" (Korn, 2015:55-56). Over time the craftsman "learns to read his material through its response to hand and tool" (Korn, 2015:55) and feedback from the material at hand is vital in this process. Korn describes the process of shaping a piece of wood and the unambiguous feedback that allows him to assess the success or effectiveness of his actions:

> Either the chisel is sharp enough to pare the wood effectively or it isn't. Joints are tight or have gaps. Surface grain is smooth or torn. The sturdiness of a table and the comfort of a chair are immediately apparent to any observer (Korn, 2015:55).

Similarly, Ingold (2011) describes sawing a piece of wood as a process of continual correction with eyes visually monitoring the material (e.g., the wood) and the fingers making subtle adjustments to keep the action constantly in check. As a result, no two strokes are the same with the fine-tuning of the body's movements dependent on what Ingold defines as "an intimate coupling of perception and action"(Ingold, 2011:58), resulting in the reliably produced actions of a craftsperson. Within games and media studies, interaction is commonly referred to as a 'human-computer interface' (HCI). In his writing, Parisi proposes the use of the term 'bodily interface' in exchange for this in order to orient the reader "toward thinking about the interface as something material that is encountered by the body" (2009:112). Drawing on Galloway (2006), he suggests that interaction with video games occurs on two levels, "the 'operator' level and the 'machine' level (p.3). It is this action, the operator acting on the machine and the machine acting back on the operator, that Galloway claims sets video games apart from other media" (Parisi, 2009:115), such a film. It is in this process of feedback between player (operator) and video game (machine) that I propose makes gaming directly comparable to those between physical material and the maker in craft.

As stated, feedback systems are considered a key trait of video games (McGonigal, 2011). Commonly, and in their most formal sense, these systems are considered to take the form of points, levels, scores or progress bars (McGonigal, 2011), giving the player "knowledge of an objective outcome" (McGonigal, 2011:21). Although you can't physically touch video games directly, in *A Play of Bodies*, Keogh describes a form of "corporeal engagement" with video games that he says "goes two ways" (2018:4). In a continuous feedback loop "we intermingle with videogames. We poke them, and they in turn poke us back" (Keogh, 2018:4). McGonigal describes "the most important difference between digital and nondigital games" being the "variety and intensity of the feedback" (2011:24), and it is this that provides an overlap with craft processes. Unlike non-digital games such as *Scrabble* where a player is assigned a score based on their performance at the end of each turn, in digital games there "seems to be no gap between your actions and the game's response" (McGonigal, 2011:24). McGonigal offers *Tetris* as an example of this tight loop, citing three kinds of feedback that the game provides: "*visual* – you can see row after row of pieces disappearing with a satisfying poof; *quantitative* – a prominently displayed score constantly ticks upward, and *qualitative* – you experience a steady increase in how challenging the game feels" (2011:24). This immediacy not only allows players to understand their progress and receive feedback on their performance in the games but enables them to respond to and act upon it. In their paper *Experts at Play*, Reeves et al provide a vignette of multiplayer video game *Counter-Strike* which illustrates "the highly localized and manually dexterous" ways "in which the player responds to the qualitative sense feedback provided by the game" (2009:213). The ever-changing terrain of the game, viewed through a screen, calls the player to be tacitly engaged, which includes an "awareness of other players", with skilled movements being "crafted with respect to the emerging appearance of the local terrain" (Reeves et al, 2009:213). Without the immediacy of feedback, the player would not be able to respond with the required dexterous movement that is "achieved smoothly in less than a second" (Reeves et al, 2009:213). This demonstrates our second direct crossover between craft and gaming:

Feedback: **An active and responsive conversation occurs between material and maker or gamer.**

2.4 Habitual Practice

Learning through habitual practice has been attributed to the acquisition of craft-based skill (Sennett, 2008; Risatti, 2013). As stated by Sennett "skill is a trained practice" (Sennett, 2008:37) and in "learning a skill, we develop a complicated repertoire" (Sennett, 2008:50) of routinized procedures, embedding them through "the conversion of information and practices into tacit knowledge" (Sennett, 2008:50). Craft quality emerges from the higher stages of this process where "there is a constant interplay between tacit knowledge and self-conscious awareness, the tacit knowledge serving as an anchor, the explicit awareness serving as a critique and corrective"(Sennett, 2008:50). This interplay between tacit and self-conscious is what drives a craftsperson to constantly improve. Habitual practice refers to this process of embedding knowledge over time through the repetition of actions. The term 'habitual' here, could be construed as suggesting non-engagement or a process of mechanical "repetition of a static sort"(Sennett, 2008:38). However, habitual practice is an active as opposed to automatic state that requires intensity, concentration and immersion, especially in the case of craft expertise. To gain and develop skill, to embed it into our knowledge system, we must be in action, as "going over an action again and again […] enables self-criticism"(Sennett, 2008:37-38) on which skill development depends. "As a person develops a skill, the contents of what he or she repeats change"(Sennett, 2008:38). This way an "open relation between problem solving and problem finding"(Sennett, 2008:38) occurs through which a rhythm of solving and opening repeats over and over in a progressive manner. This is key to the acquisition of skill over time.

The playing of video games requires a similar acquisition of skill with players displaying "remarkable dexterity developed through many hours"(Reeves et al., 2009:205) of gameplay through which they develop a deep understanding of their 'material': the game. Nørgård describes her daughter learning to master the skill of playing the videogame *Jetpack Joyride* in this manner:

> She is absorbed in the process of embedding gameplay in her crafting hands […]. It is a lesson of experience through a dialogue between tacitly knowing crafting hands and the gameplay as material (2012:66).

Similarly, Parisi describes the role of repetition to the experiences of players learning to use the 'mimetic interfaces'[4] of *Wii Sports* when using the *Wii Remote* and *Nunchuk* controllers for recreating the actions of boxing:

> Through repeated experimentation moving the controllers, the player learns what body motions produce the desired onscreen actions (Parisi, 2009:118).

In contrast, Crawford (2015) suggests that the repetitive nature of videogames is designed to merely encourage rhythmic, routine experiences that distract players into a passive state of 'absorbed automacity':

[4] Juul describes games that use 'mimetic interfaces' as those that "encourage interaction between players in player space, and in such a way that player space and 3-D space appear continuous" (2010: 18)

> In Crawford's view, what makes gaming a distraction is that it requires the most minimal input from players, in the form of repetitive button-pressing actions, which deliver satisfying experiences of control through reliably produced effects (Brock and Fraser, 2018:2).

When Crawford discusses ‘absorbed automacity’ he likens the appeal of a child’s “Leapfrog Learning Table” (2015:89), which bears many interactive features initiated through button pressing, to “machines for adults frustrated by life”(Crawford, 2015:89-90) in gambling environments. Crawford is referring to the work of Natasha Schüll that discusses machine gambling, noting “parallels to children’s electronic games”(2015:90). Crawford claims that the “sense of control” (2015:90) experienced by a player “would seem to be the opposite of control” (2015:90) explaining that the “action of pressing a button produces an effect that aligns perfectly with your will, because your will has been channelled into the spare, binary affordances provided by the buttons: press or don't press"(Crawford, 2015:91). Crawford believes that the act of pressing a button, and its binary nature, does not allow for the “[s]mall differences in your action” to “produce difference in the outcome”(Crawford, 2015:91):

> You are neither learning something about the world, as the blind man does with his cane, nor acquiring something that could properly be called a skill (Crawford, 2015:91).

Brock & Fraser argue that Crawford holds his position on button-pressing out as:

> something qualitatively different from craft labour, and argues that experiences that typically accompany woodworking or automobile repair cannot be reproduced through games. Indeed, it is suggested that the predesigned or rule-bound nature of computer games forecloses on the possibility of craft-like experiences (Brock and Fraser, 2018:1221).

Through adopting Sennett to analyse gaming labour, Brock and Fraser present an example of gameplay that “recognises that players have to establish technical skill to negotiate the increasingly demanding, complex puzzles that contemporary computer games offer”(2018:1221). Through their analysis of *Dota 2*, the authors discuss how players acquire “sense data about the game through a series of tutorials”(Brock and Fraser, 2018:1224 in which the player learns and practices the “basic mechanics of right-clicking, scrolling, and re-centering”(Brock and Fraser, 2018:1224) to progress their skills. Through practice “*Dota 2* players constantly adapt their grip to establish control over the game”(Brock and Fraser, 2018:1224. The repetitive actions of pressing buttons in the problem-solving environment of a video game thus aligns with habitual practice in the context of craft expertise.

The Extended Hand

In the process of embedding knowledge through repetitive actions the tools that the maker and gamer are using also become an embodied aspect of the engagement between material and user. McCullough states that through practice "it can be difficult to say where a tool ends and a medium begins"(1996:193) with the tool becoming almost transparent to the user over time. As Pallasmaa explains “the skilled user does not think of the hand and the tool as different and detached entities; the tool has grown to be part of the hand”(2009:47-48) and in doing so the user is free to focus their attention on the action on the material.

The console gamepad, commonly used with videogames, now often includes a complex array of inputs from triggers to thumb sticks, of which not all result in the binary signals of ‘on or off’ that Crawford dismisses. These devices are far more complex, allowing “simultaneous inputs to produce more complex digital outputs, and, as a consequence, videogame players must habitualize different ways of moving their bodies at the videogame"(Keogh, 2018:77). This is a fundamental aspect of the videogame experience (Keogh, 2018: 77), as is the habitual practice of the craftsperson through which they embody their tools.

Ingold describes “the synergy of practitioner, tool and material” (2011:53) as processional, (as opposed to successional), built up of phases that are not discrete but follow on from one another. He recalls:

> in an activity like cutting wood, my hand is not so much brought into use. In the sense that it is guided in its movements by the remembered traces of past performance, already inscribed in accustomed – that is *usual* – pattern of dexterous activity (Ingold, 2011:57).

Similarly, with ‘thumbs in mind’, Sudnow describes a manoeuvre he masters whilst playing the videogame *Breakout*:

> It was a panning action with several little articulations along the way, the hands in synchrony, one wiping past, while the other inserted punctuations. As you watch the cursor move, your look appreciates the sight with thumbs in mind, and the joystick-button box feels like a genuine implement of action (1983:19).

Just as Ingold’s eyes were free to visually monitor his material, in gaming, whilst the hands are knowingly manipulating the controls of “our organically perfect tool”, the eyes are “free to witness and participate in the spectacle from above”(Sudnow, 1983:22), hands-on controller, eyes on screen.

Stumbling Over Habitual Action

A further demonstration of habitual practice is that over time, particular gestures become habitual to particular tools and actions become device-specific for both the craftsperson and the gamer to the extent that if any aspects of practice are changed, the maker or gamer will stumble over their embodied action. This is something we all experience in everyday life:

> We experience this type of discrepancy between the habitual body and the actual body when we put ourselves in a new or unusual environment: We confuse pushing with pulling to open the door when we move to a new house; we make mistakes in typing when we start to use a new keyboard with buttons of different pitches (Tanaka, 2013:53).

You cannot swap out the input device of a gamer any more easily than you could replace a well-used tool of an experienced craftsperson and still expect that person to be able to perform their skill to the same level. If we change the 'tool' then we will change the action or cause the body to stumble over its habitual action. As Parisi (2009) explains, all interfaces require the ability to read some form of input from the player, such as key presses, movement or voice recognition. If this mode of capture is changed, “the game changes the user’s bodily experience and bodily encounter with the game” (Parisi, 2009:118) with the player having to learn again what movements are required for the desired effect on the game.

Keogh highlights that "no videogame input device is 'natural' in its incorporation of the human body that moves alongside it"(Keogh, 2018:79) yet their forms are “culturally and economically mediated, producing a ‘hegemony of input’" that perpetuate “through preexsiting competencies"(Keogh, 2018:79). The QWERTY keyboard layout, for example, has become dominant and accepted based on competencies and habitualised practices. The same could be said for game controllers that although different in design tend to have a similar layout and core elements. There are cultural variances as the technology is less democratically shared historically, yet we recognise tools for a specific purpose and according to particular mediums. We mustn't underestimate the craftsperson or gamers relationship with their specific tools and their role within habitual practice. This demonstrates another direct crossover between craft and gaming:

Habitual practice: **Skill is acquired through repetitive action and habitual practice including the embodiment of and habitual use of tools.**

2.5 Minimising Risk

Sennett states that "[c]raftsmanship names an enduring, basic human impulse, the desire to do a job well for its own sake" (2008:9). It is this impulse that highlights the craftsman's "aspiration for quality" and "evidence of truly rewarding work" (Brock & Fraser, 2018:1219). According to Pye, in craft:

> the quality of the result is not pre-determined, but depends on the judgement, dexterity and care which the maker exercises as he works. The essential idea is that the quality of the result is continually at risk during the process of making (Pye, 1995:20).

Pye refers to this as "The workmanship of risk" (Pye, 1995:20), adjusting the skilled hand in response to the material feedback. Pye uses the term risk to imply that at any moment "the workman is liable to ruin the job" (Pye, 1995:9), be that through "inattention, or inexperience, or accident" (Pye, 1995:9). According to Sennett, experiences of failure, although 'cruel', activate the craftsman's "sense of inadequacy" teaching "them a fundamental modesty" (2008:97) even if gained at great pain. McCullough links this to one of the key aspects of Cziksentmihaly's 'flow', with the "ambition to succeed or the fear of failure" (1996:196) ensuring a medium sufficiently commands our attention. The desire to succeed and the experience of failure are, therefore, closely linked. Korn describes his own experience of failure and its relationship with success:

> [I]n my experience the possibility of failure is always present in the workshop. Success and failure are magnetic poles to which I orient my compass at every moment to determine whether or not to take (or persist in) a given course of action (2015:43).

Similar to the craftsman's desire for quality, Brock and Fraser explain that pleasure in playing video games is derived from a desire to solve puzzles in a "process of experience and discovery" through which "people reach for higher-level goals" (2018:1222). Juul

(2013), as cited by Potter & Brock, suggests that “there is a ‘paradox’ to how videogame players make sense of and experience videogames” (2019:1) in that, whilst pleasurable, they often frustrate players. As a digital medium, we could defer to a fundamental question posed by McCullough: “must a true medium entail sufficient risk and irreversibility to demand the rigor and devotion that have always been necessary for great works?” (1996:212). In asking this, McCullough draws attention to the perceived reversibility of a digital medium, such as undo and save as functions, and the “general conception that to use a computer is somehow an ‘easy’ option” (Jorgensen, 2005:7). This same query could be asked of videogames with many games offering multiple ‘lives’, ‘save points’, and ‘restart’ options. Failure (such as in-game character death) and the need for repetition that these functions demand within videogames, however, is a core component of in-game progression and skill development. As Keogh describes:

> As I fail and repeat a videogame, I learn more about the videogame and how to handle it both literally and figuratively; I become more attuned to its rhythms and capable of progressing farther the next time (2018:145).

Pye goes on to explain that “[a]ll workmen using the workmanship of risk are constantly devising ways to limit risk” (1995:5) such as the use of specific tools or ‘jigs’ to assist in the making process and to improve the quality of the output. Pye defines a jig “as an appliance for guiding a tool in a predetermined path, independently to a greater or less extent of the operator's skill" (Pye, 1995:47) with the most familiar example being a ruler. Referring to Pye’s seminal work, Luscombe states:

> Just as jigs allow an action to proceed in a predetermined way, The Nature and Art of Workmanship considers human dexterity to be the ability to control movement according to a specific intent (2017:11).

This is reflected by Neal who, when challenging the conception of ‘ease’ and lack of risk when using digital tools, draws attention to the role of skill in controlling risk. He suggests that:

> if you're experienced, for instance, then throwing a pot is relatively certain. The best craftsmen work with authority, intuitively and instinctively and within the consistency of their automated counterparts. It's possible to argue that there is little risk within their approach and near-perfection can be achieved with regularity (Neal, 2018:22).

This reflects that skill and levels of expertise obtained play a role in minimising instances of risk through the use of the skilled hand.

Within gaming, Juul claims that "failures reflect on us and have different shelf lives, depending on the *goal type* of the game" (2013:85). He goes on to explain that failures result "in either **permanent loss** (such as when losing a match in a multiplayer game) **or a loss of time invested** toward completing or progressing in a game" (Juul, 2013:14). Just as it can be argued that level of skill can play a role in reducing risk in craft, Juul tells us that failing through a lack of skill in games allows players to "reconsider our strategies" and "expand our skill set" (2013:74). Experiencing failure and the enforced repetition it brings about in order to progress, in both craft and gaming, is thus closely linked to the development of habitual practice and improving skill that further reduces the risk of failure. This demonstrates the final crossover between craft and gaming:

Avoiding failure: **Elements of risk are controlled through the appropriation of jigs and skilful action.**

Throughout this Chapter I have begun to identify thematic crossovers between craft and gaming, determining meanings and approaches from where this research will draw on for creative exploration. Through identifying thematic crossovers, I have demonstrated where craft and games show potential for compatibility. Moreover, these areas will be used to further draw out and interrogate potential benefits and value that can be brought about through directly joining craft with games.

In the final section of this Chapter, I will outline 'grafting' as a method proposed for creating a direct exchange between the two disciplines. Firstly, I will discuss some existing approaches that explore connecting craft with games in order to set out how my approach will differ.

2.6 Existing Approaches

Having established four areas of thematic crossover between craft and gaming, this research will use an investigative approach to further investigate these through the development of experimental prototypes that directly combine the two disciplines. Before putting forward my own proposed approach of 'grafting', I will first outline some existing games and alternative applications that capture and combine aspects of craft.

Craft within Games

Craft exists as material representation within many existing digital games, defined by Grow et al. as "the thoughtful manipulation of materials by the player to create something else within the context of the game" (2017: online). Sand box games like *SimCity, The Sims* and *Minecraft,* are "underwritten by player creation in virtual worlds" (Grow et al., 2017: online) through which making, creating and building afford players a creative and pleasurable experience "not obtainable otherwise" (Grow et al., 2017: online). Games employing 'crafting systems' as a part of the larger game's content allow players to transform "base resources into useful goods" (King, 2015: online) in support of a game's primary goal. King claims that these systems have "expanded from a rarely-seen mechanic in role-playing games to a nearly ubiquitous inclusion in all modern titles" (2015: online). Although these crafting systems enable "players to create items without the cost, effort, and destructive modification of raw materials in the real world" (Grow et al., 2017: online), it is suggested that these digital systems risk "becoming reductive and trivializing by comparison" (Sullivan et al.,2019:1) to real world craft. Sullivan et al. highlight that in "the real world, craft expands far beyond" (2019:2) and categorizable "crafting systems that we see in digital games" (2019:2) as they "do not capture the values or principles underlying craft itself" (2019:2). Crafting within games, whether that be craft-focused games, crafting systems or craft simulations, exist solely within the bounds of the digital game where resulting creations exist only "in the context of the game world" (Grow et al., 2017: online). In summary, crafting within games, whether crafting systems, craft-focused play or craft simulation, takes place wholly within the digital space of video games. This can be visualised as follows:

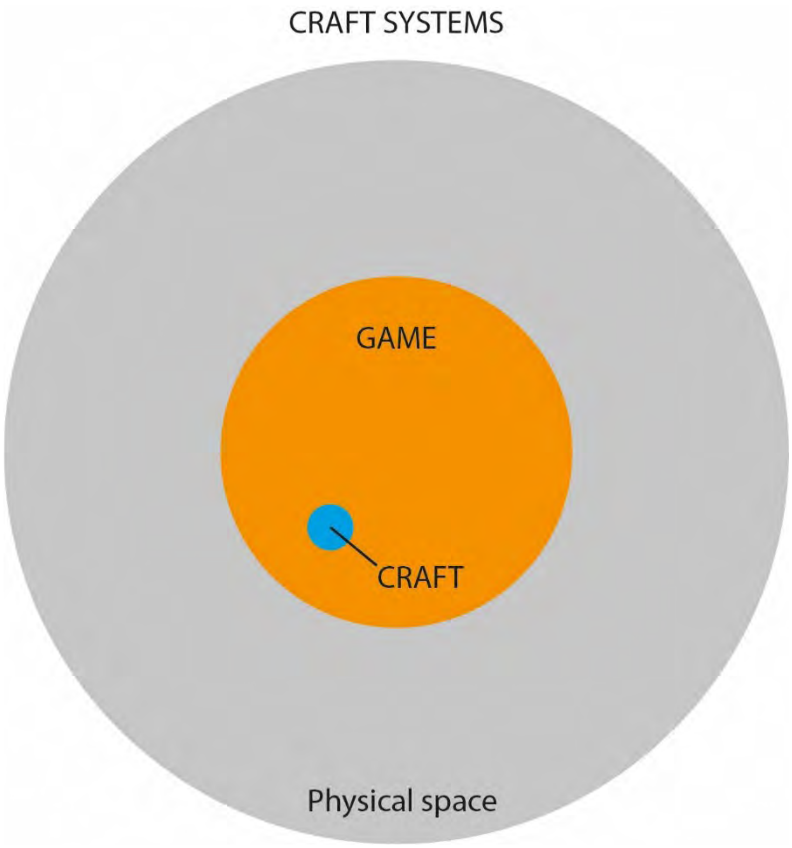

Figure 2.1: 'Craft systems' expressed as existing wholly within games

In these examples of craft within games, the only actions that take place within the physical space outside of the digital game are interactions with physical input devices that in the above examples would include game controllers, keyboards, mice and touch screens.

Craft Games

Growth of and increased accessibility of digital fabrication and physical computing in recent years has created opportunities for the exploration of alternative games and game controllers. Alternative controllers can include custom DIY controllers which may be crafted from scratch, hijacked or 'hacked' traditional controllers, custom arcade cabinets or the use of traditional controllers in "twisted and innovative ways" (Shake That Button, ND:

online). *Arduino* based electronic boards (such as *Makey Makey* and *Flora*) are good examples of a commercially available form of physical computing that enables and encourages the creation of physical interfaces using conductive materials that includes the making of custom controllers. Figure 2.2 below shows an example of an oversized plush game controller made using a Flora board and conductive fabric (Stern, 2013: online).

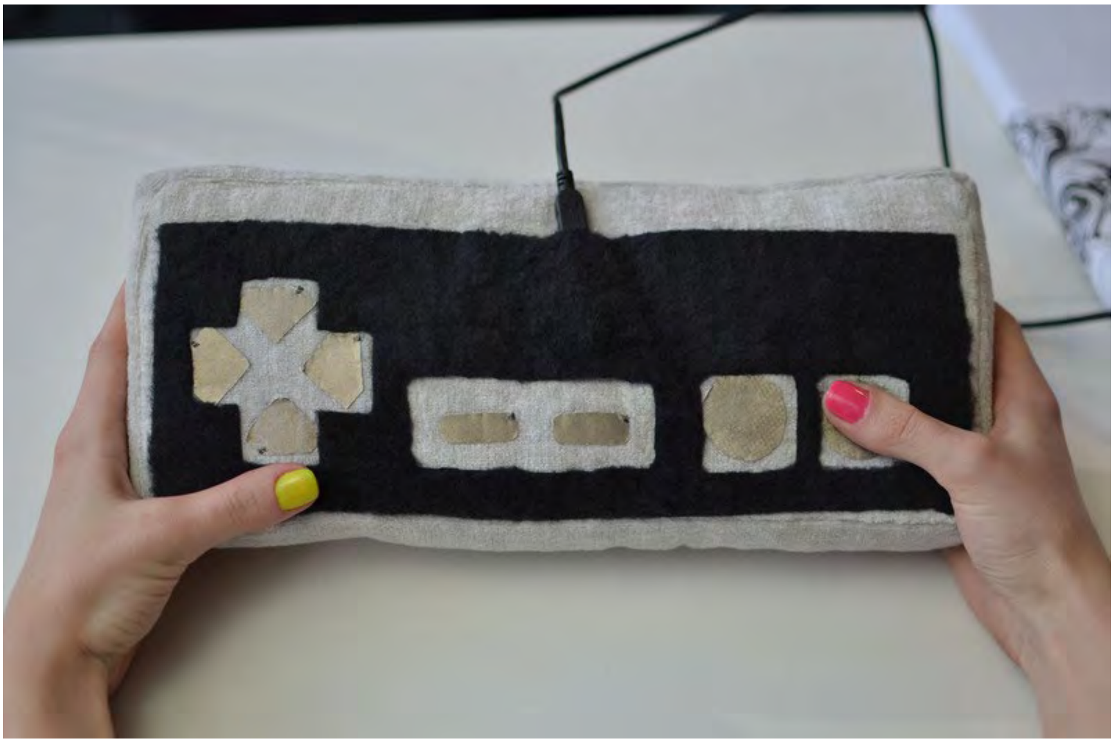

Figure 2.2: Example of a custom-made controller using a *Flora* board and conductive fabric (Source: Stern, 2013: online]

Sullivan and Smith suggest that growth of accessible technologies has created "opportunities to merge crafting activity with electronic games" and "uncover new methods for interacting with fabrication technologies, and interrogate the stereotypes associated with both games and craft" (2017:38). In response Sullivan and Smith offer up a new category of alternative games called 'Craft games'. Craft games are "games that deeply integrate a traditional handicraft into their mechanics, control scheme, of both" (Sullivan & Smith, 2017:39) which can be categorised as: games that use crafted controllers; games that used crafted machines or tools as interfaces; games that create "craft patterns" (Sullivan & Smith, 2017:39) as an output; or games that use the act of crafting as their core mechanic. Sullivan and Smith (2017) present reflections on three 'craft games' that merge sewing with game design: *Addie's Patchwork Playground* quilt (which uses a quilted controller for a 2D platformer digital game), *eBee* (board game that uses quilted hexagons and conductive components), and *Threadsteading* (a custom-design game "to be played on quilting and embroidery machines" (2017: online). These examples all use craft as either a method of creating input devices ('crafted controllers') or components for digital and non-digital games (*Addie's Patchwork Playground* and *eBee*), or craft as a physical output for a game (*Threadsteading*), but none of these examples demonstrate the use of crafting or craft action, as a mechanism of the game. If I am to explore the value of potential crossovers between craft and gaming for industry, it is vital that any applications developed fully employ the act of crafting and producing items using craft skills as a fundamental part of the game. Without this distinction the output could take away from productivity in an industrial context.

Unlike crafting *within* games discussed above, 'Craft games', as outlined by Sullivan and Smith (2017), link games with craft via external physical peripherals.

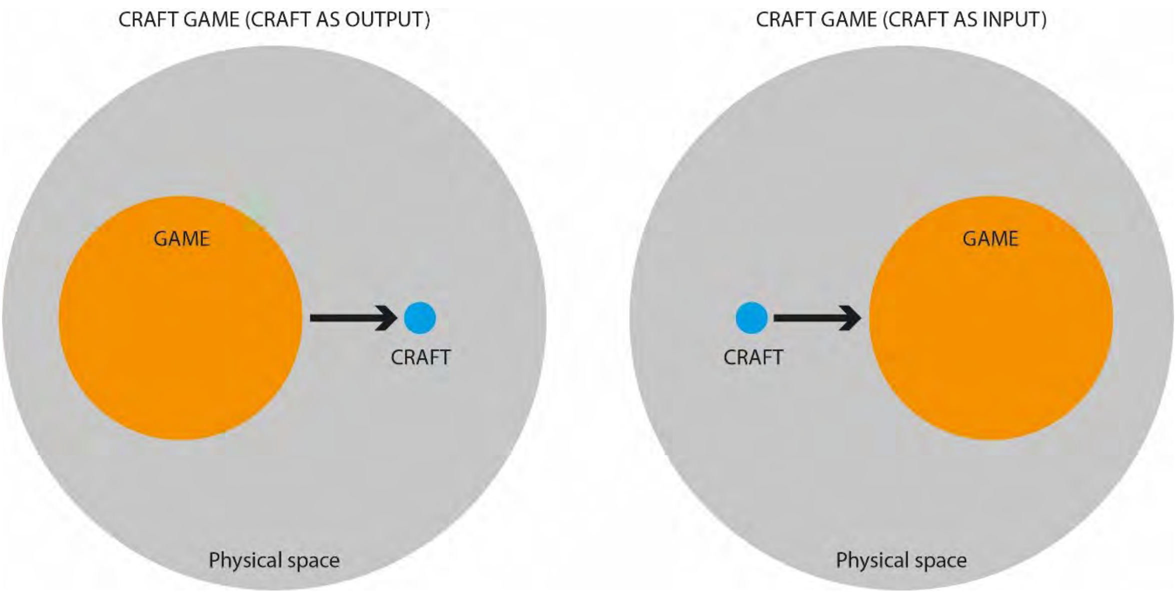

Figure 2.3: 'Craft games' expressed as outputs or inputs that sit outside of the digital game

These physical interfaces either act as a crafted input to a digital game or as a tangible craft output (see Figure 2.3). Although these inputs and outputs play a role in the gaming experience as the same way traditional peripherals and interfaces do, craft games sit outside of the sphere of the digital game itself. In addition, despite using craft processes as part of their creation, the act of craft making itself does not directly impact gameplay. The aim of this research is to seek solutions that will combine gaming with craft in a manner that could potentially improve productivity. Neither ‘Craft within games’ not ‘Craft games’ have been put forward for use in any context other than play and leisure. These approaches are unlikely to be useful in the context of manufacturing that employs craft skills as the focus remains on the digital game with the craft input/output playing a smaller role. I will now put forward an approach for directly joining craft and gaming that I propose to explore within this research in which the craft process would remain intact and not diminished.

2.7 Grafting an Approach

As outlined in the introduction (section 1.1) to this thesis, the second aim of this research is ‘to investigate the relationship brought about through directly connecting craft and gaming. In this section I will set out the investigative approach that this research adopts to assess the potential value of connecting craft and games; a process which I will refer to as ‘grafting’. I use the term ‘grafting’ to imply the bringing together of two elements that results in a combined greater effect than the total effect of two elements individually. Case studies of grafted prototypes will be discussed in detail in Chapters 5 and 6.

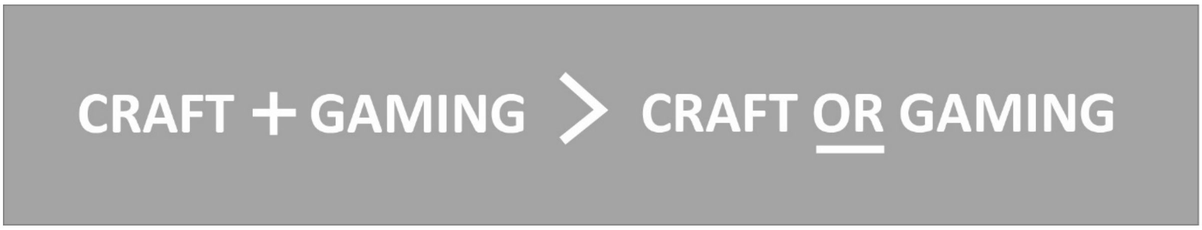

Figure 2.4: Diagram expressing that bringing craft and gaming together would result in a combined greater effect that the individual elements

This research does not seek to join craft with gaming to merely create a new input or output for a game. Instead, this research aims to bring craft and gaming together in a seamless method that generates a greater effect than original individual components, hence a potential beneficial output (see Figure 2.4). I am borrowing the term ‘grafting’ from horticulture where it is used to describe “joining parts of two or more plants so that they appear to grow as a single plant" (Bilderbeck et al., 2014: online). The process involves taking "the root and bottom portion of one plant (rootstock) and attach[ing] it to a tender shoot (scion) from the top portion of another plant" (Iannotti, 2020: online). See Figure 2.5 below as an example of how this might be done (Bilderback et al., 2014: online). Generally, a "wound is created in one of the plants, and the other is inserted into that wound so each plant's tissues can grow together" (Iannotti, 2020: online).

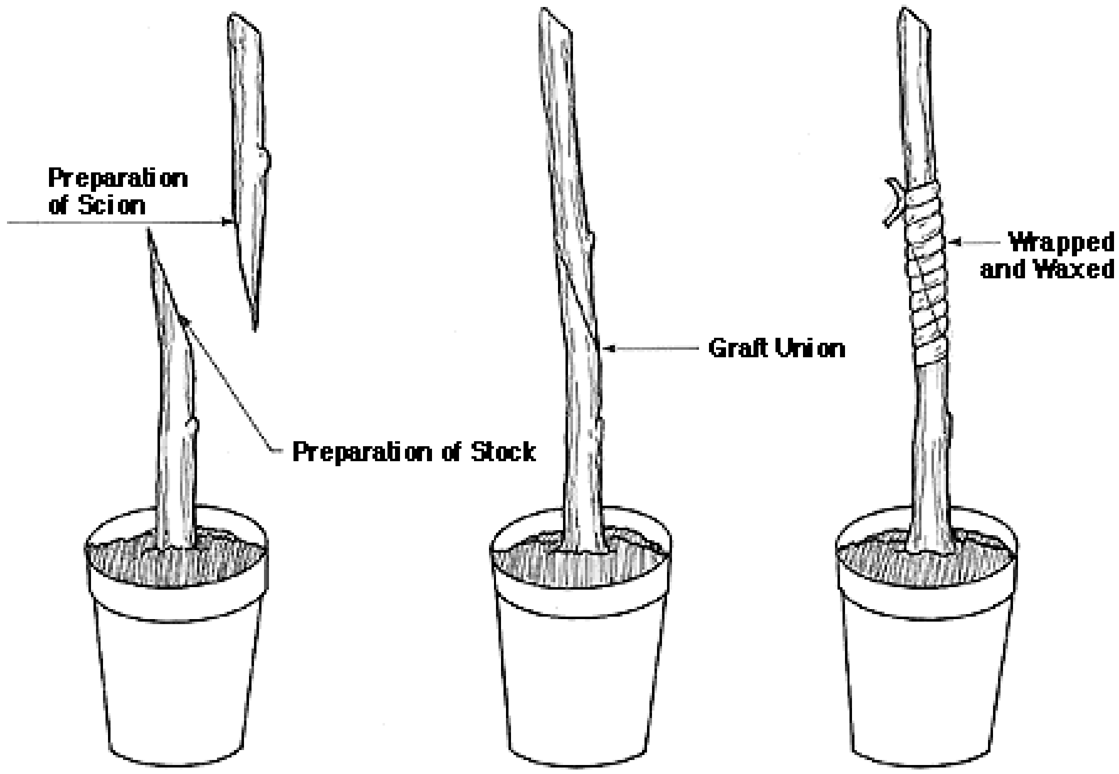

Figure 2.5: Example grafting method called 'splice graft' (Source: Bilderback et al., 2014: online)

Within horticulture, grafting is commonly carried out with trees and shrubs and although the parts "do not have to be from the same species" (Iannotti, 2020: online) they do need to be compatible. The more closely related the plants are, the better the chance of them forming a good union (Kumar, 2011). The characteristics of each part are carefully considered for grafting plants or trees. For example, certain "characteristics of rootstocks can make it possible to grow plants faster" (Iannotti, 2020: online) and the rootstock is generally selected for attributes such as hardiness or drought resistance (Bilderback et al., 2014: online). Another common use of a rootstock is in the creation of dwarf fruit trees where the lower plant and root is taken from a more established tree, having taken years to mature, enabling a hybrid seedling to produce fruit much faster (Kumar, 2011). The top portion (the scion) is usually a young shoot or plant selected for its "beneficial characteristics like great flavor [sic], colour, or disease resistance" (Iannotti, 2020: online). All outputs, for example, fruit or flowers, are produced by this upper portion and the grafting of the two may thus "increase productivity of certain horticultural crops" (Bilderbeck et al., 2014: online). In using grafting as both a metaphor for the approach and a description of the method of connecting a game to a craft activity and vice versa (through a direct and physical join), I am seeking to capture the same aims. Within horticulture, as Figure 2.5 (Bilberback et al., 2014: online) demonstrates, the grafting process predominantly occurs on the vertical, suggesting a hierarchy of the elements being used. Within this research, the proposed method of grafting is intended to be horizontal and traverse with neither craft nor games being placed in a literal or hierarchical position. Through identifying thematic crossovers between craft and gaming throughout this Chapter, areas of compatibility have been established and, through grafting craft and gaming, the potential benefits for Industry will be explored. For example, games could act as the 'rootstock' with the potential to create higher yields (increase productivity), with craft acting as the scion selected for its output (high-quality craft product). Alternatively, the process of grafting could be a solution for higher quality finishes for example. Through working with an industry partner alongside exploring grafting as an approach, this research will seek to align potential outputs with current challenges faced within manufacturing, thus seeking potential value in contexts where craft and games reside.

Grafting is a term also found in knitting, also known as 'Kitchener Stitch', to describe a method of joining two pieces of knitting seamlessly (Gutierrez, ND: online). Commonly used in areas where a seam in the knitting would be uncomfortable, such as the toe of a sock, grafting in knitting involves weaving two live pieces of knitting together without creating a ridge or bump (Gutierrez, ND). This approach also applies to this research, not necessarily in terms of a physical join between craft and gaming but in the need for the joint experience to be seamless when interacting with as one whole.

Adapting a methodological approach based on the notion of 'grafting' this research aims to explore the potential value that could be of benefit beyond the individual discipline, specifically supporting potential areas for improved productivity and efficiency for craft processes used within manufacturing. This is achieved through building upon the identified crossovers between craft and gaming, before developing a method of grafting together craft with gaming to explore outcomes that could be of value to the projects partner organisation.

_3 Methodology

This Chapter outlines the methodological approach and tools used for data collection within the empirical part of this research. First, I will establish the paradigm within which this research sits and which it is subsequently informed by.

3.1 Paradigm

This research was conducted within a constructionist paradigm, working within a phenomenological theoretical perspective. Constructionism holds the view that:

> all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context (Crotty, 1998:42).

The phenomenology of writers such as Merleau-Ponty state that meaning emerges when consciousness engages with objects in the world (Crotty, 1998). In this sense, meaning is “constructed by human beings as they interact and engage in interpretation” with an emphasis on “experience as it is lived, felt and undergone by people acting in social situations (Schwandt, 2007)” (Robson & McCartan, 2016:24). Having “developed an extensive theory of the lived body as a basis for subjectivity” (Roald et al., 2018:206), Merleau-Ponty’s ‘phenomenology of perception’ (2012) in particular, links with wider concepts of experience including theories of affect. Although “Merleau-Ponty did not explicitly develop a philosophical account of the emotions” (Cataldi, 2014:163), he did argue that perceptions “are constituted by an affective experience” (Roald et al., 2018:206). ‘Affect’ according to Kathleen Stewart “is the commonplace, labor-intensive process of sensing modes of living as they come into being” (2010:340). As a term ‘affect’ encompasses both emotions and feelings that is inherent within Merleau-Ponty’s “theory of the lived body as a basis for subjectivity” (Roald et al., 2018:205). Constructionism mirrors intentionality, bringing objectivity and subjectivity together unlike purely objective positivism. “What constructionism drives home unambiguously is that there is *no* true or valid interpretation” (Crotty, 1998:47). Sharing many features with social constructionism (Robson & McCartan, 2016), a phenomenological position might be adopted by a researcher trying to understand the lived experience of users (Durling & Niedderer, 2007). Especially relevant to my research, phenomenology is appropriate for research problems that call for a need to understand common experiences, as opposed to a narrative that reports on the life of a single individual (Creswell, 2007).

Phenomenology is highly descriptive “but it is also seen as an interpretive process in which the researcher makes an interpretation (i.e., the researcher ‘mediates between different meanings; van Manen, 1990, p.26) of meaning of the lived experiences” (Creswell, 2007:59). The researcher begins by turning to a phenomenon of interest and then writes a description of it, but essentially it involves the researcher interpreting that phenomenon. As other researchers such as Rana and Hackney (2018), whose work accesses ‘craft-based ways of knowing’, this research “draws on understandings of affect […] and the sensory world of the everyday” (Rana & Hackney, 2018:3). In doing so, it seeks to access lived experiences through the acts of ‘being’ and ‘doing’ that are inherent to art-based practice (Rana & Hackney, 2018).

Paradigms, such as this, in which views are believed to be “formed through interaction with others” require researchers to “make an interpretation of what they find, an interpretation [which is] shaped by their own experiences and background” (Creswell, 2007:21). Research, particularly in art and design, is personal to the researcher and their practice and, in practice-as-research, it is the situated practice of the researcher “that should orient the research methodology and methods, and not a discipline or objective method *per se*” (Oliver, 2018:7). My methodological approach grew out of my own creative practice and experience as a participatory practitioner which supports a primarily qualitative approach through which “researchers collect data through themselves” (Creswell, 2007:38). My practice spans art, design and craft, embracing both physical and digital materials and tools. Malins and Gray (1995) state that research, in the context of practice-led research, should be tailored in response to the expertise and nature of the researcher’s practice. I do not consider myself a craftsperson in the sense that I do not have a studio practice, but my practice draws upon and refers to craft processes, specifically textiles. I do, however, consider myself a ‘maker’ in the broadest sense with my practice closely linked to craft making processes, one which embraces digital tools, including gaming. For this research I chose to follow a practice-led, mixed methods methodology within the field of design research, drawing on my experience as a practitioner.

Gray and Malins state that whilst academic research in Art and Design has grown in recent years, it is still in its infancy. This can pose problems concerning there being few well-established methodologies in the field. “Indeed, methodology in its scientific sense implies a common or shared research approach that is transferable. This is not likely to be effective for creative practitioners!” (Gray & Malins, 2004:18). Research within Art and Design is essentially qualitative and responsive, as is creative practice. In response, Gray and Malins (2004) pose that practice-led researchers might borrow methodologies from other disciplines whilst developing their own set of ‘protocols’ that will apply to the individual’s research, acknowledging that these may not be completely transferable. The borrowing of a collection of methodologies is otherwise referred to as a bricolage approach. A “methodological bricoleur is a researcher who combines multiple research tools to accomplish a meaning-making task. This means that a methodological bricoleur engages in fluid, eclectic, and creative approaches to inquiry” (Rogers, 2012:5).

Working within and across paradigms, methods chosen are adapted and developed using research methods as tools to be deployed in response to immersion in the research context rather than being fixed in advance (Denzin and Lincoln, 1994). The emergent construction of ‘bricolage’ research can be seen as a “methodology that is derived from and responds to practice and context” (Gray and Malins, 2004:74). As this research project required working across various settings and with a range of participants this approach seemed appropriate. Watson states that “advice for researchers wishing to employ such creative dynamic approaches” (2020:67) is largely directed at those already experienced in working with complex mixed-method approaches, while arts-based research tends to be “relatively absent from these discussion” (Watson, 2020:67). In response, Watson puts forward a technique she refers to as ‘methods braiding’ as “a practical scaffold for researchers wishing to systematically undertake mixed-methods research with quantitative, qualitative, and/or arts-based methods” (2020:67). The technique provides “a methodological for doing simultaneous and sequential mixed-methods research” (Watson 2020:67) that is interpretive, iterative, and fully integrated. By integrating methods braiding into this research, I was able to create ‘rich’ and experiential ‘data’, which involved developing new methods that incorporated new technologies as tools, including the development of custom ‘grafted’ games, alongside more traditional observational methods.

3.2 Methodology

Having established the paradigm within which I worked throughout this research and having identified a multi-method, practice-led approach, I will now clarify the research methodology I used for this research.

At this stage, I will re-state my research aims:

Aim 1: To Identify existing crossovers between craft and gaming

Aim 2: To investigate the relationship brought about through directly connecting craft and gaming

Aim 3: To highlight the potential value that a direct relationship between craft and gaming could have in contexts beyond the individual disciplines

With little to no previous empirical research having been carried out across the fields of craft and gaming, it was difficult to consider previous research methods when selecting methods that might address these aims. Studies to date that explore either experiences of craft or gaming have generally used ethnographic and auto-ethnographic approaches, employing participant observation methods in the direct observation of processes (Atkins, 2013; Ingold, 2011; Keogh, 2018; Sudnow, 1983). Taking into consideration the themes outlined in Chapter 2, I chose, a mixed-methods approach in which qualitative methods, with the collection of some quantitative data, would provide a much deeper understanding of craft and gaming experiences. As the term suggests, ‘methods braiding’ is made up of distinct strands (three in the example set out by Watson) that interweave, each of which "meaningfully impacts the other strands, and the direction and larger shape of the braid as a whole" (Watson, 2020:68). In order to address the aims of this research, the study was also split into three interconnecting strands:

Strand One Identifying crossovers
Strand Two Grafting potential
Strand Three Finding value

The multi-stranded, 'braided' methodology was underpinned by two emerging methodologies: reflective practice, and investigative designing. Before further detailing my approach and how each strand was influenced by these, I will first outline these two methodologies.

Reflective Practice

Research projects in which the researcher's "own design work forms the basis for the research" (Durling & Niedderer, 2007:10) is often referred to as reflective practice. The concept of *reflective practice*, as derived from Donald Schön (1983), is one that Gray and Malins tell us it is important for "artists and designers engaging in research" (2004:22) and it plays a central role in this thesis. As discussed in Chapter 2, the phenomena that I wished to observe are predominantly embodied and inarticulable, with experiences arising in action. Schön (1983) tells us that practitioners recognise the tacit occurrences of their practice without necessarily being able to fully describe them, in what he terms as 'knowing-in-action'. During tasks, the practitioner "makes innumerable judgements" (Schön, 1983:50) and often reflects upon what they are doing while they are doing it. Schön (1983) outlines two elements to reflective practice which Gray and Malins (2004) apply to design research:

Reflection-on-action: retrospective reflection which is a "critical research skill and part of the generic research process of review, evaluation and analysis" (Gray and Malins, 2004:22).

Reflection-in-action: encompasses "thinking about what we are doing and reshaping action while we are doing it" (Gray and Malins, 2004:22). It is improvisational and "[r]elies on feeling, response and adjustment" (Gray and Malins, 2004:22).

Cowan adds another strand onto Schön's model of reflective practice, defining "a third type of reflection, which is not specifically titled by Schön" (1998:36), Cowan refers to this as reflection-for-action, or "reflection 'for' future action" (Gray and Malins, 2004:57). This additional form of reflection is more anticipatory than the other two. "It is a reflection which establishes priorities for subsequent learning by identifying the needs, aspirations and objectives which will subsequently be kept prominently in the learner's mind" (Cowan, 1998:37). Cowan adapts a "generalized model of how learning experience happens" (1998:34), usually attributed to Kolb (1984), extending the experiential cycle into an extended coil that includes reflection-for-action as seen in Figure 3.1 (Cowan, 1998:38).

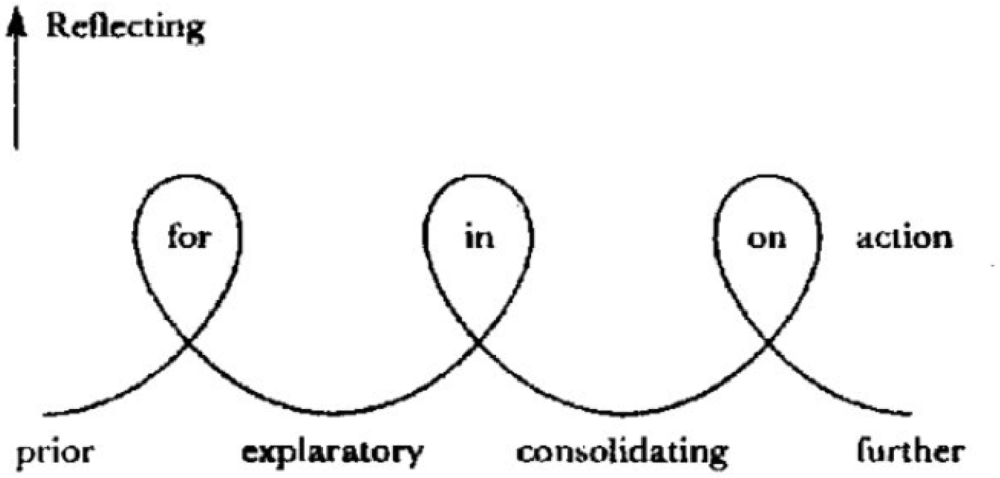

Figure 3.1: The Cowan cycle (Source: Cowan, 1998:38)

Cowan (1998) illustrates this diagram through descriptions of students in an Interdisciplinary Studies class engaged in active learning. In his example, students came to a particular activity with some prior experience and "began with or from an anticipatory reflection-for-action" (Cowan, 1998:37). Pausing briefly for this prior reflection students were then "encouraged to surge forward into an exploratory activity" (Cowan, 1998:38) which had been planned for them. During the activity, students paused at various points "with an intermediate reflection-on-action" (Cowan, 1998:38) in which they reflected upon the progress they had made and considered difficulties or gaps. Continuing with the concentrated activity, students then consolidated thinking and any outside feedback received "to make good the deficiencies which they had perceived in their learning or development, and to build upon their reflective analysis of their progress to date (Cowan, 1998:38). A final stage enabled reflection after completing the set activity, enabling them to take stock and essentially reflect-on action. For this research, I propose that the cycles of action and reflection -for, -in and -on action, are applicable to and compatible with the methodological approach used.

Investigative Designing

As an applied PhD working across contexts, as a second influential approach was used, defined as *investigative designing* by Durling & Niedderer:

> **Investigative Designing** is taken to mean: the act of designing, set wholly within a research study for the generation of new knowledge (2007:3, original emphasis).

This approach could be seen as synonymous with *action research*, "systematic enquiry conducted through the medium of practical action" (Archer, 1995:11). Durling and Niedderer suggest "several broad categories where designing may be considered in a research context" (2007:10), two of which are used within the methodological framework of this research: 'designing quick and dirty', and 'designing as creative exploration'. The authors suggest that within design research there will be occasions when an intervention is made to act as a probe. An example of this may be where improvements for artefacts are suggested following initial observations, such as for the ergonomic improvement of machines in a manufacturing context. modifications are made and the researcher then returns at a later date to conduct further observations for comparative analysis to assess whether the intervention had led to improvement (Durling and Niedderer, 2007).

The second category used within this research is that of ‘designing as creative exploration’, “perhaps the strongest way of using creative practice within research” (Durling and Niedderer, 2007:14). This category refers to the “working through of a research problem through designing” (Durling and Niedderer, 2007:14), for example through prototyping. One of two modes identified within this category is described as ‘designing as an analytical tool’. An example provided for this category is, following a literature review to establish an understanding of a conceptual model, designing can be used to translate concepts into artefacts for interaction with and testing against thematic measures (Durling and Niedderer, 2007).

Each of these categories for designing within research were used within different stages of this research; the first being ’designing as creative exploration’ (Durling and Niedderer, 2007) following the identification of crossovers between craft and gaming (Strand One) in the development of prototype ‘grafted’ games (Strand Two) and secondly in the further development of one of these games into a ‘quick and dirty’ (Durling and Niedderer, 2007) design intervention in Strand Three.

3.3 Research Design

Having discussed these two influential methodological approaches, I will now describe how this research was carried out in more detail. As introduced earlier in this Chapter, this research was split into three strands. For clarity, I will provide an overview of these strands in a linear form, although, in reality, they overlapped with some activities occurring concurrently.

Strand One: *Identifying crossovers*

Building upon the four categories of thematic crossovers between craft and gaming that were established in Chapter 2, Strand One is concerned with evidencing and further refining the identified crossovers in investigating research Aim 1. This was achieved through taking part in amateur craft and gaming activities, using an auto-ethnographic approach to make observations of actions. I took part in four activities: the PC game

Unravel and its follow up *Unravel Two; Mario Kart 8 Deluxe* played on the *Nintendo Switch*; and textiles activities of hand-knitting, completing a kit to knit a sweater from online retailer *Wool and the Gang*, and I also took part in an online macramé course, completing several macramé pieces. By 'amateur', I am referring to craft and gaming activities that take place predominately within the home as opposed to professional forms of practice. The focus on amateur craft and gaming in this strand of the empirical research allows for a direct comparison between activities with reflective practice providing a lens through which to directly reflect upon the thematic crossovers identified through the literature (Chapter 2). This includes direct engagement with the affordances and limitations of each material as well as the continuous feedback it offers to the maker/gamer. It also provides insight into how material feedback drives the development of habitual practice, which is key to skill acquisition, and the development of methods and strategies to avoid risk. In the position of practitioner/researcher, taking part in craft and gaming activities, I was able to observe and reflect upon the difficult to articulate moments that are vital for exploring crossovers between the two practices.

Observations made of personal craft and gaming processes sought to capture the retrospective reflection-on-action and, perhaps more critically, reflection -in and -for-action. According to Schön, moments of reflection are often stimulated by surprise or prompted by a particular puzzle or challenge brought about when dealing with the "stuff at hand" (1983:50):

> Much reflection-in-action hinges on the experience of surprise. When intuitive, spontaneous performance yields nothing more than the results expected for it, then we tend not to think about it. But when intuitive performance leads to surprises, pleasing and promising or unwanted, we may respond by reflecting-in-action (Schön, 1983:56).

Stewart (2010) describes these moments as existing within 'bloom spaces'; "spaces where the senses come to the surface" (Rana & Hackney, 2018:3). This highlights why it was imperative to engage directly with craft and gaming, to gain access to the inarticulable reflective moments that would be difficult to access if observing other makers and gamers.

Additionally, as an amateur in both practices myself, challenges presented more frequently than they might for more experienced makers/gamers during these practices, providing more opportunities to capture reflections brought about by surprise.

Various methods were employed to extract and make explicit these moments of reflection including field notes and video recording of actions including simultaneous screen capture in gaming. The employment of field notes and video recording enabled the documentation of the unarticulated. Gray and Malins, describe these tools as "'off-loading' devices" (2004:58) that allow for externalisation of reflection-on-action, a place to "take stock, evaluate and 'deposit' ideas" (2004:58). Rana and Hackey describe the act of filming craft activities as "an auto-ethnographic tool to promote embodied knowledge production through reflection" providing "opportunities to step back and reflect" (2018:2; 2018:3) from the process of 'doing'. Field notes recorded during practice, provided a space to pause on the action and capture moments of conscious reflection-in-action, while also providing a tool to use post activity for recording retrospective contemplation. Video recordings that focused on actions of the hand and simultaneously captured audio additionally acted as a non-invasive tool to re-observe actions post activity. Video provides a distinct perspective in this subjective process. "In its raw state [video] yields more 'objective' data, that captures data straight, including things we may unconsciously 'filter out' of [our] perception" (Gray and Malins, 2004:110). Video recording as a research method, thus provides a useful analytical tool to support the process of reflection-on-action and reflection-for-action further.

Observations made of gaming and making practices throughout this study consistently considered future action, and vitally, reflected on the potential for development of grafted games. These reflections informed investigative designing (Durling and Niedderer, 2007) activities within Strands Two and Three.

Strand Two: *Grafting potential*

Reflecting upon observations made in Strand One, the focus of this strand was to explore the potential collaborative relationship between craft and gaming that could be developed through 'creative exploration' and 'designing quick and dirty' (Durling and Niedderer, 2007). During Strand One, ongoing ideas were recorded through reflective notes and, as is common within my art practice, were discussed with fellow practitioners. As the concept of 'grafting' suggests (see section 1.3), directly connecting a game with an existing craft, I sought out the specific expertise of artist/technologist James Medd, who has previously both developed his own digital games as well as curating independent games for arcades and events. I wished to explore grafting an existing game onto an existing craft in order to be able to explore what changes and impacts a direct union between the two may have on the individual elements or, as a combined entity. As suggested by Gray and Malins:

> Research methodologies should take advantage of current cultural contexts and technologies. This can help us to extend the range of existing methods – to use multi-media, multi-sensory methods. Galileo invented the telescope so he could see further, explore further, extend knowledge – if a research tool is required why not invent it? (2004:96).

Within this strand the development of prototype graft-games was intended to act as a form of probe, translating the concepts identified in Strand One into artefacts (Durling and Niedderer, 2007) to enable the observation of effects on gameplay and craft activity. Thus, the binding together of the two experiences was intended as an 'analytical tool' (Durling and Niedderer, 2007) not about creating a fully-fledged game.

Two graft games were developed:

Hazuki Knit – the development of this first game occurred concurrently to observations being made within Strand One, drawing on the reflections of crossovers being identified. *Hazuki Knit* prototypes the attachment of existing developmental game, *Hazuki* (developed previously by James Medd), onto a domestic knitting machine through a set of switches attached to the knitting machine row counter. This addition enabled the knitting machine to be activated as an additional input into the game, controlling the speed of the existing digital aspect, resulting in a two-player game. This process and how the grafted game was played and interacted with, is described further in Chapter 5.

Pocket Racer – following reflections upon observations of interactions with *Hazuki Knit*, the second prototype was developed in response to initial observations being made in the project partner factory being carried out as part of Strand Three, where sewing machines make up a large portion of production. This prototype grafted a game to a domestic sewing machine, to explore potential outcomes that could be of value to processes used within the factory setting. Additional adaptions to the sewing machine aspect were made when inviting people to interact with this graft-game. There was an awareness that by taking this prototype to events being where people unfamiliar with sewing machines may attend, and in particular, the possibility of children interacting, the sharp sewing needle was removed from the machine, and replaced with a felt tip pen and fabric replaced with paper. The pen was attached to the sewing 'foot' to safely mimic the role of the sewing needle, the pen drawing on a paper template instead of piercing through the fabric. It was felt that this compromise was important for safety but was carried out to be as close as possible to the actual process of sewing so as not to affect the potential of more experienced participants (see section 2.5).

In order to examine the potential effects of grafting on the individual elements resulting from grafting craft with games, it was important to observe people playing and interacting with them. In this sense, the grafted games acted as an analytical tool (Durling and Niedderer, 2007) to develop them to enable observations of interactions. Grafted games would be observed on a drop-in basis as is a common approach in my practice with longer engagement possible but not essential. I drew on my existing network and contacts and was able to respond to enquiries for participatory activities with the grafted games[5]. Events were a combination of digital, making and gaming-focused, aimed at engaging members of the public or, in some cases, student communities. At each event, attendees were invited to play the grafted game being showcased. As engagement was expected to be predominantly short it did not feel appropriate to ask participants to read a lengthy participant information sheet. Instead, I created an information poster outlining how the game formed part of a wider research project (Appendix A1). This poster was then

[5] For transparency I did not accept payment for delivery of activities at events if I was using for data collection

displayed clearly alongside the game at several positions. I did not record or make observations of young people who appeared to potentially be under the age of eighteen at any of these events. Adult participants who approached were invited to play and asked if they consented to having their hands filmed whilst taking part. Attention was given to the displayed information and if they agreed to take part, were asked to sign a video consent form. No participants were filmed without their verbal and written consent and declining to be recorded did not prevent participants from being able to play the game. It was also made clear that taking part in the research was their choice and not essential. A handheld digital camera or GoPro was used to record the participants' hands during gameplay. *Hazuki Knit* was a two-player game so consent was gained from both participants before playing and video was recorded at an angle that captured both participants actions where possible. Due to the number of recordings expected to be made and the duration of the events, it was decided that it would be too complex to try and synchronise video recordings with the screen capture of the game displayed on a tv screen. Sometimes it was possible to capture elements of the screen in the background of the filming of the player's hands but the clear and simple audio mechanisms of the game enabled observations of reactions to the game when recordings were reviewed. Alongside video hand-written notes recorded verbatim quotes, observations and reflections during participation. As in Strand One, distinctions were made between direct observation notes and those of reflection (including those to be used later for analysis).

Reflections made during Strand Two interacted with those being concurrently made in Strand Three.

Strand Three: *Finding value.*

This strand aimed to identify challenges currently faced by the project partner before assessing how the synergies being developed in Strand Two might provide value in meeting these challenges. I was connected with project partner *Cookson & Clegg* via the team at the Festival of Making (whom I worked with during Strand Two) who expressed an interest in working with me to further aid their digital strategy. *Cookson & Clegg* is a garment manufacturer based in Blackburn, founded in 1860 the company now produces a range of garments including outerwear, legwear and jersey for a variety of brands. Through initial discussions with the management team, core challenges faced in the production process were identified. This is discussed in further detail in Chapter 6. To assess the potential outcomes and/or impacts brought about through grafting that might be of value, it was important to observe the actions and processes being used by machinists on the production line directly to fully investigate the outlined issues. I chose to use the same observation methods as had been employed during observations of myself in Strand One but focused upon individual machinists within the factory setting. The context of these observations required a careful approach to ensure that workflow was disrupted as little as possible and to ensure that participants did not feel pressured to take part. I spent time visiting the factory before observation sessions and was introduced to key staff members such as production line supervisors. I was very aware from these initial visits that staff generally seemed intrigued by my presence but cautious. Unable to talk to every machinist, or stop production, I gave an overview of my research to the team supervisors and left participant information sheets for them to distribute before commencing sessions. Dates for these sessions were agreed in advance with the management team to ensure there would be suitable items on the production line, with the product type and quantity representative of standard production, and to avoid disruption during excessively busy periods. Upon arrival to begin observations I familiarised myself with the current products on the line and approached the supervisors to let them know I was there and remind them of the purpose of my observations. I then approached individual machinists, at moments they were pausing between tasks, to ask if they would consent to be observed. I talked each participant through the participant information sheet again (giving them a copy for themselves) and explained that participation was purely voluntary and assured them that any data collected, including written notes, photographs and video recordings (in which faces would be avoided) would be anonymous and not shared with their employer. Participants needed not to feel pressured to take part or to perform in any particular way. If participants showed any hesitation, then I left them with the information sheet to consider it further, those who consented to take part were asked to sign a consent form. Names of staff being observed were not shared with management staff and their presence on the factory floor during observations was minimal. As with observations in Strands One and Two, a GoPro camera was used to video only the hands and work area of each participant. I used a 'jaws clamp' style tripod to clip the camera to the edge of the participants machine table, being sure not to position it where it might obstruct work tasks. Once this was set up and set to record, I moved away to a nearby position so as not to make the participant feel overly conscious of my presence, as the aim was to observe regular working practices. Whilst recording actions with the GoPro observational notes recorded prompts for consideration when watching the video back and noted wider actions around the workspace, such as organisation and movement of working batches. A total of five participants were observed over four visits with recordings captured for approximately one to two hours.

During observations, I drew on my previous experience as a garment technologist and product developer in terms of my ability to understand and interpret methods of garment construction along with an awareness of machine types and specialisms in a garment production environment.

Final Stage and Impacts of COVID

The original research plan set out to bring together outcomes of grafting developed through prototypes in Strand Two with areas for potentially adding value identified through initial observations in the factory in Strand Three and carry out a final intervention within the factory. In keeping with an investigative designing approach (Durling and Niedderer, 2007), the intention was to install a revised prototype of grafted game *Pocket Racer*, onto a selection of sewing machines on the factory floor. Further observations would then be carried out to assess its impact upon productivity and efficiency of tasks. These observations were planned to take place in the spring/summer of 2020 but unfortunately, the COVID pandemic in the UK meant that in-person observations would no longer be possible. The factory continued to operate through national and local restrictions but at various stages management staff, who acted as gate keepers for the research, were furloughed. Remote observation methods were considered, sending equipment to the factory and asking participants to record their own actions but this proved problematic without key contacts being on-site and posed additional ethical concerns with regards to having no direct contact with participants. The field work was put on hold for nine months before deciding to seek out an alternative approach. At this point, I came across an opportunity to work with a group of local domestic machinists (who carry out sewing as both a hobby and have some industry experience). I was able to become part of a group that had been invited to carry out a batch production process of attaching woven badges and a hanging loop to the side hem of two hundred T-shirts for a Manchester-based art collective. This provided the opportunity to implement a revised version of *Pocket Racer* as an intervention within the project which would closely mimic production processes whilst still unable to safely access the larger factory site. Taking part in the production myself, also enabled further auto-ethnographic observations to be carried out, aiding reflections -in and -on actions of an embodied nature in particular. Each domestic machinist (of which there were two in addition to myself) was sent a sensor kit to attach temporarily to their own sewing machine and instructed via video call to connect the sensor to an app of the game element, accessed either via a laptop, tablet or mobile phone. Observations were then recorded and observed remotely and analysed for signifiers of impacts had by the grafted game on productivity, such as adapting methods to improve the game score, which in this instance was a measure of sewing speed. The development and observations made of this stage are discussed in Chapter 7.

Research activities within each strand were planned carefully to target the themes that I had identified as being relevant to the research questions. Figure 3.2 indicates the relationship between the interrelated strands, the thesis Chapters to which they contribute, and the research aims they respond to.

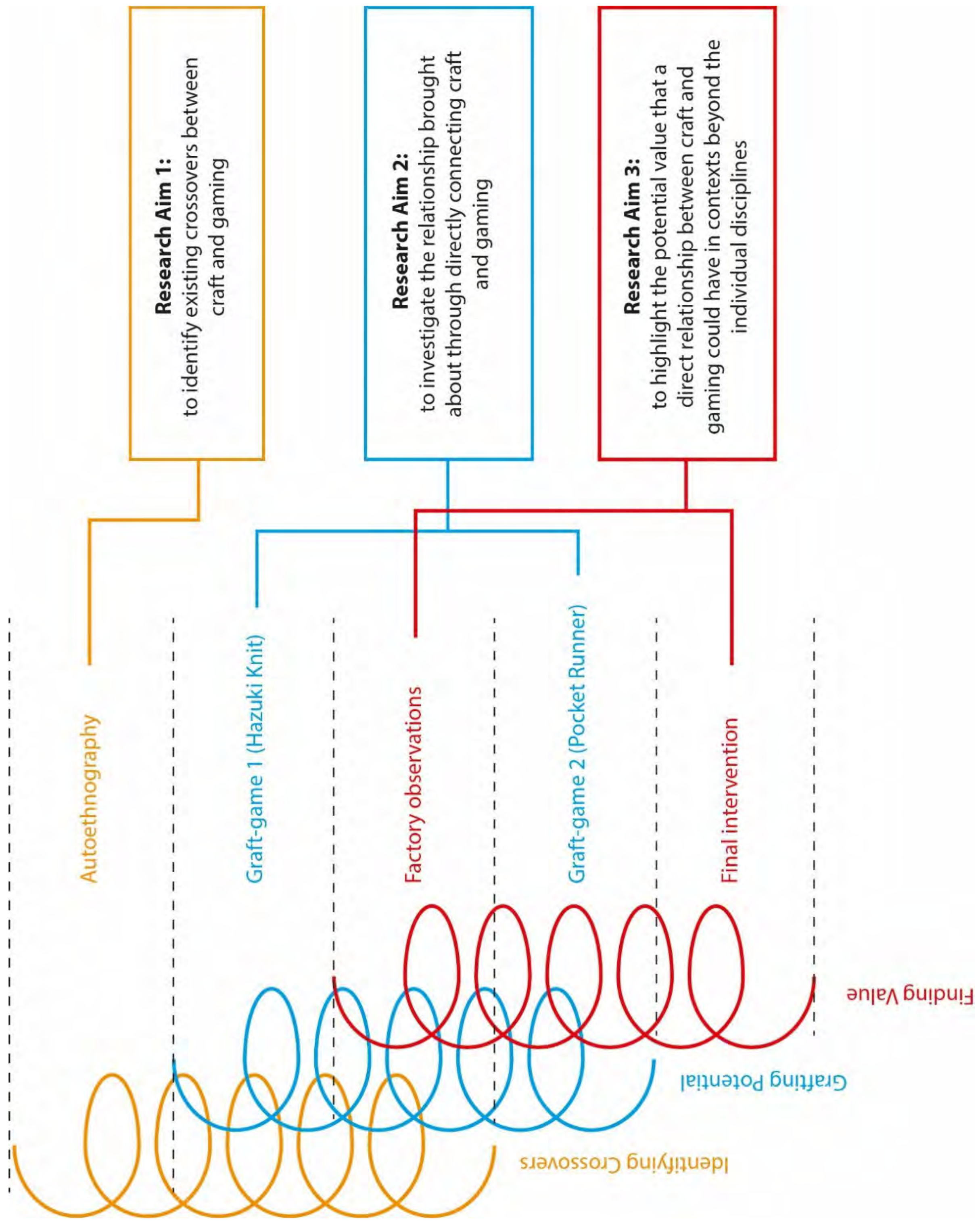

Figure 3.2: Diagram of concurrent research strands

3.4 Approach to Analysis

In this section, I will describe the approach that I took to analysing the data; the analysis of which can be found in Chapters 4 to 7.

The three strands of this research produced a variety of data sets, some of which included large video files. Video recordings made during participatory practice in Strand Two were kept relatively short (averaging around ten minutes) as the recording was planned to only be taken of individual participants during gameplay, which remained predominantly short term. Recordings were only made of participants who gave consent and due to the nature of the events attended and the number of people attending, it was simply not possible to record observations of every participant playing each game. These observations were thus supported by reflective notes made both during and post-event which were fully transcribed. All reflective notes made during and post observations within all strands were digitised and saved to a password-protected computer. This process of transcribing also enabled an extra layer of reflection and additional thoughts to be added. Recordings of craft and gaming activities in Strand One and those of machinists within the factory setting in Strand Three had the potential to be long. Limitations on memory card space of Micro SD and SD cards being used and battery life of recording equipment were taken into consideration before observation sessions. Recordings of craft and gaming at home in Strand One (using a Go-Pro camera and Aveda screen capture device) were limited to one to two hours. With gameplay and craft activities taking part over many weeks for variable lengths of time recording all activities for each complete project would have produced many hours of video recordings that would not only be difficult to capture and record but time-consuming to transcribe and analyse. Instead, sessions were observed periodically and left to record to full battery life capacity and end itself rather than restrict action in these contexts to limited recording time possible (which may have interrupted gameplay or progress of a craft item for example). Recordings made of hands during gameplay were synced with screen capture recordings into individual videos that aligned images side by side for easier parallel analysis.

Observations within the factory as part of Strand Three had the same recording limitations and experience from using recording equipment during earlier stages enabled refined planning. Observation days were pre-agreed with the management team at the partner site to ensure a good level of appropriate production would be taking place and to ensure minimal disruption. The working day was split into two to two and a half hour sessions for the machinists, so observations were planned to take this into account. I tried to observe multiple machinists over the course of visits to the site to make efficient use of travel time. Taking all these things into consideration, recordings lasted between forty-five minutes to two hours dependent upon the particular task the participant was working on. A separate private office space on site was used to transfer data to a private computer and charge recording device batteries in between observations of different participants.

Thematic analysis

I chose thematic analysis as my overall approach due to its flexibility and compatibility with a constructionist paradigm (Braun & Clarke, 2006). The accessible and theoretically flexibility of thematic analysis, being cyclical in nature, also aligns with the reflective approach that I chose as a practitioner-researcher. As highlighted by Ling-Yuan Lin (2018) themes and patterns found within data can be both informed by research questions and further define and shape research questions as the project progresses. The majority of data collected comprised of reflective field notes and video recordings captured during observations made within all three strands of the project: craft and gaming activities (observing myself), participatory events (observing game participants), and within the project partner factory (observing machinists). Objects created during Strands One and Two, for example, knitted items, acted as additional reflective tools for analysis alongside fields notes and video recordings made during their production. Game data such as scores and levels produced concurrently within the same strands, although not physical in form, were equally treated as reflective tools as physical objects made. Physical items produced during Strand Three observations formed part of the day-to-day production in the factory so could not be retained. Photographs were captured in this context to document instances for reflection and to aid analysis of additional processes taking place on the factory floor that related to the individual activity being recorded.

I am going to use Braun & Clarke's (2006) phases of thematic analysis to describe the stages of analysis carried out. Although research methods were carried out concurrently with reflective processes occurring across strands, data sets from each strand were analysed in isolation. Codes and themes were predominantly developed and refined using data collected in Strand One and used as placeholder themes when analysing data from the remaining strands, with new codes added where necessary. In all strands, a crucial stage of analysis took place during data collection in the form of notes that pointed towards initial themes and reflected upon links with theories being explored in parallel to activities being observed. Reflective notes were distinguished from main observations through the use of handwritten symbols such as asterisks and brackets. These notes would occur during or post activity, reflecting both -in and -on action as well as identifying links to other strands, aiding with initial theme development.

Phase 1 - familiarising myself with the data

Having collected the data myself and being directly involved in the activities of Strand One, I came "to the analysis with some prior knowledge of the data" (Braun & Clarke, 2006:87) which included initial analytic ideas. Written field and reflective notes, for all strands, were typed up, both to digitise them and as a process of re-familiarising myself with the content. During this process, additional analytic and reflective notes were added as thoughts occurred.

Strand One

Video recordings of my own craft and gaming activities during Strand One contained very little speech, so I chose not to carry out full transcription. Instead, video recordings were watched alongside reflective notes to align notes with actions and aid further analysis and reflection. Videos of my active hands recorded with the GoPro camera during gaming were synced with screen-captured recordings of the game being played before analysis to ensure that actions of the hand were always viewed in relation to gameplay. Instances in video recordings that were considered to be particularly powerful in support of data extracts were recorded for use in later analytic stages.

Strand Two and Three

Field notes taken during observations of activities in Strands Two and Three also contained thoughts on initial analysis and reflective notes, identified by symbols in the notes, as in Strand One. These handwritten notes were also typed up in the same way as Strand One, enabling both familiarisation with the data and for initial ideas for codes to be added. Video recordings made during observations in Strands Two and Three were fully transcribed to include detailed descriptions of actions and verbatim transcription of speech where possible. It is important to note that much speech between machinists on the production line happened in the participants' first language. This was deemed to be kept intentionally private, so translation was not sought out. Transcriptions of actions in Strand Three included recording start and finish times of individual tasks being performed to quantitatively analyse changes in performance i.e., speed. This was carried out using tools within NVivo software.

Phase 2 - generating initial codes

After familiarisation with reflective notes and aligning them with video recordings, adding additional notes where required, full texts were transferred to NVivo where initial codes were generated. Data extracts were organised into meaningful groups led by reoccurring themes arising through the data and "in relation to which arguments about the phenomenon being examined are made" (Braun & Clarke, 2006:88).

Coding was primarily 'theory-driven', approaching the data with "specific questions in mind" (Braun & Clarke, 2006:89) based on the conceptual model set out in Chapters 2 and 4. My approach was to code by identifying particular features of the data set based upon the framework, rather than coding the entire data set, especially in relation to lengthy videos of observations. A combination of NVivo software and manual methods, utilising methods such as highlighting, cutting and organising physical printouts, to assign initial codes to data sets. Identifying codes was done reflexively, initially searching for extracts of data that demonstrated concepts within the conceptual model but also allowing for patterns and new codes to be identified whilst exploring all the data in each set. Coded extracts were then collated both into 'nodes' within the NVivo software and manually.

This and the following stages were carried out for each data set, gathered within each strand, in isolation. For example, auto-ethnographic field notes and video recordings from observations of amateur craft and gaming activities were coded and analysed separately from field notes and videos gathered of participant interactions with prototype games in Strand Two.

Phase 3 – searching for themes

> This phase, which re-focuses the analysis as the broader level of themes, rather than codes, involves sorting the different codes into potential themes, and collating all the relevant coded data extracts within the identified themes (Braun & Clarke, 2006:89).

The initial codes from each data set, once collated, were gathered into tables split across the four broad themes of the conceptual model (material affordances, feedback systems, habitual practice, and minimising risk) along with some additional miscellaneous themes if they had arisen from the data. I then moved data extracts from these tables to work with them visually in CAD software *Adobe Illustrator*. This is not a piece of software typically associated with analysing data but as a piece of drawing software I am comfortable with, it enabled me to arrange and group coded data extracts into various themes and sub-themes across a larger visual space. This resulted in a series of thematic maps, an example of which can be seen in Appendix E2.

Phase 4 – reviewing themes

At this phase, collated extracts were re-read and reviewed again according to the assigned themes to check for a coherent pattern, with themes reconsidered if not deemed to adequately represent the data. Full data sets were reviewed and assessed for any additional data that needed coding into the designated themes.

Phases 5 (defining and naming themes) and Phase 6 (producing the report)

From the thematic maps (of each data set) themes were further refined and defined for presenting the analysis before final write up and analysis. Phases 5 and 6 worked in tandem with themes of each data set being refined both before and during the process of write up, the results of which can be found within the empirical Chapters (Chapters 4 to 7) of this thesis.

3.4 Ethical Issues

As this research involved working directly with other people, including members of the public and staff with the project partner factory, it was important to fully consider ethical implications and gain ethical approval. Ethics was approved by MMU on the 18th of May 2018, with subsequent amendments approved on the 10th of October 2018 and the 21st of January 2019. In order to ensure that participants were able to give informed consent, participant information sheets were prepared for each of the different contexts that would be carried out. Due to the varying situations in which observations were to take place, it was important to tailor information sheets accordingly. I have already discussed how participation in activities at public events was expected to be predominantly short term and so a lengthy information sheet would not be appropriate, so a simpler poster was developed instead. Participation of staff within the factory setting was more in-depth and required more detailed information for research participants. Observations made within the factory posed particular ethical issues. Care had to be taken to ensure that staff did not feel pressured into taking part in the research. Participants were informed and assured that all data collected would be fully anonymised using codes for participants instead of names and that no raw data would be shared with the participants' employers at the factory. This applied to written field notes as well as video recordings. Filming was planned to focus only on the hands of the participant and not include faces, but it was considered that hands may still allow participants to be identifiable to management staff due to features such as jewellery. Recordings were saved directly to an SD card which was only ever handled by myself and then transferred to a password-protected personal computer as soon as possible after recording and then immediately deleted from the memory card. It was especially important to ensure that recordings were not available to the management team as videos focused upon work tasks that gave attention to time taken to complete tasks which could be construed as evidence of a machinists' level of performance. I did not want the data collected throughout this research to form a stealth form of surveillance or worker performance that could have an impact on their employment.

During the COVID pandemic in the UK, the factory continued to operate but workflow veered to temporary production of PPE and management staff were furloughed at various stages between March 2020 and the end of this PhD. These factors raised additional ethical issues. Although the factory put into place various protocols to reduce virus transmission within the factory including increased spacing between workspaces, hand sanitising stations, temperature checks and the wearing of face masks, national and regional lockdowns made travel for myself to the factory site difficult and the University considered the risk too high. Alternative remote methods were considered as a replacement for in-person observations including obtaining additional GoPro cameras and delivering them to the factory for machinists to record their own activities. However, although a much safer method in terms of virus risk, this method posed additional ethical issues. Sending recording equipment would require gate keepers at the factory to facilitate distribution, risking giving management staff access to the raw data, and with my contacts within the management team not being on-site (when furloughed) this would be extremely difficult to manage. As described in the previous section, this resulted in a change to recruiting domestic sewers to take part in the final stage of the research. Recordings of these participants activities were to be recorded remotely, using the participants' own phone or camera. These recordings were managed solely by the participants themselves with no intermediaries required, and participants sent recordings directly to myself. As each of these participants were working on a freelance basis there were no conflicts in terms of performance surveillance. As recordings were to take place within a home environment, I was careful to explain to the participants that recording should focus solely on their hands working at the sewing machine to avoid filming potentially personal areas of the participant's home. It may have been useful to have asked participants to record a wider view of their work area, based on experiences of observations made in the factory but I did not want participants to feel that their private spaces were being invaded, especially as I had no control over where they chose to work within their home. Both participants involved in this stage of the research had families, including children, at home. I was unable to control background activity whilst participants recorded their actions, but I was careful not to transcribe any additional conversations or voices from the recordings. Children could sometimes be heard in the background or talking to the participant, but these conversations were not relevant to the actions being observed.

4_Evidencing Crossovers

In Chapter 2, key areas of overlap were identified through an in-depth review of crucial craft and gaming literature, identifying critical aspects of embodied practice that are present in both traditional forms of making and video gameplay. In summary, these are:

1_Material Affordances
Both physical and digital materials (including games) pose a set of limitations and affordances.

2_Feedback Systems
An active conversation occurs between material, tool and maker or gamer.

3_Habitual Practice
Skill is acquired through repetitive action and habitual practice, including the embodiment of tools.

4_Minimising Risk
Elements of risk are controlled through the appropriation of jigs and skilful action.

This Chapter seeks to further analyse these thematic overlaps and evidence the themes through empirical research in seeking to answer the first research aim: to identify existing crossovers between craft and gaming. This Chapter will build upon the theoretical crossovers, engaging directly with craft and gaming to access the inarticulable reflective moments from which the development of 'grafted' prototypes will be explored and interrogated. As part of reflective practice discussed in Chapter 3, direct engagement in craft and gaming activities will provide insight into moments of surprise that may prompt reflection-for-action as well as -in and -on-action (Schön, 1983), that will feed into Strands Two and Three of this research.

Amateur craft, specifically textile making, that has become popular in recent years (Gauntlet 2018; Twigger Holroyd 2018), alongside that of casual gaming (Juul, 2010), are considered within this research to be comparative practices that can signpost potential collaborative outcomes as well as reflect the critical themes outlined above. As discussed in Chapter 3 (Methodology), amateur practices are predominantly intrinsically motivated activities without external goals or requirements, for example, through the absence of payment for labour. This Chapter will focus on crossovers between amateur craft and video gameplay as practices that predominately take place within the home. Evidencing the above thematic crossovers within amateur practices will enable the development of creative interventions that explore the collaborative potential between craft and gaming. Indeed, by evidencing crossovers I will come to demonstrate (in Chapters 5 and 7) how they can be used adaptively to assess the impacts and outcomes of grafting craft with gaming that could provide potential value beyond amateur practices.

Case Studies

Throughout this Chapter, I will draw upon reflections made during observations of both amateur craft and gaming activities using four case studies: the games of *Unravel,* (including *Unravel Two*) and *Mario Kart 8 Deluxe*, alongside textiles activities of hand-knitting and macramé. These activities were selected as amateur projects that allowed for the observation of complete processes within the research time frame. All required dexterity, and utlised technology and tools which I had available within my home meaning they could be observed using the methods described in Chapter 3. More specifically, the video games selected were chosen for the opportunity they offered to observe different embodied ways of interacting with games. Parisi states the way that the graphical interface of a game (including on-screen elements such as camera positioning and navigation menus) is navigated by the player's hands varies "greatly from game to game" (2009:115). By using a PC game, that uses a keyboard to navigate the game's graphical interface, and a *Nintendo Switch* game, that uses hand-held controllers (with two analogue sticks and an array of button inputs), these case studies offered opportunities to observe different ways of interacting with the games. Games that more clearly used the whole body with more exaggerated movements such as *Dance Dance Revolution* (that uses a dance mat), which could be assumed to more directly link with the actions of craft, could have been chosen. Instead, this research uses these case studies to explore the subtleties of movement. As Parisi states, "all human-computer interfaces are bodily ones" requiring "the body to function as an input device" (2009:116), just as the actions of knitting and macramé require focused action within the hands that is supported by the rest of the body.

Game One: Unravel

The first case study, *Unravel* by Coldwood Interactive (2016), was selected as a game that thematically presents a synergy with craft due to its representation of yarn as a core interactive element in the game. *Unravel* is a sequential puzzle-based platform adventure game in which the player takes on the role of a small amorphous being called 'Yarny', that is made of yarn.

Figure 4.1: Bridge made from the thread that trails behind 'Yarny' (Source: Electronic Arts, 2021: online)

As you move through the game, 'Yarny' unravels into a single thread to be used for swinging and creating bridges (see Figure 4.1). The game was played on a PC with a keyboard (this game does not require a mouse) but is also available on PS4 and Xbox One consoles. *Unravel Two* is the second game in this series and presents as very similar to the first game with 'Yarny' taking on a new adventure. Having completed the first game, I immediately went on to purchase and play the second game to extend observations. In this game, a second version of 'Yarny' is introduced to play alongside the first.

Figure 4.2: Two main characters of *Unravel Two* (Source: Electronic Arts, 2022: online)

The two characters can be played together, in a connected form and separated when needed to solve puzzles in the game with a single-player able to switch between the two characters. This game offers the opportunity to play the game as a two-player game, but for this case study, I continued to play in single-player mode only.

Game Two: Mario Kart 8 Deluxe

Figure 4.3: *Mario Kart 8 Deluxe* (Source: Nintendo, ND: Online)

Mario Kart 8 Deluxe is a racing game for the *Nintendo Switch* console, designed as a follow on to a long-running series of Mario Kart games produced for various *Nintendo* platforms. The game is competitive in nature with players entering individual or Grand Prix style races. This can be done as a single player, playing against computer AI players, or in multiplayer mode, playing against up to four other people on one console. When using the Switch console, players have several options for the controls. If played in handheld mode, the Joy-Cons remain attached to the side of the device. The game can also be played in table-top mode, with the Joy-Cons detached from the screen. When disconnected, the player can play with one Joy-Con in each hand or can choose to connect them to a 'comfort grip' (making them one singular controller).

Figure 4.4: Still from observation video showing use of 'comfort grip' with the *Nintendo Switch*

When playing *Mario Kart 8 Deluxe* myself, I played in various modes including holding the Switch as a handheld device (as shown in Figure 4.4), holding the Joy-Cons individually and occasionally using a comfort grip. In multiplayer mode, each player will use just one Joy-Con and hold it horizontally. This version of *Mario Kart* also offers a new 'Battle Mode', where players compete in an 'arena' environment to defeat their opponents in a friendly battle. Players may, for example, be tasked with popping balloons on the back of other players' cars or players may be split into teams to battle and capture players from the opposing team using the 'Potted Piranha Plants'. I did not include this mode within the research.

Craft One: Hand-Knitting

Alongside these two games, comparative observations were made of two forms of amateur textile activities. The first, hand-knitting, a practice through which two knitting needles (one in each hand) are used to manipulate yarn to create a knitted fabric, often resulting in the creation of wearable garments. A completable knitting project in the form of a kit, a *Mother of Pearl (MOP) Sweater*, was purchased from online retailer *Wool and the Gang*.

Figure 4.5: *Mother of Pearl* kit and completed jumper (Source: Wool and the Gang, ND: online)

The project chosen represented an everyday amateur craft carried out in many homes and is an approachable craft in terms of tools and materials. As a brand, *Wool and The Gang* create and sell a range of kits for different items, mostly wearable but some for the home, alongside selling separate yarns and tools for hobbyists. Their kits range from beginner to advanced skill levels with the *MOP Sweater* being marketed as an 'easy knitting kit'. Like all of their kits, this kit came with all the wool needed for the project, knitting needles (optional) and instructions as well as a sewing needle for stitching up the final seams.

Craft Two: Macramé

The second textile activity chosen as a case study was macramé*,* a textile activity that uses rope and cord as opposed to yarn and, like knitting, involves creating a fabric-like structure through building individual stitches, or in this case, knots. The process does not require any specialist tools as knots are constructed by the hands working directly with the rope, but items such as rails, hooks, scissors and combs aid in set up and finishing processes. Macramé is generally used to make decorative pieces for the home such as wall hangings and planters but can be progressed into more functional items like bags. For this case study, I enrolled on a four-week online course led by Isabella Strambio of *TwoMe*.

Figure 4.6: Isabella Strambio of *TwoMe* (Source: Cosy Craft Club, ND: Online)

As a mostly self-led course, it consisted of a series of pre-recorded online video tutorials and written instructions that taught 8 basic macramé knots and talking participants through a collection of completable projects, of which I completed three: a wall hanging, a wreath, and a plant hanger. In addition to these resources, the course was supported by a weekly group video call in which participants could discuss progress and ask the tutor any specific questions about the work.

All of these amateur activities (games and craft) were containable in terms of time and resources and considered to be indicative of broader amateur practices. Having played some games on PC and the Switch previously, and completed some small textile projects, including knitting, I was already familiar with most of the tools to be used and had experience with similar materials (including video games). When approaching these particular activities, however, I did not consider myself to be an expert at any and thus had not reached a level where tools or practices had been fully embodied or habitualised (see section 2.5). In terms of reflective practice, this enabled greater potential to experience surprise upon which “[m]uch reflection-in-action hinges” (Schön, 1983:50). As discussed in section 3.3 it was imperative that this research gain access to inarticulable reflective moments through directly engaging in these practices. These attributes provided the opportunity to directly observe and further evidence the existence of crossovers between craft and gaming through the four key themes identified in Chapter 2: material affordances, feedback systems; habitual practice; and minimising risk. I will now consider each of these themes in depth, evidencing their existence as experienced during engagement in the case studies discussed, whilst also drawing on reflective moments that point towards potential areas for exploration through grafting which will be discussed in later Chapters.

4.1 Material Affordances

In Chapter 2 I identified that both craft and gaming involve an encounter with material, whether that be the physical matter of craft such as clay or yarn, or the less tangible digital material of gaming; the game itself. As set out in section 2.3, every material has a unique set of “accompanying gestures, tools and materials” (Greenhalgh, 2002:1) that the craftsperson must adapt to work it successfully (Korn, 2015). Whilst contemporary craft pushes the boundaries and possibilities of material properties and cross-fertilisation of properties and processes, this strand of the research investigates engagement with a singular material (physical or digital) within specialised activity. The distinct properties and qualities of each material, what it can do, is referred to as a set of material ‘affordances’ (McCullough, 1996). Within both practices, we come to understand the possible actions of each material in two ways. Some possible actions are made explicit, especially within amateur forms of craft and gaming, where instruction and tutorials set out a simple set of potential actions. I will begin this section by outlining the potential actions of each material that are made explicit through the case studies described. The subtleties and more nuanced qualities of each material, its quirks and character, however, cannot be understood immediately through these explicit forms but are instead learnt over time by the maker/gamer through direct engagement with material (Korn, 2015; McCullough: 1996; Juul, 2011). Using case studies of the craft and gaming activities explored, I will demonstrate how affordances encountered during making and gameplay become recognisable to the person through repeated encounters with them.

Controls and Explicit Possible Actions

Possible actions that are made explicit are those that can be easily accessed or ‘found out’ via written instructions, a list of controls (in games) or video tutorials (in game or via video format). Both the playing of the video games *Unravel* and *Mario Kart 8 Deluxe* and the act of hand-knitting the *MOP sweater* and creating macramé pieces require the embodying of what may be perceived as a limited set of actions. These processes are made explicit through the controls set out by each game or the techniques given in the instructions of each textile activity.

Game One: Unravel

The available controls for *Unravel* can be found listed in the main menu of the game (see Figure 4.7), with each action assigned a ‘key’ on the keyboard.

Figure 4.7: Controls menu captured from the game *Unravel*

The list communicates to the player the limited set of controls that are available during gameplay. The range of controls not only suggest what can be done but also limit potential actions. For example, walking is only given two directions, ‘Walk Left’ (LEFT arrow key) and ‘Walk Right’ (RIGHT arrow key). From this, the player can assume that they can only walk in left and right directions across the screen. In action this movement is revealed as the character (‘Yarny’) walking forwards across the terrain (RIGHT) or in the opposite direction, retracing steps (LEFT) (see Figure 4.8 below). This is a limit placed on the player that is typical of platform games. Navigating the terrain and obstacles within each level is otherwise possible via ‘Climbing’ (using the UP and DOWN arrow keys) and ‘Jumping’ using the SPACE bar. Additional actions offered via the controls are ‘Shoot’, ‘Grab’, ‘Grab Object’ and ‘Attach’ which all imply forms of potential interaction with the game world and the objects found within it. This explicit list of controls enables the player to begin playing the game, understanding that pressing any of these keys should result in the actions described whilst not yet fully understanding the resulting action or how it interacts with the game world. Juul (2007) suggests that limitations placed on actions in video games is linked to the goal of the game. For example, when discussing the arcade game *Scramble* he describes how the movements of the player are controlled and enforced through the screen scrolling “right to left at a steady pace” (Juul, 2007:194) giving the player no option but to follow the goal of the game of invading a ‘scramble system’ that lies ahead in the level. The set of controls available to the player of *Unravel* similarly limit movement through the game space, linked to the goal of proceeding to the end of the level. The movement from left to right, supported by the actions of climbing, jumping, shooting, grabbing and swinging that enable the player to overcome the challenges presented on the way to complete this goal.

Figure 4.8: Images demonstrating walking directions of 'Yarny' in *Unravel*

Game Two: Mario Kart 8 Deluxe

As the most recent game (at the time of playing) in a series of Mario Kart games, *Mario Kart 8 Deluxe*, encompasses a core set of actions that have carried through from previous versions. An experienced Mario Kart player would likely already be familiar with the potential actions of the game, such as knowing that ‘Accelerate’ would move the kart forwards on the track and knowing what to expect when using an ‘Item’ (see Figure 4.9 below). Parisi describes actions such as the finger movements of an experienced player as being second nature “having been inscribed through years of training into his or her muscles” (2009:114). To an inexperienced *Mario Kart* player, the same actions may act as a barrier with an array of buttons being “fumblingly complex in the hands of new gamers” (Parisis, 2009:114). As a relatively inexperienced *Mario Kart* player, my hands certainly struggled to grasp the required actions and their related buttons for commencing a race through activating acceleration.

Figure 4.9: Character in *Mario Kart 8 Deluxe* holing an ‘item’ ready to use it.

As with *Unravel,* an explicit list of the controls for *Mario Kart 8 Deluxe* can be found via an in-game menu, accessed when pressing the ‘+’ button on the right Joy-Con.

Figure 4.10: ***Mario Kart 8 Deluxe*** **in-game control menu – for handheld mode**

Figure 4.11: ***Mario Kart 8 Deluxe*** **in-game control menu – for comfort grip mode**

This brings up a diagrammatic layout of controls, depending on the Joy-Con set-up being used (see Figures 4.10 and 4.11 above). This game was purchased as a physical game cartridge which also includes an explanation of the controls on the inner cover (see Figure 4.12).

Figure 4.12: ***Mario Kart 8 Deluxe*** **in-game controls given on the inside of the game cartridge cover**

Controls for gameplay are limited to five potential actions: 'Steer' which uses the left thumb stick; 'A' to accelerate; 'B' to brake (only made explicit on the game cover); 'L' to use an item; and 'R' to drift. Players have the choice to automate some of these actions through 'Smart Steering' and 'Auto-accelerate', available to turn on or off. Players could also select to use the inbuilt 'Tilt Controls' (where the angle of the controller is used to control turning in-game) instead of the left thumb stick to control direction. These options are made explicit also in the in-game controls menu. From this range of controls, the player can interpret a variety of potential actions. Navigating a racetrack alone would, from the available controls, be available in all directions; using forward (accelerate) and the left thumb stick (which moves in all directions). The player can also assume that they will be able to control speed (accelerate and brake) and access competitive tactics (drift and use items).

Craft One: Hand-Knitting

Similar to lists of controls, the knitter following the set of instructions provided with the *MOP Sweater* kit is given a set of potential actions in the form of 'techniques' to be used for completing the jumper. The material provided is wool, a specific quality called 'New Wave Yarn'. It is a lightweight yarn that in itself defines a set of stitch possibilities or techniques that would reveal the yarn's inherent qualities. These possibilities are dependent upon the yarn's weight, thickness, flexibility, stretch recovery etc. just as different qualities of wood lend themselves to different uses and finishes due to their inherent qualities (McCullough, 1996), as discussed in Chapter 2. The kit recommends the yarn be knit with a particular size of knitting needle to achieve the desired dimensions for the jumper. At the time of purchasing, the 'New Wave Yarn' was available in kits from the same brand for knitting other objects (using different stitches or needle sizes) as well as for crochet projects (which uses a hook instead of needles). For the *MOP Sweater kit,* the knit designer has assessed the possibilities of this yarn and outlined a distinct collection of stitch types and techniques to be used to complete the specific jumper design. The maker using this kit does not need to experiment with the yarn and the knitting needles to discover what might be possible; instead, the maker is guided and led by the instructions. The specific stitch types outlined in the instructions combine in a variety of ways to make up the overall stitch patterns used throughout the jumper.

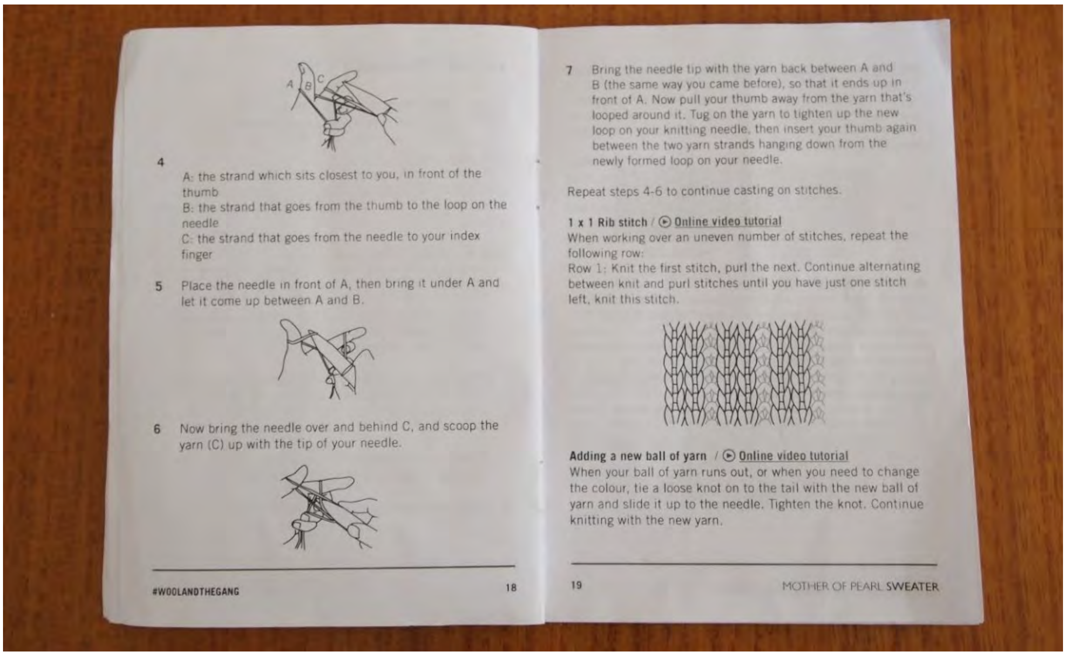

Figure 4.13: Example page from *MOP Sweater* instruction booklet showing knitting techniques

All of the knitting 'techniques' are outlined at the back of the instruction booklet (see Figure 4.13). Each knitting technique required is described in detail and supported with diagrams where necessary. Stitch types and methods include: 'Long-tail cast on', '1 x 1 Rib stitch', 'Adding a new ball of yarn', 'Stocking stitch', 'Moss stitch', 'Right-leaning decrease', 'Increasing', and 'Casting off'. Each of these also had a supporting online video tutorial where an experienced knitter demonstrates the processes involved. Just as the list of controls for *Unravel* outlines 'what can be done', these specific knit techniques make explicit the actions that can and should be used to complete the sweater. Watching the videos does not provide the knitter with the embodied 'know how' to complete the action seen.

Having done a small amount of knitting previously I was familiar with how to create the basic stitches (knit and purl) and familiar with some materials; for example, how some yarns felt in my fingers, and how the yarn created tension as the fibres brushed up against itself. The *MOP Sweater* kit required using a yarn I had not used before, and it had its own set of properties that determined how it would behave. The 'New Wave Yarn' that comes with the *MOP Sweater* kit has a very particular texture that makes it almost appear knitted itself. The yarn is formed of a tube-like net with a looser inner tubing. This structure tended to fray at the ends and the outer mesh snagged very easily. The *MOP Sweater* instructions advise the maker to knot the end of the yarn due to the likelihood of it fraying (an explicit instruction). The tendency for the yarn to pull or snag (aside from at the cut end) is only discovered in the act of knitting though. Having encountered a pull in the yarn in one instance, the knitter learns to take care in handling the yarn when proceeding further. Amateur knitters may come across a variety of yarns in their practice, depending upon the project they are working on and the desired appearance and feel of the final object or garment. I had recently knit a hat using a much 'fluffier', thicker yarn from the same company, called 'Crazy Sexy Wool'. Described as 'chunky' (Wool and The Gang, ND), the recommended knitting needle size for this yarn is between 10 and 25mm, much larger in diameter than the needles provided in the *MOP Sweater* kit. The sweater required the use of 6.5mm straight needles for the main body sections and required a 5mm circular needle to knit the 1x1 rib of the hem, cuffs and collar. I already owned a pair of straight 6.5mm needles that were metal needles (inherited from my grandmother) and ordered the correct size circular needles with the kit, which were made of a similar metal material at the ends with a flexible cord joining them in between. In previous knitting projects, I had often used chunkier yarn with thicker, wooden needles. The combination of yarn and needle size/type creates a different knitting experience. Even when using the same knitting techniques with each yarn, the knitter must respond to how each yarn behaves and is manipulated with the different needles. For example, when knitting moss stitch with the ‘Crazy Sexy Wool’ (chunkier yarn), the hands must hold larger needles. Due to its texture, the chunkier wool grips slightly better against the wooden needles. The smoother ‘New Wave Yarn’ had more of a tendency to slip on the metal needles and required a different level of grip in the hands. Despite the same ‘action’ being carried out technically, the material properties of each different yarn require the hand to adapt and adjust as it interacts with each material.

Craft Two: Macramé

Unlike the *MOP Sweater* kit, in which yarn is provided, participants of the online macramé course are given a list of recommended materials and suppliers. This list includes explicit descriptions of cord types, thicknesses and lengths that will be required for each project during the course. The intended uses for these cords are then made somewhat explicit by the tutor who provides a set of guides for the creation of certain macramé pieces that have been designed as part of the course. In this case study, the tutor breaks down lessons into a series of macramé pieces that enable each participant to learn and practice a set of common macramé knots. Before signing up for the course, participants are told (through the online description) that they will learn 8 main macramé knots and utilise them in making macramé pieces including a wall hanging, a plant hanger and a wreath. Once enrolled on the course participants can access individual lessons, of which there are 32 in total split across four modules (one released each week of the course) and an introductory section, and each participant can work through them at their own pace. Lessons in the course include photographs of example projects, written instructions and video tutorials in which the tutor demonstrates particular knotting techniques and shows a variety of sample completed pieces. See screenshots from the online course below (see Figure 4.14).

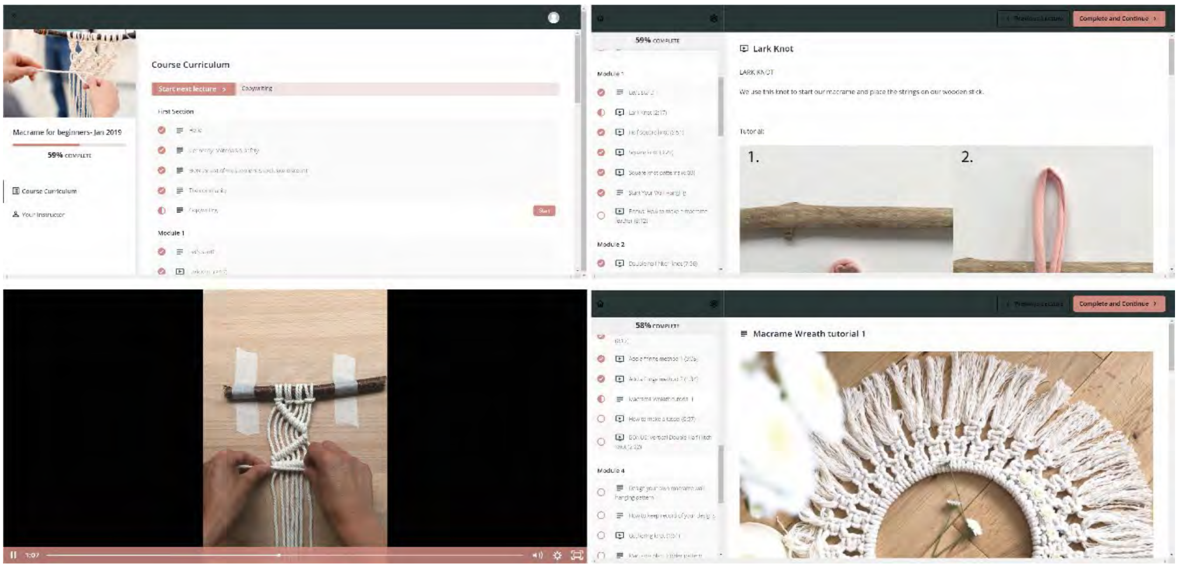

Figure 4.14: Screenshots from *TwoMe* online macramé course

The main techniques (macramé knots) are introduced slowly as the course progresses with each knot technique explained in detail. The ability to browse ahead in the course allows the participant to visually see the potential outputs of using the various macramé knots taught. In knowing this, however, the participant, without fully understanding how to create each knot and in what combination, is not able to proceed with making the projects immediately. As discussed in Chapter 2, the actions required to carry out the different techniques and combinations of knots need to be fully understood and this only comes through direct engagement with material (McCullough:1996). The processes and instructions given show how to acquire and embody knowledge through practice which is instigated through the stages of the course.

Encountering Properties in Action

Having outlined the potential actions made explicit through the instructions and control lists described in each activity I will now discuss further how the material properties are discovered further and better understood through direct engagement. Material, whether it be physical or digital, as outlined in Chapter 2, has a set of qualities that we sense *only* in action (McCullough, 1996; Pye, 1995). Despite potential actions being set out within a list of controls or the instructions of a kit or course, the full qualities of the material are only truly understood ‘in action’. The potential actions of materials within both the game and textile case studies were experienced to have been understood more fully when encountered in action. Through encountering properties in action, the maker and the player become aware of what is possible with that material, how the material responds to their actions and how to respond to them (Korn, 2015; McCullough, 1996; Adamson, 2007; Juul, 2013; Keogh, 2018).

In the previous section, I outlined the potential actions available in *Unravel,* made explicit through the game's controls menu. Each control, however, is more complex and, the player must learn to use the appropriate controls in the proper instances and at the correct time. It is only 'in action' that the player discovers, for example, that climbing, and jumping are both actions that must be carried out in combination with other operations and are only fruitful when interacting with objects in the game.

Whilst playing *Unravel*, the player often comes across small items or objects in their path. Sometimes the objects fall directly in front of the player, triggered when a certain position is passed in the level. Throughout the game, the player must solve puzzles to progress each level and in doing so may need to make use of these objects or items. The player must learn to recognise, through trial and error, what objects can be interacted with and how they might be used to solve challenges. Within the list of controls, the player is made aware of 'Grab objects' as a potential action but when to use this action and to what end is implicit and is not discovered until in gameplay. For example, in level one of the game, Chapter I: 'Thistle and Weeds', the player comes across apples at various points. When an apple falls from above and lands next to 'Yarny', it acts as a hint that this object can be interacted with and used to solve an immediate puzzle. Through moving around the player comes to understand that the apple can be pushed simply by moving 'Yarny' towards them or pulled using the 'pull objects' button. This first level in the game also acts as a tutorial, offering prompts on screen to guide the players actions. For example, the prompt "Press [E] to grab objects" informs the player how to grab an object, suggesting that this action would be appropriate at this point. The player then discovers that several other apples are lying around the same area. The player discovers (through action) that the apples can be utilised to cross a 'well' slightly further ahead in the level, once it is filled with water, by pushing all the available apples along. The player has thus come to recognise that objects can not only be pushed or pulled along but that this ability affords puzzle-solving in the game.


1


2


3


See the whirling light? It means that you'll start here if you quit and come back to this level.
4


5


6


7


8

Figure 4.15: Video stills from observations of *Unravel*, demonstration use of apples to problem solve in game

The above example demonstrates a simple aspect of puzzle-solving within *Unravel* and how puzzles are solved through trial and error, learning to recognise and understand affordances of this material. The maker following the online macramé course primarily learns to recognise material affordances through following instructions. The online macramé course demonstrated a series of basic knots. The maker does not have to work out, through trial and error, how to make each knot, the video demonstrations allow for almost direct replication of movements. When faced with wanting to learn a new knot, however, some problem solving is required. For example, in seeing an image of an unknown knot, a maker may wish to try and replicate it. Without a tutorial, the maker can analyse the image and experiment with cord building upon knowledge gained through creating other knots. The same applies to the combination of different knots to achieve their own overall design.

Summary

Having identified in Chapter 2 that both craft and gaming involve an encounter with material, this section has explored, through the craft and gaming case studies, two ways in which the materials of both craft and gaming come to be understood: through explicit instruction, and through encountering affordances in action. Within the case studies, explicit potential actions are considered to be those that are easily accessed via written, verbal or audio (including video) instructions or through lists of controls. The range of actions or controls available suggest potential actions that may be performed but can also limit potential actions. In playing *Unravel*, the actions of walking left or walking right across the screen, limit player movement to keep the player focused on the goal of the game (Juul, 2007). Some potential actions that are made explicit may also be understood to a certain extent through previous experience with a similar material. The basic action of 'accelerate' in *Mario Kart 8 Deluxe* for example, or the action of a 'purl' stitch in knitting. Such action, understood from previous experience, may already be inscribed to particular tools and actions but may not enable the player or maker to instantly understand the particular affordances of the current material which may require some adjustment from previous embodied actions. For example, adjusting to working with a different yarn quality in knitting despite 'knowing how' (Tanaka, 2013) to make a particular stitch. A fuller understanding of material affordances within both craft and gaming can only be gained through direct, and repeated, engagement with material. Players engaging with the game *Unravel* must learn to instigate correct 'actions at the correct time, in the correct combinations and used to interact with the required objects within the game. This process requires aspects of trial and error, exploring various actions to see which have a successful outcome. For example, discovering that objects such as 'apples' in the game, can be utilised to assist in traversing certain terrains in the virtual space. Similarly, despite the potential knots and stitches of macramé and knitting being made explicit through instructions for completing patterns and objects, the maker may need to use a process of trial and error to explore the potential beyond these predesigned outcomes.

Explicit potential actions and the need to engage directly with the material will need to be considered when grafting craft and games together and assessed to see how each material's affordances might impact upon the other.

4.2 Feedback Systems

Borrowing a term more commonly used in game studies, in Chapter 2, I identified that both craft and gaming have 'feedback systems' that involve an active conversation between material, tool and maker/gamer. As stated by McCullough "[t]he actions of our hands, eyes, and tools must be mediated" (1996:193), with material, tool and body actively communicating with each other. For communication to occur, the maker/gamer needs to receive feedback from the material, either directly or via tools, to enable the body to respond and take further action. Without feedback, the maker/gamer will not have a clear understanding of what impact their actions have upon a material and would be unable to take or maintain full control. Clear feedback is considered a key feature of digital games (Juul, 2013; McGonigal, 2011), providing the gamer with feedback on their performance (Pausch et al., 1994; Inchamnan & Wyeth, 2013) as part of their corporeal engagement with material (Keogh, 2018). In craft, the practitioner receives constant "sensorial feedback" (Luscombe, 2017:12), allowing for continuous calibration of the body and tool(s). The eyes and ears of a craftsperson monitor progress and remain alert, while the body responds, adjusts and fine-tunes movements in "an intimate coupling of perception and action" (Ingold, 2011:58). In this section, I will outline the various forms of feedback observed in the case studies of casual gaming and amateur textile practices. The physical and digital materials of these case studies provide a range of forms of feedback that I will categorize here as visual, audio and haptic (touch). I will then discuss how explicit quantitative and qualitative forms of feedback enable the maker and gamer to track their progress and respond to the ongoing quality of their work.

Types of Feedback

In his paper "*What's a Mallet for?*", Luscombe draws on "Bernstein's study of hammering and Kirsh and Maglio's analysis of Tetris" summarising that in both practices "responding to sensory feedback is key to the tasks' success" (2017:12). The body is involved not only in acting out a process but in being alert to the feedback being communicated through the medium of tool and material. According to Keogh, how a video game looks, sounds and feels are "vital components of the experience of videogame play" (2018:110). Gaming literature often discusses the sensual experiences of gaming in terms of being related to three forms of feedback, visual, audio (or audio-visual) (Keogh, 2018) and haptic (Parisi, 2019). The sensory experience of craft is generally discussed in a less delineated way with feedback offered by the physical material being received and responded to in a more bodily way. For this research, however, it is useful to consider the individual aspects of sight, sound and feel to assist in the analysis of the impacts of such forms of feedback especially in terms of grafting where the 'artificial' feedback mechanisms of a game could affect the 'feel' of the craft to which it is grafted. Thus, in this section, I will outline three forms of feedback observed in the craft and gaming case studies: visual, audio, and haptic.

Visual Feedback

As stated by Keogh "the acts of looking and listening are themselves vital components of the experience of videogame play" (2018:110) with many video games relying on a screen to provide visual feedback as the predominant form of visual communication with the player. This is the case in the games *Unravel* and *Unravel Two* which utilise a PC screen. *Mario Kart 8 Deluxe* either uses the built-in screen of the Switch console when played as a handheld device or is connected to a peripheral television screen to display the game. As described by Sudnow, when playing a video game, with our hands balanced in our lap, controller in hand, "the eyes are freed from the hand guidance work, free to witness and participate in the spectacle from above" (1983:22). When playing *Unravel* the player's eyes do the same, while the hands remain mostly unobserved placed directly on the embodied tool of the keyboard. While watching the screen, the eyes constantly track back and forth monitoring the in-game terrain for upcoming challenges, visual prompts and clues as to what items or structures might provide the potential for action (as discussed in the previous section). The eye also observes where the character has been, which in *Unravel* is further visualised by the trailing yarn that 'Yarny' leaves behind (see Figure 4.16 below).

Figure 4.16: Trailing yarn reveals where the character has been

Physical materials also offer visual feedback as they innately have aesthetic qualities that, as manipulated by the maker, offer visual feedback, whether that be a materials surface texture, structural patterns, or an object's overall form. As discussed in Chapter 2 (section 2.4), in his account of sawing a piece of wood, Ingold describes a process of sensory correction in which the eyes visually monitor the material while the fingers fine-tune movements in response to this visual feedback:

> The fine-tuning or "sensory correction" of the craftsman's movement depends, however, on an intimate coupling of perception and action. Thus in sawing, the visual monitoring of the evolving cut, through eyes positioned above to see the wood on either side, continually corrects the alignment of the blade through subtle adjustments of the index finger along the handle of the saw (Ingold, 2011:59).

When knitting the *MOP Sweater*, I similarly visually monitored the knitting, observing the yarn as it wrapped the needle to ensure it did so successfully and in the correct direction, looking at the position of the loop whilst preparing for the next stitch, and tracking stitches already formed to gauge their success. At moments of pausing in the activity, the eye will assess the work more as a whole and look along the whole length of the needle, rather than focusing on the needle point as it does in the act of forming stitches, as the hands carefully move bundles of stitches along each needle (see Figure 4.17). The knitter may use these moments to visually assess the growing garment, perhaps holding it against their body to both check sizing and imagine the finished item being worn.

Figure 4.17: Visually inspecting knitting in progress after completing a row whilst the hands move the stitches along the needle

Audio Feedback

In addition to visual feedback, video games also offer players various forms of audio feedback, it is certainly common for games to have background music composed specifically for them. The music of *Unravel* and *Unravel Two* is particularly emotive during gameplay and adapts to the developing narrative of each level. At various points in both games, the music is prompted to change subtly or dramatically when the player reaches a certain position. In the level titled Chapter III 'Little Frogs' of *Unravel Two*, for example, 'Yarny' emerges into the open air after progressing through a cave area and begins to walk across the terrain. Dropping down from a rock the player then moves 'Yarny' past an image of children (who feature many times throughout the game) which prompts the music to pick up the pace (Appendix B5.1). The player becomes aware that this quickening is an indicator that something is about to happen and, as I recorded in my field notes, "you know something is about to happen", you can 'sense' it. Sure enough, a turkey predator proceeds to chase the player as they try to traverse obstacles. The change in music acts and an indicator for action and induces a sense of urgency in the player.

Keogh (2018) describes a similar experience in his account of playing a level of *Audiosurf* in which *Fatboy Slim's* "Right Here, Right Now" is translated into a video game space:

> For several beats, the song's volume is reduced to almost silence and the track curves upward, almost vertical, and gives me the distinct feeling of being on the precipice of a roller coaster's plunge (2018:109).

In this description, the change in intensity of the music meets what Steve Swink (2017) refers to as the 'feel' of the game, just as I experienced in *Unravel*. Other sounds in the *Unravel* series include ambient noises such as crashing waves, birds squawking, or gates creaking. In addition, the player also receives audio feedback of the character's movement. For example, the player can hear the sound of 'Yarny's' footsteps as the player moves him or as he lands on surfaces (sound changes depending on the surface), objects scrape along the floor when moved (sound of interaction with objects - water flowing when something is opened, a branch snapping), shuffling noise as he climbs up or down the yarn, a flapping sound when 'shooting' yarn out. Swink describes such effects as 'polish': effects that "add appeal and emphasize the physical nature of interactions" (2017:5). Keogh summarises the importance of such effects to player experience:

> If all polish were removed, the essential functionality of the game would be unaltered, but the player would find the experience less perceptually convincing and therefore less appealing (Keogh, 2018:6).

Mario Kart 8 Deluxe offers very similar forms of audio feedback to players. Each 'race' or course has music playing in the background which tends to be high energy in pace to match the speed of the game. Similar to *Audiosurf* being played by Keogh (2018), the music behind *Mario Kart 8 Deluxe* was designed to change the background music in response to player actions, speeding up when the player commences the last lap, promoting a sense of urgency (Appendix B5.2). The player's sensory experience is further added to through added audio effects, for example, the vehicle makes a satisfying noise when accelerating. Objects provide positive feedback sounds when collected, with the character cheering and making 'yippee' and giggling like sounds when jumping and throwing objects. Likewise, picking up coins successfully along the course is confirmed by a specific coin sound. Keogh (2018) describes a similarly satisfying experience provided through the audio-visual design of mobile game *Angry Birds:*

> The birds feel weighty as I watch them fly through the air on a slow parabola and hear them hit the structures with a satisfying "thud" […] amplifying my input with excessive feedback (Keogh, 2018:65).

Just as the 'polish' effects discussed by Swink (2017), these audio effects make the experience of playing *Mario Kart 8 Deluxe* more appealing and provide auditory confirmation of actions being performed by the player. Such elements of audio feedback are used quite significantly in this game to indicate the start and end of a race (the moment of passing the finish line) as well as marking the starting of a new lap.

In addition to providing feedback on successfully performed actions, audio feedback in *Mario Kart 8 Deluxe* also provides what McGonigal refers to as "positive failure feedback" (2011: 67). For example, sounds such as the noise made when an object is deployed and used upon another player, each object has a unique sound that relates to its purpose. When such an object is used negatively on the player by an opponent in a way that is designed to slow them down or hinder their progress in some manner, such as lightning striking the car, an accompanying sound reinforces the experience. Such sounds, in accompaniment to a related animation sequence, makes failure an enjoyable aspect of the game. According to McGonigal, such aspects of feedback reinforce "our sense of control over the game's outcome" (2011:67) and play a role in maintaining our interest in the game.

There is no music or artificially applied ambient sounds within amateur textile making. A maker may of course choose to play music whilst knitting and there will be background noises of the space in which they work. These sounds, do not, however, respond to the actions of the maker as in the examples above. The case studies of macramé and hand-knitting used for this research are innately quiet activities and any audio feedback from the material is subtle and works very closely with feedback experienced through touch. This is not to state that audio feedback in these activities does not exist but that this element of feedback is so subtly connected to the visual and haptic feedback that it is difficult to draw it out as a distinct entity from the video recordings made in observation. In later Chapters (5 and 7) that discuss prototype graft-games, audio feedback from the knitting and sewing machines involved will be discussed in more detail due to the more obtrusive sounds of the equipment involved.

Haptic Feedback

As highlighted by Keogh, aspects of visual and audio are not singular in the video game player's experience:

> the videogame's audiovisual output converges with the player's gestures at the input device to produce a distributed and irreducible sense of perception and proprioception (Keogh, 2018:111).

The input gestures involved in this feedback loop are also inseparable from the sense of touch received from the input device.

As the material in video games is digital it is not directly accessible to the body. In response to this, some game devices have been designed to include artificial forms of touch in the form of 'vibrational feedback' through which "the player feels vibrations corresponding to onscreen events" (Parisi, 2009:119). Many game console controllers have some form of inbuilt vibration functionality, however, as emphasised by Parisi "all human-computer interfaces […] involve felt sensations of interfacing; [and] this felt experience will differ from interface to interface" (2009:119). Following Loomis and Lederman (1986) as Parisi does, within this research I am using the term 'haptic' "to indicate the involvement of cutaneous (skin) and kinesthetic senses” where ‘kinesthetic’ “refers to the body’s ability to sense the limb positioning and movement” (Parisi, 2009:113). The keyboard of the PC when playing *Unravel* does not offer any artificial vibrational feedback but still produces a “haptic experience for the hands, but also for the rest of the body, as a *byproduct of game-play*” (Parisi, 2009:119).

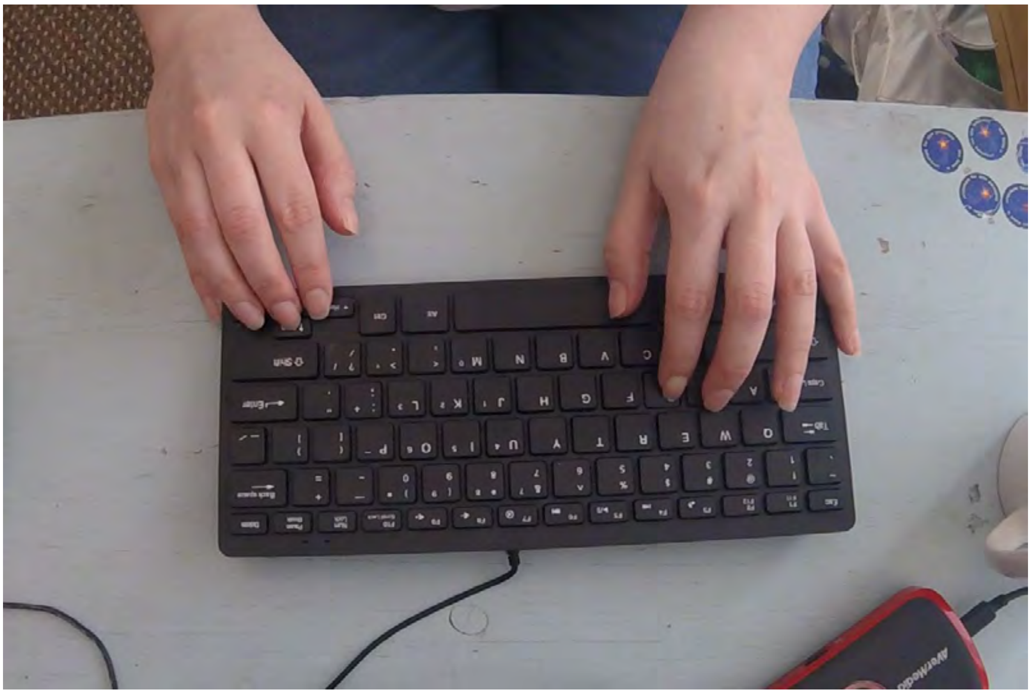

Figure 4.18: Fingers and hands making contact with the material quality of the keyboard and its keys during gameplay

The keyboard has a material quality and involves the actions of the player’s fingers, hands and arms, as do the knitting needles that play a part in the sensory experience of knitting.

Whilst working with cord during macramé activities, the hand has direct contact with the cord, feeling its movement, tensions and subtle vibrations as the cord rubs against cord as knots and loops are formed and tightened.

Figure 4.19: Hands making direct contact with and manipulating the material (cord) in macramé

All the while, these sensations feedback the actions being carried out by the body. Equally unsuccessful actions are confirmed via changes in tension, especially if a cord becomes stuck or tangled. Through haptic feedback, the body senses the length of the cord being pulled through, the distance to the knot as it is formed and it's ‘completeness’ as it tightens thus confirming through touch the knots successful positioning and relationship to the previously formed macramé knots of the piece. Similar to the game controller in the hands of the gamer, when knitting, the knitting needles in the hand extend the knitters sense of touch, providing access to the material whilst simultaneously directly manipulating the yarn with the fingers. As stated by McCullough, “when enhanced by a tool, the hand remains such a two-way conductor, but its powers become narrowed and intensified” (McCullough, 1996:62). The tensions and the vibrations of yarn moving against itself and the needles as knitted loops and stitches are formed, and felt, not only directly by the fingers but through the needles in the hands.

The *Switch* console offers additional touch feedback for players through its vibration feedback branded as ‘HD Rumble’ function embedded within the Joy-Con controllers. Attracting much attention around the time of its release, the highly sensitive tactile feedback of the *Nintendo* Joy-Con’s is now seen as an iterative step in the progress of the rumble function rather than a transformative one (Parisi, 2019). When playing *Mario Kart*

8 Deluxe, this feature is utilised through gameplay to provide additional feedback to players throughout races. Varied levels of haptic feedback are felt through the handheld controller by the player, that reinforces both successful and failed actions such as the 'revving' action when the 'A' button is triggered waiting for the start of the race; vibrating briefly to confirm the successful collection of 'item boxes' and 'coins'; rumbling when colliding with another player or being hit by 'offensive items' thrown by other players. The rumble feature also provides subtle tactile feedback of track surfaces when the player veers off the track, for example, providing a sense of roughness that reinforces the effect of being slowed down. This feels close to a natural simulation in this game, whereas other rumble effects have an artificialness about them.

Table 4.1: Summary of types of feedback discussed

Type of feedback	**Games**	**Amateur Craft**
Visual	-ability to look ahead and back	-ability to look back and ahead
Sound	-responsive sounds	-material sounds respond to action
	-responsive background music	-non-responsive ambient sounds
Touch	-rumble/vibration through controllers in some games	-material touch

As outlined in the table 4.1, in gaming, sound and visual feedback are predominant and provide consistent ways of informing the player on action and pre-empting action. Within craft, visual feedback is also important alongside touch with sound not being artificially added or overlaid at all.

Having outlined the different types of feedback given through the game and textile craft case studies, I will now discuss what these feedback mechanisms are used to communicate to the player or maker.

Feedback on progress (explicit/quantitative)

As discussed in Chapter 2, McGonigal uses the game *Tetris* to outline three types of feedback that combine to make the game particularly addictive, compelling the player to work harder and harder despite never being able to win.

> As you successfully lock in *Tetris* puzzle pieces, you get three kinds of feedback: *visual*-you can see row after row of pieces disappearing with a satisfying poof; *quantitative*-a prominently displayed score constantly ticks upward; and *qualitative*-you experience a steady increase in how challenging the game feels (McGonigal, 2011:24).

Having discussed visual, audio and haptic feedback aspects of making and gaming in the previous section, I will now consider quantitative aspects of feedback provided within each of the craft and game case studies. With *qualitative* forms of feedback relating to the more sensory experiences of visual, audio and haptic, that are less explicit, *quantitative* feedback is explicit and measurable. These forms of feedback enable the maker and gamer to assess summative aspects of progress in each activity. Quantitative forms of feedback are often accumulative and measurable either consistently updated during action or available as a summary at a pause point, or upon completion of a section or the entire activity. For example, a gamer may receive updates on their score at the end of a level or, as in the case of *Mario Kart 8 Deluxe*, a consistent update on their position in a race. Similarly, a knitter may count the number of stitches on their needles or keep track of the number of rows completed. This form of feedback is valuable for tracking progress towards the completion of a level in a game or for gauging proximity to finishing a row or section in knitting. It also enables tracking progress towards macro-level goals that Liboriussen (2013) states are found in linear and narrative-driven games and which can also be found in games with completable goals defined by Juul (2013). Liboriussen (2013) describes completing these goals as triggering a sense of closure. I suggest that this feeling is also triggered when completing all, or an aspect of, a crafted artefact, such as the *MOP Sweater*, or a macramé wall hanging.

Unravel

Quantitative feedback on progress in both games within the *Unravel* series is provided within a 'home' area of the game, outside of live gameplay. The player begins in this area and returns to it when completing each level or before quitting the game. Generally, the 'home' area is a place used for navigating levels in the game and functions as a space to track progress. In the first game in the series, the home area is set within a virtual home with levels represented by picture frames. As levels are completed, a new picture frame becomes 'accessible', indicated by the word 'ENTER' appearing above it (see Figure 4.20).

Figure 4.20: Accessibility of level 'The Sea' indicated by prompt '[ENTER] The Sea' above it

Levels that have been started may display the number of 'secrets' collected in that level in the form of small objects sitting against the picture frame. The frames and 'secrets' displayed act as indicators as to whether a level has been started, however, they do not provide feedback on the progress within those levels i.e., how much of the level has been completed. This is 'sensed' within the level over time though. *Unravel Two* provides more detailed feedback on progress in the home area, which in this game is set within a windmill. Levels in this area are represented by sparkling portals throughout different floors of the building which aren't immediately accessible.

Figure 4.21: Achievements displayed for 'Chapter II: Hideaway' in *Unravel Two*

When approaching a portal, a pop-up bar across the bottom of the screen displays a series of circles (see Figure 4.21): a visible 'tick' in the first informs the player if the level has been completed (not just started); the next circle keeps a total of the number of 'secrets' collected out of a total available in that level; a star symbol becomes highlighted if the player completes the level uninterrupted without dying, and the final circle indicates completing the level in a particular time frame without interruption if achieved. These become additional goals for the player to work towards.

Mario Kart 8 Deluxe

Mario Kart 8 Deluxe provides quantitative feedback at the end of each race and completed Grand Prix (comprised of four races). As the overall goal of this game is to win races, scores and leader boards are an important way of feeding back to the player on their cumulative performance (see Figure 4.22).

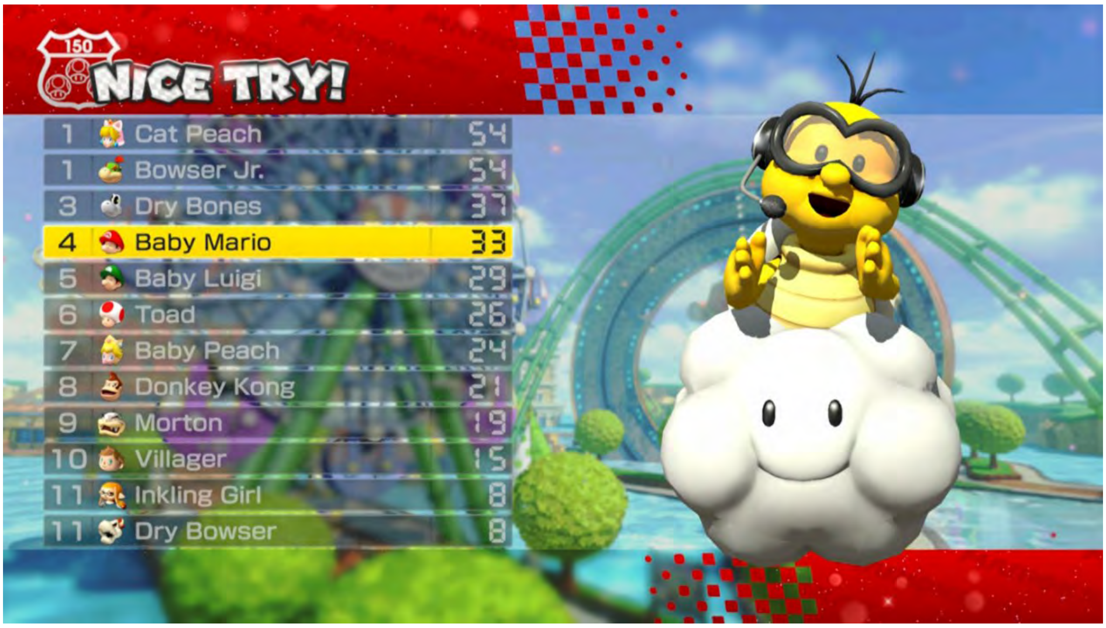

Figure 4.22: End of race leader board in *Mario Kart 8 Deluxe*

Unlike *Unravel,* Mario Kart 8 Deluxe provides additional explicit live feedback through an on-screen display (*game interface*) that overlays the game screen. This provides the player with continuous information that enables live adjustments to be made, motivated by the tracking of progress towards the competitive goal. During each race, the screen is 'annotated' with three items that allow for progress to be tracked: firstly, a large number in the bottom right corner indicates the player's current position in the race; above that a map of the current race displays the moving positions of every player in the race, with your character being highlighted for easy reference; and in the lower-left corner the current lap number is shown, for example, lap 2 out of 3 laps (see Figure 4.23).

Figure 4.23: ***Mario Kart 8 Deluxe*** **screen overlaid with game data during a race**

As this information is continuously updated during races, the player is made aware of their progress towards the goal of winning i.e., aiming to be first, and able to act upon that feedback. Games in the *Unravel* series do not provide annotated overlays of information in this manner.

Hand-Knitting

The physicality of craft inherently provides an observable object that can be visually monitored for progress. The more tangible activities of amateur textiles, especially those involving hand making, do not have in built metrics that are formally fed back to the maker, but quantitative feedback still takes place, usually measured by the maker themselves. As discussed in the previous section, the *MOP Sweater* kit was provided with an instruction book that contains a distinct set of steps to follow. This provides the knitter with the opportunity to track progress by measuring what has been completed against individual steps or sections, for example keeping track of the number of panels that have been completed. Within individual steps, the knitter might keep a note of how many rows have been knitted in the form of writing physical tally charts alongside the instructions (see Figure 4.24)].

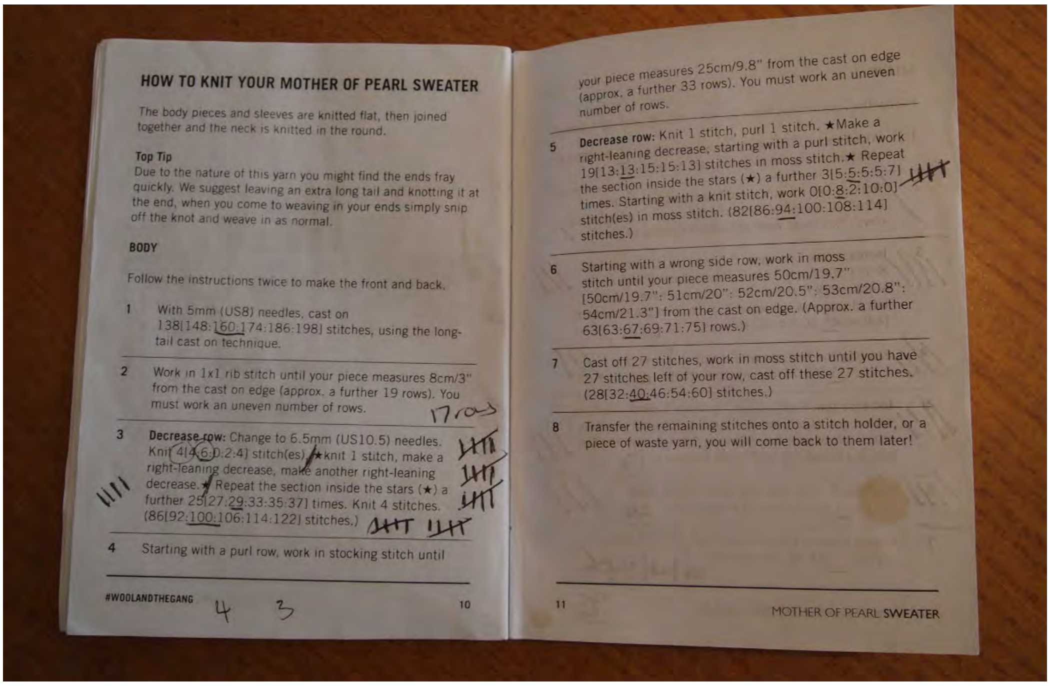

Figure 4.24: Hand written notes and tally charts written alongside the *MOP Sweater* instructions

In my own experience, these handwritten notes became less necessary as I gained confidence in tracking progress instead of learning to count the number of rows completed on the knitting itself. It is difficult for a beginner to recognise how to count individual stitches at first, but this comes through experience and through knowledge gained from fellow knitters via online videos demonstrating such methods. The counting of rows completed or the number of stitches along a row not only enables the tracking of your position in the instructions given but also makes the knitter aware of their proximity to what Juul (2013) would describe as ‘transient goals’ in games such as the number of rows left until the end of a section. The *MOP Sweater* took me several months to complete and the webpage for the kit suggests it could take thirty hours. With a total of fourty-eight steps to complete over such a long period, it is possible to see why tracking progress would be important not only to remain motivated but to not lose track of the current position in the steps.

Macramé

When taking part in the online macramé course, explicit forms of tracking progress were available in the form of an online checklist of tutorials and small projects to complete (see Figure 4.25). Unlike the explicit forms of tracking measured by the game examples and the methods of tracking steps carried out when in the knitting kit, however, this checklist merely tracks progress through the course. It does not allow for the direct monitoring of the progress of macramé pieces. For this, the maker may use methods like those found in knitting, counting knots and rows, and observing the piece physically growing. Unlike following the *MOP Sweater* knitting kit, the macramé pieces made during the course were less specific in design with the course encouraging the customisation of designs, adapting suggested designs or even finding inspiration and designing your own pieces. This results in less defined end points or goals to measure progress against.

Figure 4.25: Online checklist for *TwoMe* macramé course showing progress through the course

The goal of *Mario Kart 8 Deluxe* is to win races. Continuous feedback enables the player to respond during gameplay rather than feedback on progress just at the end of a section. *Unravel* and the *MOP sweater* kit have completable goals which require feedback on progress towards this and at interim moments. Pause points or completing sections in knitting allows for assessment of progress towards full completion, as does the home area of Unravel. Within both *Unravel* and knitting, feedback 'in action' also provides progress to be tracked. As described in the previous section, *Unravel* limits navigation and the player is predominately limited to moving towards the end of the level (this is also the case in Mario Kart, although some have taken on the challenge of trying to complete races in reverse). This is confirmed visually and through changes in sound and increasing intensity in challenges as each level progresses. In knitting, the maker is also able to see (through visual feedback) and monitor progress of each row or section/panel and can choose to pause and count at any time they choose. The *Unravel* player can return to the 'home' area at any time to review progress also. This ability to monitor and track progress can lead to a desire to progress further, especially as a goal becomes close to being achieved.

Feedback on quality (flaws and failure)

Quantitative forms of feedback not only inform the maker or player of their progress towards their goal but combined with sensory forms of feedback, it also communicates the quality of their performance through the confirmation of both success and failure. Both craft and gaming tap into an 'autotelic' need to succeed and feel competent (Sennett, 2008; Brock & Fraser, 2018) whilst overcoming the challenges of both practices. In *The Art of Failure,* Jesper Juul (2013) suggests that whilst fun and pleasurable, video games often frustrate players as they fail to succeed. This paradox is also experienced in amateur textile practices where developing skill involves trial and error. Failure experienced in video games is generally recognised via the resulting punishment that the game rules apply to the error made. Punishment is an inbuilt function within a game and the means by which the game communicates failure to the player. The level of punishment deems how 'fair' or easy a game is perceived by the player (Juul, 2013). Punishment, at its most extreme in a game, is applied through the permanent death of the player (catastrophic failure) that immediately ends the game (Juul, 2013). In casual games, however, punishment and feedback on failure provide the player with the opportunity to try again.

Unravel

Failure in the *Unravel* series is fed back to the player in two ways. Firstly, the player is punished with the death of the character when failing to traverse an obstacle or tackle a challenge 'safely', for example being swept away by waves rolling in, or by being caught by predatory creatures. When this happens, the screen fades to black and the character is then taken back to a previous point in the level (usually at the beginning of the challenge). The screen fading acts as confirmation of unrecoverable failure, but the player will sense they have or are failing moments before this occurs. Just before dying the game provides visual feedback that suggests an error has occurred as 'Yarny' struggles, for example when caught by a predator or trying to stay afloat in water. This will be accompanied by appropriate audio feedback also. In these moments, the player may be able to make additional actions that enable recovery and prevent character death. Death, however, is not the only form of failure that occurs in *Unravel,* the character can also run out of yarn, at which point the player is punished by being unable to proceed further. When 'Yarny' runs out of yarn the player is provided with visual clues that include knots appearing in the yarn that trails behind 'Yarny', his body becomes 'weak' looking and he stops and pulls on the yarn as if to be trying to drag more yarn (Appendix B5.3).The visual feedback of these collectively informs the player that additional action needs to be taken to proceed further. In this instance, the player needs to go back and take a different route across and around obstacles so that the limited yarn length is used more efficiently. Keogh describes a similar process of a player retracing their steps through an in-game 'rewind' function in a game called *Sands of Time:* "the player fails at a task and tries the task again and again with the knowledge (and competency) gained from the previous failure" (Keogh, 2018:150). These moments of failure and the need to repeat actions, thus, add to the player's knowledge.

Mario Kart 8 Deluxe

Mario Kart 8 Deluxe does not punish players through death when failing. All forms of punishment in this game are designed to delay and slow the player down with feedback given supporting this. For example, if hit by an obstructive item the character may spin off course and take a few seconds to recover. In built mechanics, such as 'smart steering', will prevent a player from driving off the track, but this function can be turned off. When this is turned off, if a player drives off the track they are simply guided back onto the track by a 'Lakitu' referee using a fishing pole, which further delays the player in the race (see Figure 4.26). These visual forms of feedback (supported by relevant sounds and haptic feedback) communicate to the player that an error has been made and the player needs to work harder to recover their pace in the race.

Figure 4.26: ‘Lakitu’ referee bringing the *Mario Kart* player back onto the track

Hand-Knitting

‘Failure’ is an aspect of practice that craftspeople may embrace, but ‘punishment’, as a potentially designed in element as it is within the rules of a game, is certainly not. Craft as a process, however, can be experienced as punishing with crafters experiencing a similar sense of frustration and sense of loss when things go wrong (Potter & Brock, 2019). Failure, or errors, in hand-knitting generally occur when an incorrect stitch or combination of stitches are used resulting in ‘physical failures’ (Robins, 2017) or flaws in the fabric. Failure in knitting the *MOP Sweater* included dropped stitches, where a stitch falls off the needle, or the passing of a loop from one needle to the other without being ‘knit’ into a stitch (an example is shown in Figure 4.27), both of which lead to visible holes or the appearance of ‘laddering’ in the knitted fabric.

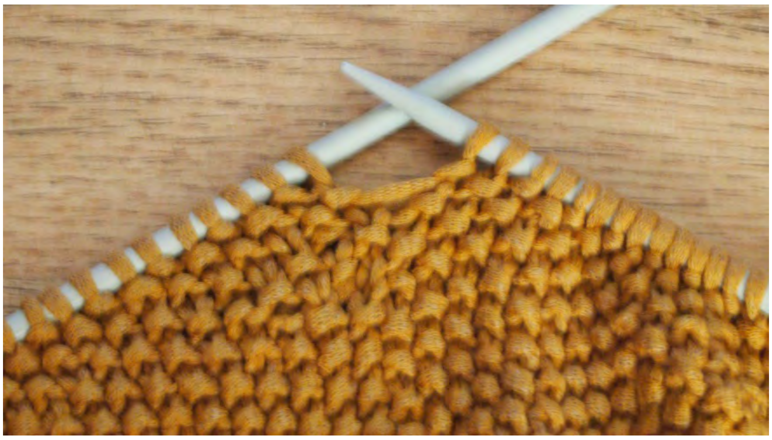

Figure 4.27: Dropped stitch and knit errors

The dropped stitches may be witnessed in action through visual feedback but may also be felt by the knitter as the wool between the fingers responds differently. For example, as the hands wrap the yarn around the needle to form a stitch, the yarn pulls back as it becomes restricted slightly, if the yarn fails to loop correctly the yarn will feel looser than it should. Errors may also occur if a needle slips out of the stitches, which happens quite easily with metal needles. In this case, the hands will feel the loss of the needle and there may be an audible sound as the needle lands on a surface. The discovery of an error in action like this, generally calls for immediate action to recover from it otherwise the knitting can no longer proceed. Flaws, such as holes and ladders due to dropped stitches, or pattern errors (see Figure 4.28), may otherwise not be noticed until the fabric is visually inspected at a later point, leaving the maker with an aesthetic decision to make regarding the quality of the final piece and whether to correct the error or not. This will be discussed further in the next section.

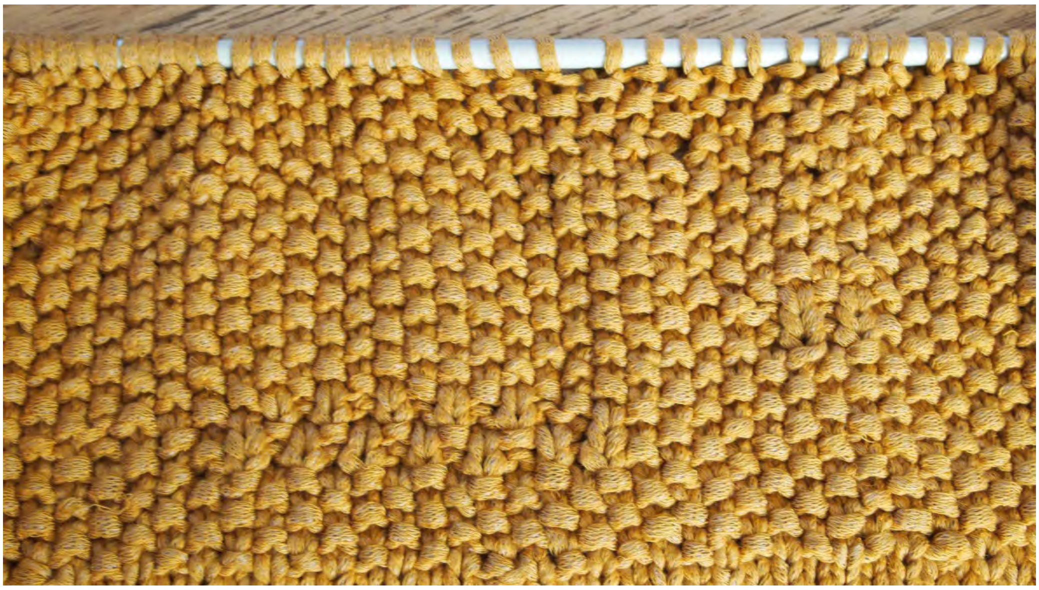

Figure 4.28: Image showing pattern errors in hand-knitting

Macramé

Feedback on errors in macramé is experienced in a similar way to knitting, with feedback predominately being visual with eyes 'drawn' to pattern errors. These mistakes may be noticed visually when a knot is made or later when visually assessing the whole piece, in progress or when completed. Due to the way macramé is constructed, failed knots are less of a problem as it does not result in other knots potentially unravelling. Similar to *Mario*

Kart 8 Deluxe if a knot does not get made successfully it slows down progress and requires the maker to catch up. Touch is involved in this process as it is in knitting due to the relationship between the hand and material. If a knot fails, the rope or yarn will not pull back as it should, just as the knitter would feel the difference between the yarn successfully wrapping around the needle and when it misses. These senses (visual, audio and haptic) become better understood as the maker experiences these moments repeatedly.

Summary

Throughout this section I have discussed types of feedback that exist within both craft and gaming and what that feedback communicates to the maker and player, enabling them to adjust their actions as part of an active conversation with their material. The section began by outlining the three types of feedback: visual, audio, and haptic. Many video games rely on an external screen to provide visual feedback to the player with hands mostly unobserved, with the case studies observed here proving to be no exception. With the craft activities, the eyes observe the material which resides within, or close to the maker's hands. In both practices, the maker/player visually track back and forth to assess if actions carried out have been completed successfully and monitor upcoming challenges, preparing for the next steps. In doing so, the maker and player fine-tune the movements of the fingers and hands in response to the feedback in what Ingold describes as "sensory correction" (2011:58). Audio feedback in games can take the form of background music that adds to the emotive experience that supports the game's narrative. Within some games, this background music is programmed to respond to the player's actions and/or progress in the game, for example changing pace when a predator is about to attach in *Unravel* or when the player begins the last lap in *Mario Kart 8 Deluxe.* Additional sounds, such as the sound of 'Yarny's' footsteps (in *Unravel*) not only emphasize physical effects in the game but also indicate if actions have been successful or not. This includes feedback of 'positive failure' (McGonigal, 2011) such as being hit by objects deployed by another player, thus setting the player back in the game but still being an enjoyable experience due to the sound effect employed. In the craft case studies, audio feedback was experienced as being innately linked to the visual and haptic feedback, experienced less distinctly than in games. Similarly, the audio-visual outputs fed back to players of video games converges with the player's input gestures, such as the sense of touch from the hands and fingers on the input device. In some games, for example, *Mario Kart 8 Deluxe* when played on the *Nintendo Switch*, artificial vibrational feedback is provided through motors within the Joy-Cons, responding to in-game events. Parisi (2009) highlights though, that all forms of interfacing with games involves felt sensations involving kinesthetic senses of the body. The maker, when taking part in the knitting of the *MOP Sweater* and macramé activities, has direct contact with the yarn or cord vis the hands and fingers. The maker's sense of touch, like the gamer's, enables them to receive confirmation of either successful or unsuccessful actions. Within each activity, all three types of feedback are linked and collectively provide feedback that enables the maker or gamer to continually adjust their body in response, correcting as required for further actions.

The feedback provided via these three types of feedback communicates both quantitative and qualitative information to the maker or gamer. Quantitative feedback, which is both explicit and measurable, enables the maker and gamer to track their progress in the chosen activity. Within *Mario Kart 8 Deluxe* this takes the form of a cumulative score provided at the end of each race or Grand Prix, or the race position updated continually as part of the annotated on-screen display. In knitting, the maker might count the number of rows completed through a tally chart against the provided instructions. Within *Unravel,* the gamer tracks their progress via visuals in the home screen that displays details of completed levels and the number of 'secrets' collected. Each of these aspects is fed back either continually or during pause points in the activity. This explicit and quantitative feedback is linked to completable and/or transient goals of the activity (Liboriussen, 2012; Juul, 2013). As each goal is achieved or becomes closer to being achieved, the desire to proceed is increased.

Sensory forms of feedback can also inform the maker or gamer of the quality of their work. This taps into their autotelic need to succeed in confirming ongoing success and failure. Games, in nature, are paradoxically fun whilst also being frustrating (Juul:2013), using various in-game mechanisms to 'punish' players when their actions fail, for example, through character death, or preventing players from proceeding. In these instances, feedback (visual, audio, and haptic) communicates to the player that errors have been made. Similarly, feedback of dropped stitches or patten errors, fed back to makers, confirms that actions have been unsuccessful. Through confirmation of failure or flaws (such as in the quality of a knit fabric), players and makers are either forced to try again, prevented from proceeding further or encouraged to try again. In the next section, I will discuss how this feedback leads to the repetitive actions that are required for the acquisition of skill.

4.3 Habitual Practice: the role of repetition

In the material section of this Chapter (section 4.1), I discussed potential actions and affordances that are made explicit via instructions and descriptions or lists of techniques or controls. Through the case studies, I explored how knowing or having these explicit affordances does not allow the player/gamer to be able to take more than preliminary action. It is only through repetitive encounters with material affordances and feedback that the player or maker can fully acquire skill. Skill is acquired through habitual practice i.e., through repetition the body can embody knowledge of tools and material and learn to the respond to feedback. Having discussed what each material communicates to the player and maker, in this section I will explore how feedback promotes repetition that leads to embodying of skill through habitual practice. As players/makers receive feedback on their progress and performance they are either forced to correct errors through punishment or provided with the choice to improve on quality. In Chapter 2 I discussed how embodied skill and tacit knowledge, the act of doing something instinctively rather than having to think about it consciously, is embedded through the routinised procedures of habitual practice (Sennett, 2008). I identified habitual practice as the third key crossover between craft and gaming. I will now build on the previous section to outline how feedback on quality and performance leads to repetition which enables skill acquisition and the embodiment of tools. The case studies discussed throughout this Chapter, involve repetitive tasks as part of their practice. For example, knitting and macramé require the repeated creation of knots and stitches to create the resulting fabric. Both *Unravel* and *Mario Kart 8 Deluxe* utilise a limited set of actions to perform well in each game, resulting in those actions being used repeatedly throughout each game. However, I will argue that feedback, specifically feedback on failure and quality of performance, enforce the need to repeat specific actions or skills again and again either through a desire to improve or through an inability to proceed without correcting errors. The act of repeating sections of a game, or tasks within a textile project, enable the hands to enact movements that may initially be unfamiliar until they become habitual. In doing so the maker or gamer becomes accustomed to the tool being used for the task and habitualised in its use.

Recoverable and unrecoverable failure

Juul tells us that failing through lack of skill in games allows us to “reconsider our strategies” and “expand our skillset” (2013:74). As discussed in the previous section, a player is informed of failure in *Unravel* via visual and audio feedback including missing jumps, running out of yarn and potentially the death of the character. In my own experience of playing the game, one section of the first level (’Chapter 1: Thistle and Weeds’) resulted in repeated death when miss-timing swings whilst trying to traverse a section of water. The player is required to ‘shoot’ yarn and ‘grab’ knots positioned along the top of the screen, and swing and land on a series of posts that protrude from the water below. If the player fails to successfully swing and land on a post the character may land in the water and, if unable to climb out, die with the screen fading to black (as described in the previous section). In Appendix B5.4 it is possible to observe the repeated failure in this section of the game. By overlaying a simultaneous video of the hands on the keyboard it is possible to see, and hear, the stumbling of the player's fingers on the keys and witness the frustration of failing (Appendix B5.5). This demonstrates that death in the game comes not as a result of having the wrong strategy but that the hands and fingers do not press the correct buttons at the correct time as they have not yet embodied the knowledge of how to do this at the required pace. Dying returns the player back to a previous save point, forcing them to attempt the section again. This necessitates the practice that is linked to the acquisition of skill (Sennett, 2008), repeating the actions required for swinging (jump, shoot, grab, release and land) again and again until the fingers can successfully and consistently press the required controls in correct time. The failure of missing a grab point or miss-timing a swing doesn’t always result in death though, sometimes it is recoverable, through navigating out of the water before drowning, grabbing another point mid-fall before hitting the water, grabbing the yarn you swing from and/or swerving to land on a safe platform. All of which provide opportunities to acquire skill. At other points in the game, the player may miss time a grab or jump whilst not above water and could safely land on the ground, having to then simply walk back to try the manoeuvre again. The game provides a strategy for this, allowing you to grab the yarn that trails behind so that you can pull yourself back up and over obstacles.

Failure and repetition in knitting

As outlined in the previous section, failure in knitting includes dropped stitches or passing a stitch from one needle to the other without creating a stitch, both of which can lead to holes or laddering in the knit. The knit can also become distorted through the accidental creation of additional stitches through looping yarn over the needle too many times or at incorrect points. Failures or mistakes such as these if not corrected can lead to visible errors in the knit pattern (as shown in Figure 4.27 earlier in this section). When faced with such flaws in the knit material a maker can choose to accept the visual errors and continue knitting or they may decide to unravel the knitting to the point of the flaw, correct it and recommence knitting. The process of unravelling a knit fabric is referred to as 'ripping out' and requires care and control (Appendix B5.6). Visible flaws can also present themselves as object errors, where additional stitches created repeatedly in the wrong area result in the knit piece being uneven. For example, when knitting the '1x1' rib hem of the *MOP Sweater* I managed to create an uneven hem. This occurred when the knitting was put down momentarily mid-row and when picked back up again, the knitting was continued in the wrong direction on the row. The result, which was noticed on later inspection, with more rows to one side of the rib hem than the other, giving an uneven finish. Just as the player in *Unravel* is able to re-trace their steps and re-do a section until it is correct, the knitter, when choosing to 'rip out' the knitting, has to repeat sections and the actions required for it, providing the opportunity to acquire skill.

Repetition as a desire to improve

Alongside feedback that informs the player of error or failure as described above, feedback on the quality of performance or workmanship can also support repetitive practice, motivated by a desire to improve on quality. Visible flaws and pattern errors such as those that occur in both macramé and knitting can taunt a maker into wanting to correct those mistakes and avoid them in the future. When making some larger macramé pieces, specifically, pattern flaws were more visibly obvious to me. One error that bothered me in the making of a wall hanging piece was unclear in the earlier stages of the piece but as it progressed, a square knot, that had been looped incorrectly, started to 'stand out'. The construction of a macramé piece allows for undoing and redoing of knots several times before a cord begins to break down in quality. This enables correcting of such errors. Undoing and re-doing of a piece in this case is driven by the maker's own perception of the quality of the piece. As stated by Sennett, "the aspiration for quality will drive a craftsman to improve, to get better rather than get by" (2008:21). The desire to undo and redo such errors supports the development of habitual practice through which skill is further improved through practice. A similar desire to improve through practice has also been observed in the playing of *Mario Kart 8 Deluxe.* Through the explicit feedback provided both during gameplay and at the end of races, the player becomes driven to improve their 'score'. Becoming a more skilled *Mario Kart* player can be achieved through repetition of races to 'learn the track' and improve the embodied response to visual and audio feedback provided throughout.

Summary

Through the craft and gaming case studies I have demonstrated in this section that the repetitive actions that are associated with the acquisition skill-based knowledge, refined through repetition and embodied, are encouraged and often necessitated through experiences of failure and through desires to improve. Experiences of failure and punishment in both knitting and *Unravel* prevent the maker and gamer from proceeding, enforcing them to correct errors and try again. In knitting, these experiences are manifested through knitting errors, including dropped stitches or pattern errors. If these errors would lead to problems later in the process, or if the stitches are not recoverable, the knitter can be forced to 'rip out' sections, or the entire piece of knitting, and redo the section. Within the game of *Unravel* mis-timed swings, running out of yarn, or character death are all experiences that required the player to return to a previous point in the game to try again, and again until actions are completed successfully. Initially, such experiences of failure can be through a lack of skill, with fingers fumbling to find the correct buttons at the exact moment they are required to be pressed. These moments, as expressed by Juul

(2013), provide the player with opportunities to expand their skills as repetition becomes practice through which skills are embodied.

In addition to repetition through experiences of failure, repetition also occurs through a player's or maker's desire to improve on the quality of their work or performance. In knitting and macramé, this can be driven through a desire to correct perceived mistakes in patterns, such as imperfect stitches or knots, or a single 'purl' stitch that stands out against a pattern of 'knit' stitches. Within *Mario Kart 8 Deluxe* the desire to improve can be linked to quantitative feedback of the game score with the player wishing to improve their position on leaderboards and win more races. In the next section, I will discuss the development of strategies, led by these experiences of failure and desire to improve, to minimise risk.

4.4 Minimising Risk

As outlined consistent feedback on progress and quality of work as part of an active conversation between maker/gamer, tool and material encourages the workman to seek ways to avoid failure and improve. Alongside the acquisition of skill through habitual practice, the maker/gamer will also explore methods, tools and strategies that may aid in further preventing failure. As discussed in Chapter 2, the maker and gamer continuously adjust the movements of their body in response to the feedback received from their material with the "quality of the result" being continually at risk (Pye, 1995:20). As outlined by Pye (1995), in using the workmanship of risk all workmen, whether they be makers or gamers in this context, are "constantly devising ways to limit risk" (1995:5) and avoid flaws and failure. In the previous section, I outlined how embodying actions through repetition is one method of preventing failure that occurs through a lack of skill. As skills are acquired the ability to control the tool(s) and material at hand increases alongside an expanded understanding of the feedback received from the material. Every workman, or as I will set out in this section, maker and gamer engaged in the workmanship of risk is continuously devising ways to limit risk which might include the use of jigs or templates (Pye, 1995) that allow "action to proceed in a predetermined way" (Luscombe, 2017:11). In this section, I will outline methods utilised to minimise risk that has been observed during the case studies discussed throughout this Chapter. These methods include using the body as a form of a jig and the development or use of inbuilt strategies and shortcuts to improve overall performance.

Body as jig

In Chapter 2 I discussed Pye's concept of the workmanship of risk, introducing the use of jigs as a method for controlling action to minimise error in the making process. As discussed Pye defines a 'jig' "as an appliance for guiding a tool in a predetermined path" (1983:47). Through the craft and gaming case studies outlined in this Chapter, I would like to put forward the notion of using the 'body as jig' as a strategy for controlling and minimising risk in support of or instead of standalone 'jigs'. According to Pye (1983), in seeking methods to reduce risk, a craftsperson may use 'skilled' or 'mechanical' constraint, or a combination of both. A 'skilled system' involves variable constraint "exercised by man or computer" (Pye, 1983:51), in the case of 'man', the body controls and limits movement of the hands and tools. As skill increases, control improves, resulting in better quality and more consistent output. Alongside acquiring skill through habitual practice, through which greater control is achieved, the maker and gamer will also develop bodily methods that limit unnecessary movement. I will refer to this method as 'body as jig', where the body and hands gain improved consistency of control through constraining unnecessary movement. In his auto-ethnographic account of glassblowing, Atkins (2013) describes the importance of posture in maintaining control over the hot glass and iron rod:

> In the first place, poor posture makes it even more difficult to manage the iron; it also leads to backache. Second, it can make one's movements clumsy. Rolling on the marver needs to be done smoothly. If it is jerky, then it is all too easy to flat-spot the glass, instead of creating a smoothly rounded piece. […] Third, if one's movement is clumsy or restricted it can make it hard to keep working the glass consistently – so it can get droopy and off-center (Atkins, 2013:401).

By positioning the body and hands in particular ways, the maker and gamer, as I experienced during the craft and game activities, can gain greater control over their actions. The range of movements involved in each activity is closely related to the tools and materials involved.

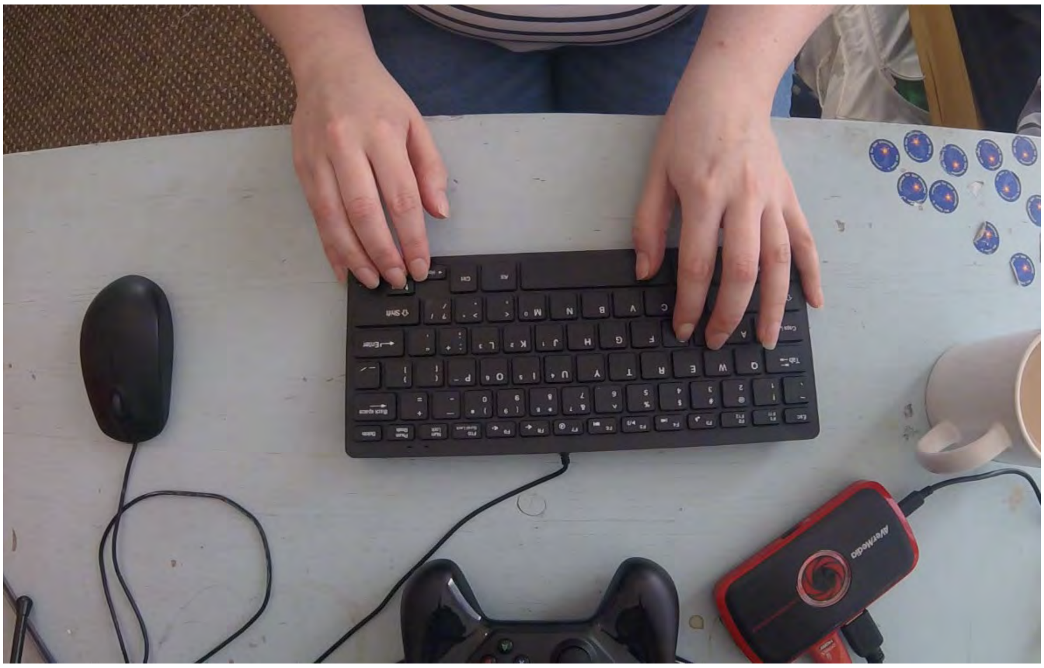

Figure 4.29: Image shows the players wrists resting on the edge of the desk whilst the hands and fingers are positioned on keys of the keyboard.

Unravel (on the PC) is accessed and controlled with just one tool, a keyboard. A mouse is not required for this game leaving both hands able to access the keys on the keyboard. The use of a keyboard with fingers resting on the keys and forearms resting on the table or desk surface is commonplace for most keyboard users, not just gamers. Unlike typing, when playing *Unravel* a limited number of the keys on the keyboard are required, allowing for keys to be assigned to individual fingers by the player. Having the forearms resting on a surface reduces movement of the arms beyond the hands, allowing greater control of finger movements.

Mario Kart 8 Deluxe offers a deeper insight into the ‘body as jig’ in its use of the *Nintendo Switch* Joy-Con controllers. In each of the various playing modes available with the Joy-Cons, the hands each grip a Joy-Con and arms are constrained by the body. The elbows may rest on the lap or knees or may be held close to the sides of the body. Restricting the arms steadies the hands as they control the tool, the Joy-Con controllers, whilst the rest of the body is “managed in relationship to the controller” (Parisi, 2009:119). When knitting, the body is similarly used as a jig. Just as Ingold's carpenter "steadies the blade [of his saw] against the joint of the thumb" (2011:59) the hands hold the knitting needles, are steadied by the elbows held in at the side of the body. The arms only move from this position to wrap yarn around the needle. At the moment the right-hand moves to begin wrapping the yarn around the needle, the fingers let go of the right needle. As this happens the fingers, hands and body work collectively to keep the knitting steady and maintain control, the left-hand moves closer to the end of the right needle and holds the knitted material close to the right yarn. At the same time, the body acts as a prop with the end of the right needle resting against it. All part of what Atkins refers to as "the choreography of making" (2013:401). See Figure 4.30 below:

Figure 4.30: The knitters hand working in 'choreography'; elbows tucked into the body whilst moving the needles, the left-hand supporting both needles whilst the right-hand wraps yarn

Optimising and Other Strategies

The use of the body as a jig discussed above has the purpose of limiting risk and increasing consistency and certainty in the processes. These methods may also be used to improve aspects of performance, such as speed in *Mario Kart 8 Deluxe* to win more races and achieve a higher score. Speed is not necessarily something that is generally deemed to be a concern in amateur craft as it is often engaged in for pleasure. Some amateur makers do move into batch production of goods if, for example, they wish to start selling the items they produce. In this case, time and efficiency may become a focus. The case studies observed, however, focused purely on making as an amateur practice in the home with my motivation to be engaged in craft activities for pleasure and to produce items for myself. As discussed at the start of this Chapter, amateur gaming does not produce a tangible, physical outcome, although it may produce virtual items of value. Just as the case studies observed in craft-focused on amateur making, the gaming activities were also carried out in the home for pleasure only. Despite the focus on intrinsic reward, some video games, however, make speed and efficiency part of the goal of the game. *Mario Kart 8 Deluxe* is one such example, with the main goal of the game to win races, completing them in as fast a time as possible. As mentioned previously, the game provides virtual tools to assist with this goal such as 'auto accelerate' which may be implemented by the player to aid competitiveness alongside the improvement of skill. In games without a competitive aspect, such as *Unravel*, players may compete against themselves and challenge themselves to complete levels within certain time limits or without dying. Although the general aim of *Unravel* is to complete the game, in seeking out this goal the player may still develop strategies to save time and become more efficient in their actions. Earlier in this Chapter, I discussed the use of objects in the game using an example of apples to solve a challenge in the first level of the game, 'Chapter 1: Thistle and Weeds' (refer back to Figure 4.15 in section 4.1). By examining this example further, it is also possible to see how objects can be used in more effective ways. The apples in this section of the game, are to be pushed along a yarn bridge (constructed by the player) to a well that once filled with water will make apples float enabling the player to cross. Six apples are needed in total to cross the water, one is already in the well with five more needed to be pushed into place. Through trial and error, the player realises that more than one apple can be pushed and discovers that all five apples can be pushed together making the action more time efficient.

Knitters also develop and use methods to make their knitting time more efficient, for example, in the way they hold their yarn in the hand for looping it around the needle to make stitches. In English style knitting, the yarn is held between the fingers on the right hand and looped around to the left. Some experienced knitters can be very fast while using this method and speed would be improved through practice. This method, however, involves a relatively excessive amount of movement. Switching between knit and purl stitches in this hold also requires extra movement when taking the yarn from the back of the needle to the front before starting the next stitch. A method, called 'continental knitting', is used by some knitters as an alternative either simply because it is the method they were taught or because they are seeking out a method to specifically speed up their knitting. Continental knitting speeds up the wrapping yarn process by simply reducing the distance the hand moves. There are similarly many videos online for gamers, sharing tips on how to hold a controller or position and use a keyboard and mouse in order to maximise efficiency of hand movements when gaming.

Summary

It was established in Chapter 2 that both craft and gaming practices involve the minimising of risk through the appropriation of jigs and skilful action. Throughout this section, I have used the craft and gaming case studies to build on this and further evidence ways that risk and failure is minimised through the development of strategies including using the 'body as jig', and optimising performance. Having discussed Pye's (1983) concept of 'the workmanship of risk' and the use of jigs to increase certainty in skilled processes within section 2.6, the case studies within this Chapter have demonstrated the role of the whole body within skilled action. I have termed this as 'body as jig', putting forward the notion that the whole body plays a role in controlling action in the same way a stand-alone jig might be used. This includes actions such as resting the arms and wrists on either a desk or the lap to reduce 'clumsiness' and allow for greater control of hand and finger movements in both games and knitting.

Methods such as the use of jigs, including the 'body as jig', aim to increase certainty, ensuring a level of quality in the outcome. In gaming, this quality could be considered as a quality of performance which in some games, such as *Mario Kart 8 Deluxe,* requires speed. Speed is not often deemed a prime concern in amateur craft unless perhaps pursuing batch production, however, some knitters do develop methods for making their actions more efficient. Efficiency within *Unravel* was found within the optimisation of using items which reduces time spent traversing obstacles.

The development of strategies to minimise the risk of failure, improving and ensuring the quality of output and increasing efficiencies could be of value for both practices and within related contexts. Chapters 5 and 7 will consider if the act of 'grafting' could encourage and promote such behaviours.

4.5 Conclusion

Throughout this Chapter, I have drawn on reflective practice whilst engaging in amateur craft and gaming activities in order to further explore the four key crossovers between craft and gaming as identified in Chapter 2: material affordances, feedback systems; habitual practice; and minimising risk. Comparative observations were carried out and analysed through case studies of video games *Unravel, Unravel Two,* and *Mario Kart 8 Deluxe,* and textile crafts of knitting using a *MOP Sweater* kit and participation in an online macramé course. I have outlined the potential actions of the material within each case study (physical and digital) exploring the potential actions and affordances made explicit through instructions and control lists. The case studies have highlighted further that material properties are encountered through engagement with the material in action. Through encountering properties in-action, the maker/gamer is able to recognise the specific affordances of each material, for example, the appropriate handling of different yarn qualities or recognising objects that afford the potential for puzzle solving in gaming. The need for trial and error and experimentation was less observed in the textile craft case studies due to their highly instructive and explicit nature but was required in the development of the maker's own pieces or in customising designs.

As an integral part of the active conversation between maker/gamer, tool and material, feedback within the case studies explored have been categorized into the sensorial forms of visual, audio and haptic (touch) feedback. I went on to discuss how these feedback forms provided both the maker and gamer with quantitative and qualitative information that communicates further aspects. Quantitative feedback enables the maker and gamer to track their progress within each activity whether that be through assessing progress, through times and scores achieved in-game levels, or by counting rows in the knitting of the *MOP Sweater*. More implicit forms of feedback communicate to the maker/gamer the quality of their performance, specifically through communicating failure in games or when errors or flaws occur in making. Qualitative feedback drives and encourages repetition that supports the acquisition of skill through habitual practice. Failure promotes the need to repeat processes, either through enforced re-doing of actions or by instilling a desire to improve through feedback on the quality of work. Consistent feedback on progress and quality of work leads the maker and gamer to devise methods to minimise risk and avoid further failure. In the final section of this Chapter, I outlined three methods that were observed in the case studies discussed: the use of ‘body as jig’, constraining unnecessary movements to support skilled control; and the optimising of processes to make movements and actions more efficient and improve performance.

Building on the theoretical analysis in Chapter 2, the below diagram (Figure 4.31) summarises the findings of the amateur practices discussed in this Chapter that form a conceptual model of crossovers between craft and gaming.

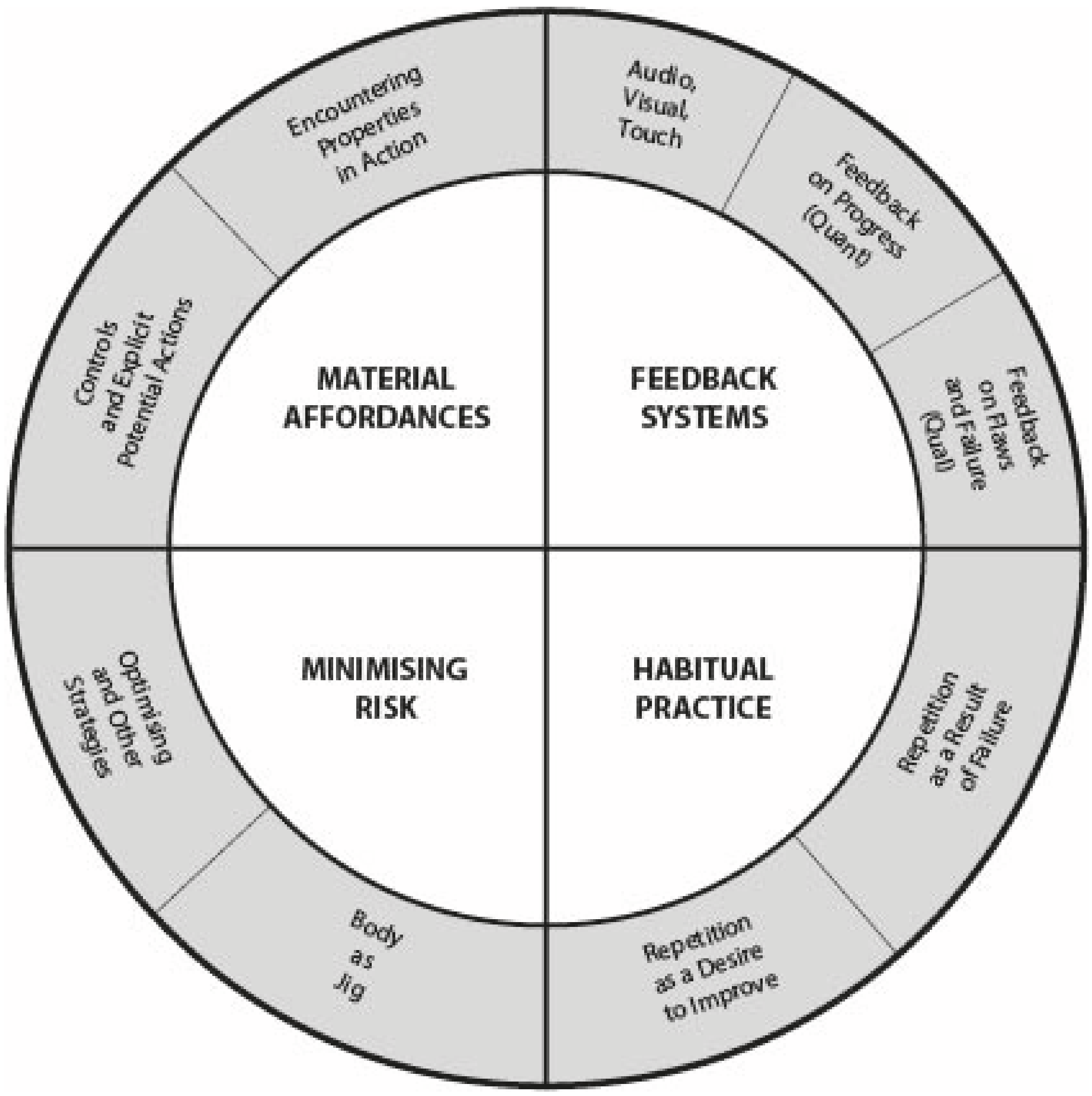

Figure 4.31: Conceptual model of crossovers between craft and gaming

In summary, using the four craft and gaming case studies the following sub-categories have been added to the thematic crossovers identified in Chapter 2:

Material Affordances

Both craft and gaming involve an encounter with material. The quality and potential of each material is understood through explicit controls and instructions that outline potential action, and further when encountered through repeated action.

Feedback Systems

An active conversation occurs between material, tool and maker or gamer with feedback given in three forms: visual, audio, and haptic. These aspects of feedback inform the player of their progress towards the activities goals (quantitatively), and on the quality of their performance, including confirmation of failure and flaws.

Habitual Practice

The repetitive actions required for the acquisition of skill (including the embodiment of tools) is encouraged through a maker or gamer's desire to improve the quality of their output and/or as a result of failure. Habitual practice is thus inextricably linked to feedback.

Minimising Risk

Makers and gamers develop strategies for minimising risk through the appropriation of jigs, including using the 'body as a jig', employing the use of save points, and through the development of strategies to optimise performance.

These outputs are summarised in the diagram above (Figure 4.31) and will be utilised in the following Chapters to assess the impacts of grafting craft with games.

5_Hazuki Knit

Having identified crossovers that exist between craft and gaming in Chapter 2 and explored the four key themes through case studies of amateur activities in Chapter 4, this Chapter begins to explore grafting as an approach in meeting research aim 2:

To investigate the relationship brought about through directly connecting craft and gaming

This Chapter moves away from observations of amateur craft and gaming in the home to focus on the prototyping and observations of an experimental 'graft-game' at a series of participatory events. By 'participatory events' I am referring to thematic events that are open to the public hosting a range of activities that invite a non-specialist audience to engage. These events were generally made up of a curated selection of activities along either the theme of gaming or making. Such events were thus appropriate to this research with audiences having some general interest in the themes being explored, possibly already taking part in casual or amateur practice in either category and thus likely to be curious and willing to engage in the proposed activity.

Introduced as a concept in section 2.5, 'grafting' is a term borrowed from horticulture where it is used to describe the process of joining two plants so they may grow together. Within this research I am using the term 'grafting' to define a method of binding together physical craft processes with a digital game. In this Chapter I will discuss the creation of graft-game, *Hazuki Knit*, before evidencing the resulting impacts using the 'crossovers lens' developed through Chapters 2 and 4 with the intention of identifying potential value that may arise as an outcome. This will be achieved through analysis of observations made during participatory events where members of the public were invited to play the grafted game. A simple prototyping approach supported an investigative designing methodology of 'designing as creative exploration' (Durling & Niedderer, 2007) (see section 3.2), as a preliminary investigation into the potential relationship between craft and gaming. Throughout this research, prototype graft-games produced are not intended as artefacts for objective evaluation in and of themselves (Durling and Niedderer, 2017). Instead, each graft-game is developed as an analytical tool for research through which observation of interactions can be made. Observations made were thematically coded using the identified thematic crossovers discussed in Chapters 2 and 4 as a lens through which to explore potential impacts and value. As discussed in Chapter 1 (section 1.2), value within this research will be deemed as an outcome of grafting is of benefit to either, or both aspects being grafted. With collaboration being defined as a joint endeavour "that leave(s) one or both sides significantly changed" (Felcey et al., 2013:1), changes to or impacts upon the individual elements of the grafted game will be assessed using the 'crossover lens' developed in previous Chapters.

5.1 Development of Hazuki Knit

Selecting the individual elements

This Chapter will focus on a preliminary prototype of *Hazuki Knit* developed in collaboration with independent artist, technologist and designer of alternative games, James Medd. For this aspect of the research, I wanted to work with someone who had experience with designing stand-alone digital games so that their knowledge and expertise could be drawn upon. Just as grafting in horticulture utilises existing crops to shortcut to a desired outcome (discussed in section 2.7), I wanted to graft an existing game with an existing craft in order to interrogate the resulting outcomes as opposed to developing a game from scratch. Through sharing my reflections of the amateur craft and gaming activities I had been taking part in, James Medd and I discussed options for existing items that we could connect and what technology we could employ to do so. Having worked with textile processes predominantly in my practice and within the case studies of this research, focus was given to this discipline. For games, we discussed the possibilities of games that James had already designed, many of which I was familiar with. An initial prototype of a game called *Hazuki Knit*, through which we explored the possibilities of connecting a textile making process to an existing game, *Hazuki,* was developed, *grafting* them together. *Hazuki* itself, is a standalone game, already developed by James Medd to be played online (www.hazuki.co.uk) using the arrow keys of a computer keyboard. As described by Medd on his artist blog, *Hazuki* is a "QTE-centric game" (Medd, 2020: online) inspired by 'quick time events' experienced in video games. Quick time events are "a mode of context sensitive control that asks the player to respond to events in a gameworld by making specific control inputs, either in a limited time, or to a particular timing" (Tavinor, 2017). These events often occur during cut scenes where the mechanic is separated from the game's narrative but could also be considered as a core game mechanic of games such as *Dance Dance Revolution* (DDR) where players must 'hit' particular buttons (on a dance mat in the case of DDR) at a certain time as they appear on screen. *Hazuki* is designed to focus solely on this playing style utilising four buttons (the arrow keys on the keyboard), 'up', 'down', 'left' and 'right', that must be pressed within a certain time limit when a corresponding symbol of each button appears on the screen (see Figure 5.1).

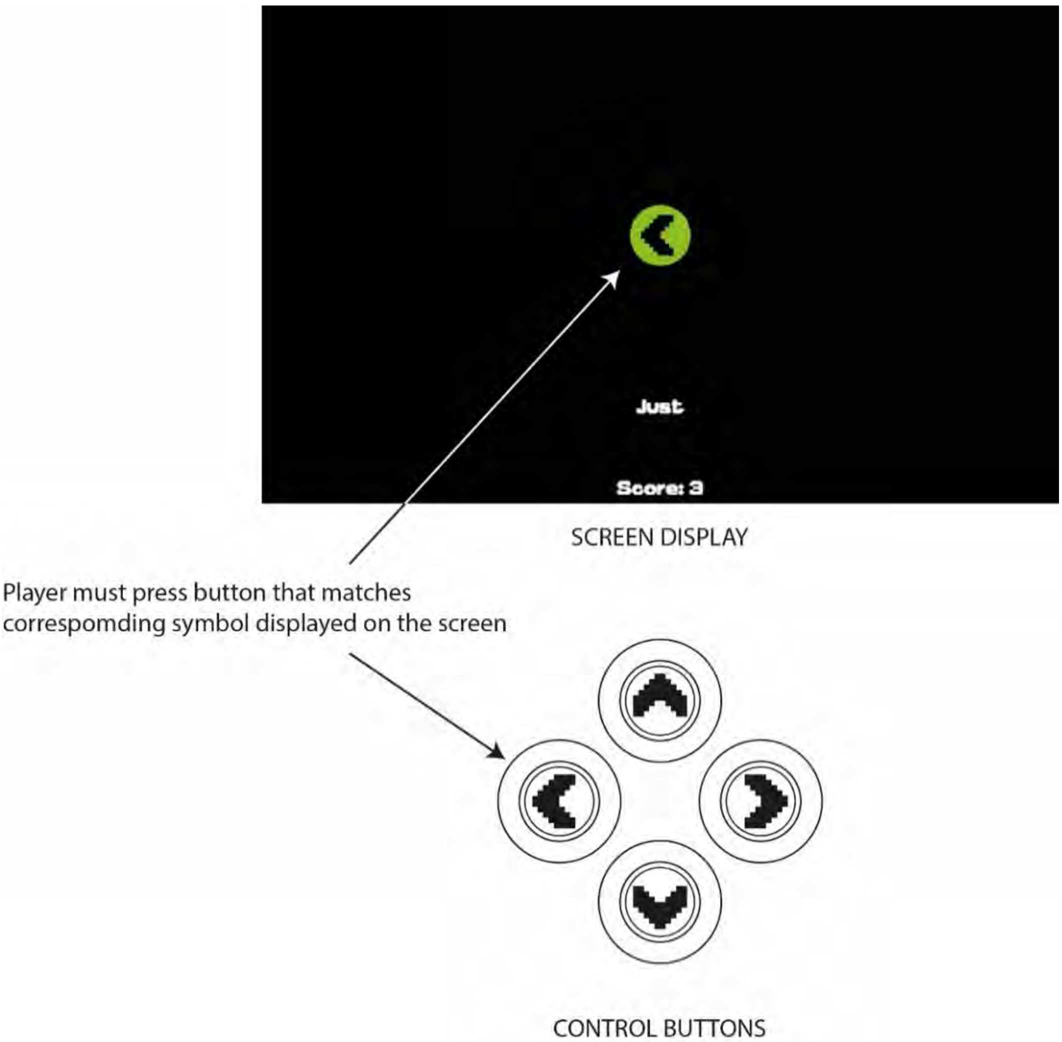

Figure 5.1: ***Hazuki*** **screen displaying symbol of button to be pressed**

If the player fails to press the correct button within the time limit, the game is over. The goal of the game is simply to achieve as high a score as possible with a live score displayed throughout. *Hazuki* strips away the narrative and graphic features of arcade games such as *Shenmue* and *Dragon's Lair*, from which the name *Hazuki* originates, to focus purely on the mechanic of responding to on-screen prompts. In discussion on how we might combine a game with a textile making action, Medd put forward *Hazuki* as an already developed game that may be suitable for grafting due to this simple mechanic. I recognised the potential of using the simple mechanic *Hazuki* to match with the repetitive nature of the concurrent movements required in textile making, experienced in both hand-knitting and macramé activities (Chapter 4). With repetition playing a core role in the development craft expertise and skill in gaming, this game had the potential to further explore how the identified crossovers might interact with and impact upon one another once grafted.

For this research it was important that a particular craft action formed part of the core mechanic of the game so that the act of making remained intact i.e., that the craft output would still be produced as part of the grafted gameplay. This was to ensure that the impacts of grafting upon the craft and the original game could be assessed whilst also being conscious of the possibility of using similar approaches in industry where the actual production process of any items using craft skills would need to remain functional. At this stage, an industrial partner for Strand Three of this research had not yet been established so craft processes were considered in relation to the amateur textile activities being carried out concurrently as part of Strand One. Although developments in physical computing have created opportunities to "merge crafting activity with electronic and digital game design" (Sullivan and Smith, 2017: online), current commercial technologies are still somewhat limited in terms of capturing the fine-tuned movements of hands in craft. This posed a key design consideration for prototyping a graft-game. Instead of trying to employ technology to monitor hand movements, we decided instead to utilise the movements of craft tools, including machines, for which a wider range of electronic components such as switches and sensors were available. Having engaged with hand-knitting in the parallel period of reflective practice, knitting was chosen as the craft activity for this graft-game so that consistency could be retained through the interrogation. Knitting also offers an immediacy in production of a knitted fabric with no requirement of digital technology. However, as explained, the availability of appropriate sensors to monitor the movements of the hands was limited so handknitting presented as too complex to graft the game to. I had some previous experience using a domestic knitting machine and owned one that could be adapted. A domestic knitting machine is a portable mechanical device developed for amateur knitters which uses a "weft knitting method which produces a fabric similar to hand knitting" (Wikipedia, 2021: online). These machines are used by both amateur knitters and professionals using batch-production methods due to its ability to facilitate faster production of plain knit. The process of knitting on the machine is typically much faster than knitting by hand (using two needles) as instead of knitting one stitch at a time, the machine knits an entire row in one action. A flat bed knitting machine, a Brother KH-836 in this case, has a bed of over 100 needles, which allows the knitter to produce various widths of fabric. A carriage, manoeuvred by hand, is pushed back and forth across the knit bed to knit successive rows of fabric. The action of moving the knit carriage of the knitting machine was seen to still represent a craft that offered an immediacy of production and that would retain some continuity from Strand One of this research.

Creating a graft

Having decided upon using a knitting machine and an existing digital game, a method of grafting it to the *Hazuki* game was developed. We wanted to capture the action of 'knitting' which, in the case of the knitting machine, was the act of moving the carriage back and forth. For machine knitters this action would generally be done at an optimal pace which responds to yarn type, tension and width of the knit fabric being produced. In order to capture this action, we added two simple switches onto an inbuilt row-counter on the knitting machine (see Figure 5.2).

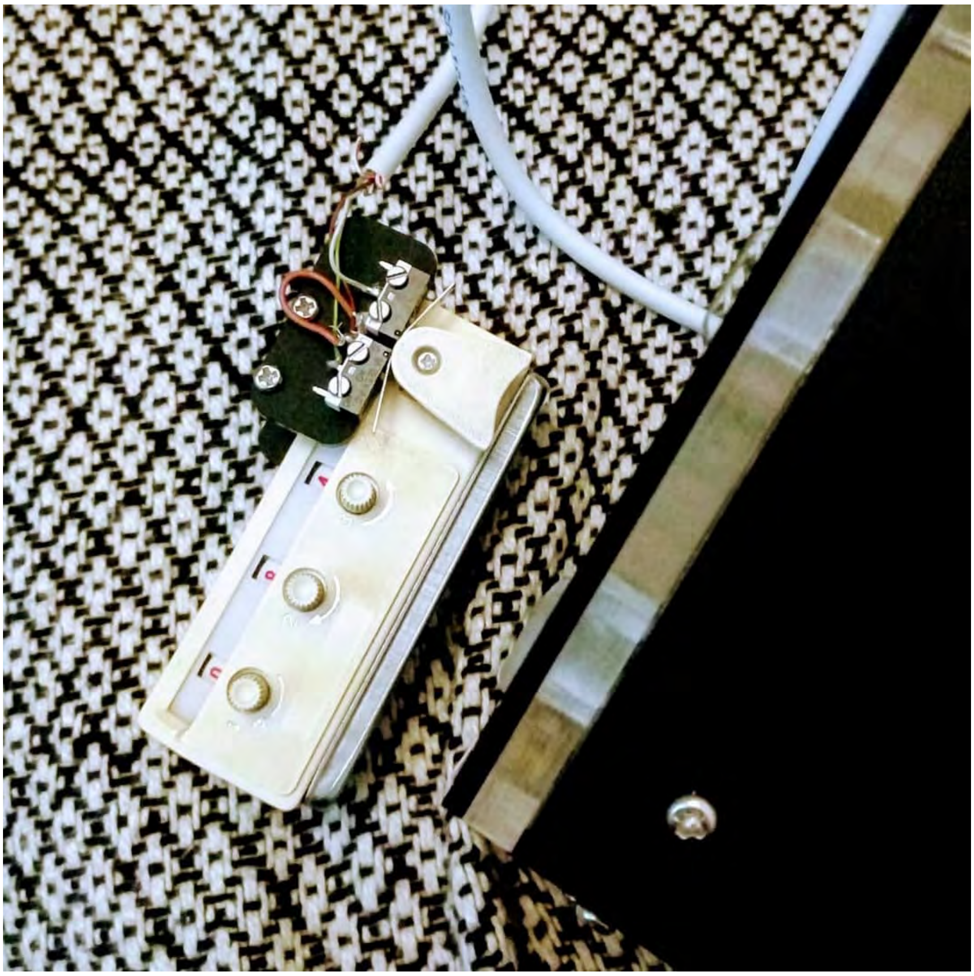

Figure 5.2: Row counter from knitting machine with added switches above carriage trigger

The row counter of the knitting machine consists of a simple trigger that flicks back and forth when the carriage pushes past it as it travels along the knit bed, in either direction. Adding a switch to each side of this trigger would capture this movement in order to harvest a digital input for the game. The movement of the carriage (triggering the switches) was then used in the game to control when the directional symbols would appear on the screen, thus controlling how fast or slow the game aspect would be, making it more, or less, challenging. A custom tabletop control panel was built with four large arcade buttons, each with a directional arrow applied to it. As grafted game, *Hazuki knit,* became a two-player game with one person controlling the knitting machine and the other using the control panel to respond to the button prompts displayed on a standalone screen.

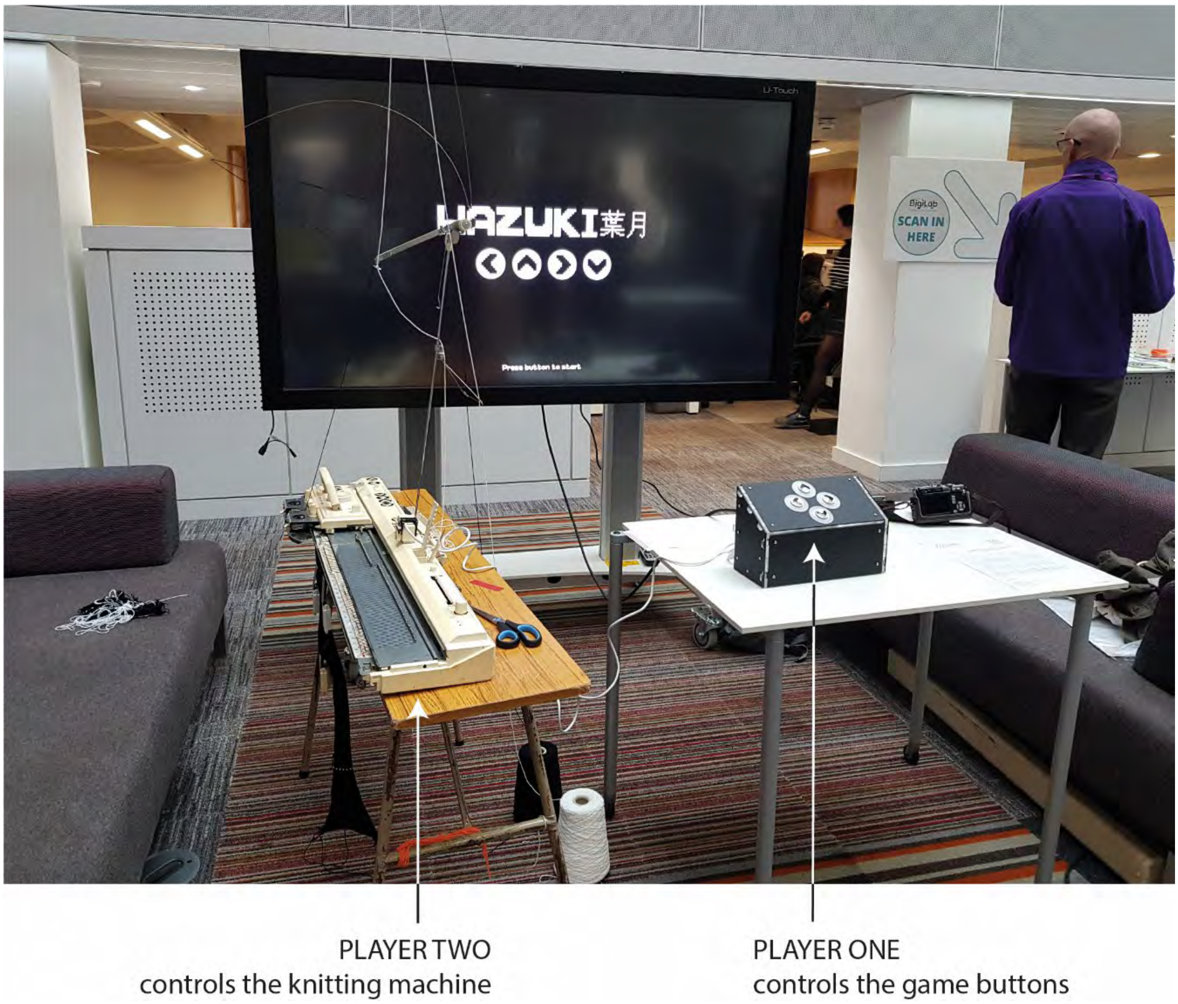

Figure 5.3: Hazuki Knit set-up with screen, control panel and knitting machine

Hazuki Knit was first showcased on the 18th May 2018 at a Light Night event at FACT Liverpool. The event took place in their gallery spaces alongside their exhibition at the time 'States of Play: Roleplay Reality' and invited members of the public to engage with a variety of game-based activities. The 'grafted game' was then taken to additional events over the following year: DigiLab at Manchester University, November 2018; Games Lab at Salford University as part of Manchester Science Festival, October 2018; and Liverpool MakeFest at Liverpool library, June 2019. At each event observations were made of adult participants as they played the 'grafted game'.

Designing to account for habitual and non-habitual tool use

Hazuki Knit was designed to be accessible for a range of skill levels so that non-gamers and non-crafters could participate as well as more experienced players and makers. Accessibility for a variety of skill levels and previous experiences was achieved through the design of a simple control panel design for *Player one.* This had only four large buttons, for the four required symbols, arranged in the style of an arcade cabinet panel.

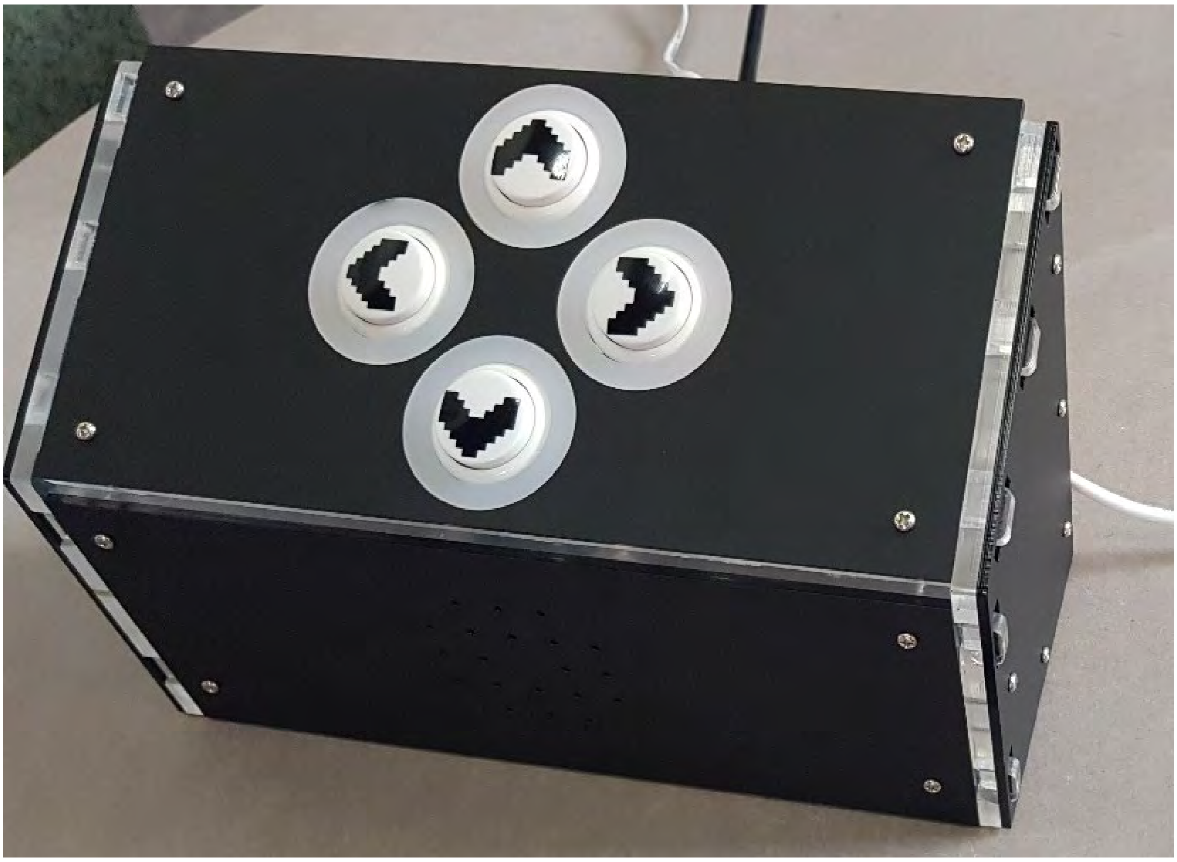

Figure 5.4: Custom built *Hazuki Knit* control panel

Accounting for habitual tool use in gaming, we chose not to use a hand-held game controller that may have been specific to certain game console (Parisi, 2009) and thus potentially habitual only to players of that console. We also wanted non-gamers to feel reasonably comfortable using the controls. Many existing console controllers have a complex array of buttons and thumb-sticks that would be excessive for *Hazuki Knit*. A custom control system was therefore decided as being most suitable.

Similarly, a knitting machine has many possible functions that an experienced knitter may utilise. For example, knitted fabric panels can be shaped by adding in needles or reducing the fabric width by transferring stitch loops onto adjacent needles, to produce full panels for full garment. Stitch patterns can also be created by manually reversing stitches or adding in additional colours. For *Hazuki Knit* we deliberately chose not to complicate the functionality of knitting by using different stitch patterns or attempting to shape the knitting being produced. Instead, the knitting machine was set up to knit a set width in a plain stitch which would allow each participant to only need to move the carriage back and forth.

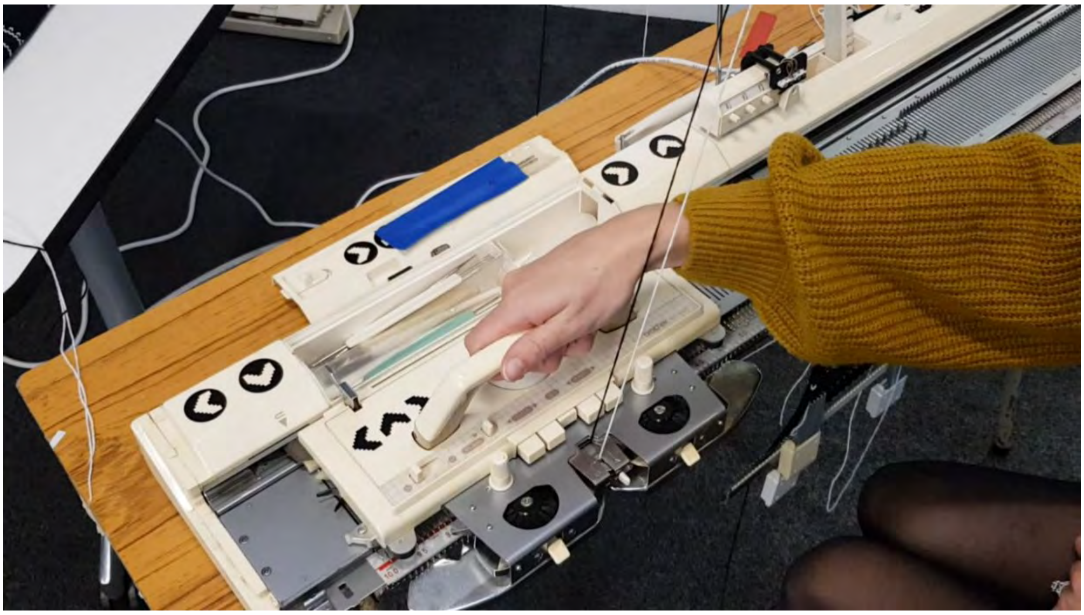

Figure 5.5: Participant using the knitting machine as part of *Hazuki Knit*

Additionally, casting off knitted fabric and casting on anew is a time-consuming process so we decided to knit a continuous length of fabric during events, with every person continuing knitting the same fabric piece. As a result, the properties of the game and the method for playing it would be simple enough for a large proportion of players to understand and it generally did not take participants more than one round of the game to grasp the basics of what needed to be done in order to play.

Previous experience and embodied knowledge

Very few (if any) participants confirmed that they had used a knitting machine before, although some recalled older family members having owned one. The handle of the knit carriage appeared to be very approachable for participants with players instinctively placing their dominant hand around the handle. The knitting machine did, however, have various protruding items such as tension rods and yarn stranded across the knitting area. Participants were given safety guidance on these aspects and as a result some participants were cautious when first using the knitting machine, for example moving the carriage slowly and then swapping hands at the end of each row so their arms would avoid yarn threaded across tension rods. In general, though, it did not take long for participants using the knitting machine to get ‘into a rhythm’ and settle into a standard position of holding the carriage handle with the dominant hand and resting their other hand out of the way on their lap or using it to hold the edge of the table to steady it and themselves.

Previous experiences of participants did not come as a surprise based on the audiences attending the thematic events, for example it was unsurprising that experienced gamers may attend a gaming event. Prior experience and familiarity with machines and tools may be an important consideration for any future interventions in industry.

5.2 Affordances and Grafted Gameplay

As established in previous Chapters, ‘material affordances’ was identified as a crossover between craft and gaming. Material affordances and those of their associated tools, have a set of properties that enable potential actions alongside certain limitations (Ingold, 2011; McCullough, 1996; Adamson, 2007; Pye, 1995). As demonstrated through the craft and gaming case studies in Chapter 4, these affordances are understood through explicit instructions and recognised further as they are encountered in action (McCullough, 1996; Pye, 1995; Juul, 2013; Keogh, 2018). As evidenced within the amateur craft and gaming case studies, potential actions and limitations are to some extent made explicit through tutorials, written instructions, or via a list of game controls. The same was provided for participants of *Hazuki Knit*. After receiving an explicit set of verbal instructions participants were able to further understand the potential actions and limitations through direct engagement with the grafted game. The activity was always framed as a complete game with all participants being informed that the aim of the game was to achieve as high a score as possible. The purpose of the activity as a game was reinforced by the context of the events *Hazuki Knit* was showcased at, most being themed around games (with the exception of Digi Lab at Manchester University which was a broader event based around digital play testing).

Explicit instructions

All participants that approached the game were given simple verbal instructions on ‘how to play the game’, including safety measures for using the knitting machine. It was explained that Player one[6], on the control panel, needed to press the appropriate button as symbols appeared on the screen and that Player two[7], on the knitting machine, needed to move the knit carriage back and forth and that this would determine the speed of the game. Some participants would ask additional questions such as “do these [referring to the control buttons] light up?” or “do I need to watch this?” [pointing to the screen], for which clarification was given. The explicit verbal instructions given enabled the basic affordances of each material and the tools required to access them (the knitting machine and yarn, and button controls with the digital game) to be understood at an initial level. Player two was made aware that they could move the knit carriage in two directions only (back and forth). The participant would also be informed that the edge of the carriage needed to move past the end of the row of the ‘active needles’ before being moved back in the reverse direction. Participants were also informed to take care not to let the carriage move off the end of the knit bed at either end.

The below table shows a summary of the explicit instructions given to participants for each aspect of the graft-game.

[6] Note that throughout this Chapter, every participant using the game controls at any point will be referred to as ‘Player one’.

[7] In addition, any participant controlling the knitting machine will be referred to as ‘Player two’.

Table 5.1: Summary of explicit instructions given to players of Hazuki Knit

Player 1 **(game controls)**	**Player 2** **(knitting machine)**
-Press button on control panel that matches the symbol displayed -Prompt will appear on the screen (not the control panel)	-Move knit carriage back and forth using the handle -Speed of movement determines the speed of the game -Take care to move carriage past active needles and not to move beyond end of knitting machine bed

For unaccompanied participants, facilitators (myself or James) would act as the second player and give the participant the choice between playing on the game controls (as Player one) or at the knitting machine (as Player two). Many participants in this situation would begin as Player one but would ask to try controlling the knitting machine (as Player two) also. The desire to experience both elements of the game was also observed of pairs playing the game, with participants swapping places between games.

Encountering affordances

As with the craft and game case studies discussed in Chapter 4 (section 4.1), the full affordances and limitations of both aspects of the grafted game could only be understood through encountering them 'in action'. For example, understanding that the 'Jump' function listed in the controls of *Unravel* had to be carried out in conjunction with other actions, such as a directional button or 'Shoot', to provide any significant outcome in the game. Similarly, adapting to using smaller, metal knitting needles for the 'New Wave' yarn of the *MOP Sweater* after using a chunkier yarn and thicker wooden needles in a previous knit project even when carrying out the same 'Moss stitch' technique. Potential actions of *Hazuki* (the game element) were generally simple with players actions being limited to four buttons (up, down, left and right). All participants were told that in order to play they needed to press the appropriate button when a symbol (in the shape of an arrow) appeared on the screen i.e., the button with the matching symbol. Players were also instructed to ‘press any button’ to start playing the game both via a prompt on the screen and by the activity facilitators. Doing this would instigate a countdown to the start of the game with numbers counting down from ‘3’ to ‘1’ being displayed sequentially on the screen, each accompanied by a ‘BING’ sound, followed by a higher pitched ‘BING’ and the text ‘Go!’ appearing. These prompts informed both players that the game had started. The screen would then remain blank until the knitting machine triggered the first symbol prompt, actioned when Player two moved the knit carriage across the knit bed, pushing the grafted switch. On many first games for new participants, there would be a momentary pause whilst the players both awaited the first symbol to appear on the screen. Sometimes, as facilitators, we would then point out that Player two needed to start knitting, following which a symbol would appear on screen. In further games, the same participants, specifically Player two, would start knitting as soon as the countdown sound began (or even before), as they had learnt that their action enables the game to truly begin. The act of replaying the grafted game, therefore, supports an increased understanding of potential actions and what actions are required in order to proceed, just as the *Unravel* player (see section 4.1) learns the effects and requirements of the ‘grab object’ function through repeated interaction with objects in the game.

In a similar way to the knitter discussed in Chapter 4, adapting to the particular affordances of the ‘New Wave’ yarn and the knitting needles being used, participants of *Hazuki Knit* also had to learn the particular affordances of their tools. Neither the actions of button pressing or moving the knit carriage by pushing it with a simple handle, appear from the outset to be complicated actions. The pressing of the buttons (as experienced by Player one) did not require any particular level of force to be pressed successfully but as Keogh states “the way a videogame feels to play will depend on the very specific makeup of a particular gamepad controller: the strength of the springs beneath the buttons, the texture of the plastic buttons, the shape and size of the gamepad itself” (2018:96). Although the control panel is modelled on custom arcade buttons and not a handheld gamepad, the subtleties of touch and response of the buttons affected gameplay in the same way. Not all players were immediately comfortable with how to use the buttons in relation to the game. For example, some players would start by looking at the buttons not realising that they needed to look at the screen in order to see the prompts. Sometimes this would be pointed out to the players either by us or a fellow participant. Players who continued to be unsure of the button positions would continue to switch between looking at the screen then looking to the buttons to find the correct one. This was only a small number of players though and the majority were able to watch the screen for prompts without looking at their hands. This also links to habitual practice, or lack of, and players having not embodied the button positions (see section 5.4).

The act of grabbing the handle of the knitting machine did not require any further explanation or demonstration for players and all instinctively grabbed the handle with what appeared to be their dominant hand, some placing both hands upon it. Sennett (2008) describes this act of physically reaching for and grasping an object as ‘prehension’, upon which the developmental process of skill begins (Brock and Fraser, 2018). The act of pushing and pulling the carriage using this handle was, however, less straightforward with some participants being surprised at the force required to move the carriage across the needles of the knit bed. Directly experiencing how much force was required to ‘push’ the carriage along the bed and feeling how the carriage met with resistance when moving over needles with yarn thus allowed for direct engagement and further understanding of the limitations and affordances of the knitting machine and the yarn attached to it.

Grafted gameplay

As a grafted game that encompassed both craft and gaming processes, participants not only encountered the properties of the individual elements of the grafted game (dependent upon their playing position), but also the affordances and limitations of the full two-player game. I will demonstrate this by discussing examples of observations made of two sets of players. The first example is a duo who played just two games, switching places in between. For the first game, Participant one[8] acted as Player one on the button controls and Participant two as Player two on the knitting machine. Participant one got to a score of 10 before experiencing ‘GAME OVER’, as displayed on the screen. The player is surprised by this outcome:

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[8] All participants observed and discussed throughout this chapter have been assigned a participant number, keeping them anonymous. This label is given in addition to the ‘Player’ number which indicates the participants position at either the game controls (Player one) or the knitting machine (Player two).

> Participant one (on button controls): “What?! I pressed it right”
>
> Participant two (on knitting machine): “Maybe I was too quick”

In this exchange we see that the players are still learning the limitations of the game. Participant one is convinced that they pressed the correct button so is perplexed at the reason for getting a Game Over, not yet understanding the impact of Player two’s actions on the game. Participant two recognises that their role as Player two may have had an impact on the outcome, acknowledging that they may have moved the knit carriage faster than Player one pressed the correct button. The pair then switched positions and Participant two took the button controls with Participant one taking position at the knitting machine. Participant one is unsure of what to do and asks:

> Participant one (on knitting machine): “Do I have to wait until you’ve done it?”

Having experienced playing the game as Player two in the previous game, Participant two replied: “You don’t have to”. This response was based on the participant’s direct experience and encountering of affordances based on what they had understood of the first game, namely that the actions of Player two have a direct effect on the digital output. Participant two, through direct engagement with the knitting machine and the digital game, had come to understand that the actions of Player two had the potential to be carried out slowly (waiting for Player one to press a button), to make it easier for Player one, or to be carried out faster (not waiting), thus making the game more difficult for the other participant. Even though the participant’s may have been told before playing that “the faster the person on the knitting machine goes, the harder the game is for the other player” this may not truly be understood, and the implications of the opposite action (going slower) was not expressed.

In a second example a duo, Participants three and four, played a total of nine games together, switching positions several times. Through each successive game it is possible to evidence understanding of the games affordances and limitations increasing in a shared manner. These two players come to understand that the game increases in difficulty as the score increases. Between 0 and 10 the game only prompts the left and the right arrows to be pressed. After 10 the game introduces the up and down arrows making it slightly more challenging. After 20 points the game would get harder still and instead of displaying one symbol to be pressed, it would provide two prompts for every move of the knit carriage. After 30 this would increase to three prompts, and so on (table 5.2).

Table 5.2: Incremental increase in number of prompts based on score level

Score	**Number of prompts**
0-10	1 (left or right only)
11-20	1 (up and down introduced)
21-30	2
31-40	3
41-50	4
…and so on	…increases incrementally

Participant three and four's understanding of this aspect of the grafted game, and the role the each of their actions plays within this mechanic, is understood the more it is encountered together.

[Note: Appendix B5.7 shows recordings of these games]

Game 1

Participant three takes the button controls for the first game and scores 21 but their hands can be seen to scramble across the controls. The players then swap places. At this stage both players seem unaware that the Game Over was prompted by the score of 21 increasing the game's difficulty.

Game 2

Participant four is on the button controls this time and scores 13. Their hands appear to be in a more considered position, but they are 'thrown' when the up and down arrow are introduced for the first time with their hands having been positioned close to only the left and right arrows up to that point.

Game 3

Participant four remains on the button controls and scores only 5. They speak to the other player suggesting participant four is annoyed and laughs as they begin to change places.

> Participant four (leaving button controls): “I want to see what happens when we get to the extra characters”
>
> Participant three: “What? There’s more characters?”

Participant four had witnessed conversations during previous games and so was aware the game was going to get harder by adding in additional symbols after reaching a score of 10. I clarify this to the other player.

Game 4 and 5

Participant three is on the button controls now and quickly gets Game Over with a score of just 8. They sigh and quickly press the button to start another game. At this stage it is possible to see that Player two (Participant four) on the knitting machine, is pausing the carriage momentarily at the end of each row. This time Participant three gets a higher score of 18 and their hand retracts as the lights turn red.

> Participant four (on knitting machine): “I wasn’t going fast then either” (acknowledging their actions were deliberate in order to be favourable to the other players score)
>
> Participant three: “I know”

As they begin to swap places, Participant four advises:

> Participant four: “go all the way to the end on this one”, pointing to one end of the knit bed.

This demonstrates a form of knowledge sharing based on Participant four’s learned experience.

Game 6 and 7

Participant four, now on the button controls again, scores 21 and both players pause. I can be heard saying "ooh, you got to 21", hinting that this is why Game Over occurred. Starting another game quickly the player gets Game Over at 21 again and says:

Participant four (on button controls): "It did it again then"

This response shows Participant four is still somewhat 'thrown' by the increase in challenge once getting to 21 points despite previously showing an awareness that this would happen.

Game 8

Participant four is on the knitting machine again. They now firmly watch their fellow player to see when they press the buttons and use that to gauge when to move the knit carriage (previously they were watching the screen). Participant three only scores 10 and 'pulls a face' at Participant four then shrugs and they smile, responding:

Participant four (on knitting machine): "You don't have to be fast"

Participant three quickly presses a button to start a new game.

Game 9

Still watching Player one's hands closely, Participant four remains on the knitting machine, moving the carriage with very clear pause points as they wait for Participant three to press a button each time. Participant four may have been counting in their head because when the score reaches 20, they turn to look at the screen before looking back at the other player's hands. Both players now appear to be aware and ready for the additional button press that is introduced. As Participant three presses two buttons they almost nod their head with each press as if to confirm a count of two. Participant four can be seen to be waiting longer while Participant three presses two buttons before moving the carriage again. This continues until Game Over occurs at a score of 32.

Participant three (raising her hands in the air): "ah, three buttons"

Participant four: "ah"

They both now recognise the pattern in the game in terms of increasing difficulty. Having achieved their highest score, the pair finish playing at this point.

This example demonstrates that collectively, the Participants three and four have better understood the affordances and limitations of the grafted game. For example, the game aspect increases in difficulty as the game progresses requiring additional button presses, and that the speed of the knitting from Player two directly impacts the pace of the game for Player one. This example also demonstrates the role of repetition in both understanding limitations and affordances but also in learning how to respond and move the body to act to produce a desired outcome. Parisi stresses that through repeated experimentation of movements a "player learns what body motions produce the desired onscreen actions" (2009:118). In the above example, the participants were seen to adapt their bodily movements as their understanding of the grafted games' affordances deepened. For example, Participant four takes a more considered approach to their bodily response, pausing movement of the knitting machine carriage, or extending the reach across the knit bed, in response to the other player's actions.

Summary

Through the above examples, it is possible to see that, despite the explicit instructions being given for the individual aspects of the grafted game (knitting machine and game controls), players engaging with *Hazuki Knit* encountered and gained understanding of an additional set of affordances, not just those of the knitting and game elements. These additional affordances are the potential actions and limitations for the combination of two materials and involve the actions of the other player also, which can only be understood through grafted gameplay. As suggested in the last example given, developing an understanding of the grafted material affordances is highly linked with repetition which Sennett describes as "[t]he open relation between problem solving and problem finding" through which "the rhythm of solving and opening up occurs again and again" (2008:38) in a progressive manner. The act of repeating actions is thus a process through which knowledge is expanded, in a cycle of repeating, learning and progressing. In the play of *Hazuki Knit* this process of repetition was perpetuated through grafted gameplay in which learning is shared and progressed via the actions of both players.

When considering the impacts of grafting upon the individual elements (craft and gaming), through the observations discussed throughout this section, it is clear to see that grafting provides an additional set of affordances to each aspect. For *Hazuki Knit,* this resulted in each player encountering affordances of both the game and craft elements, whilst extending to limitations and affordances produced through the grafting process. Within the final part of this section, the examples given demonstrate that knowledge was gained by participants in a shared, repetitive manner, which could be seen to support skill acquisition, increasing material understanding and embodying of actions.

5.3 Feedback and Tracking Progress

Forms of feedback

As established in Chapters 2 and 4, consistent and sensorial forms of feedback (including visual, audio and haptic) are an important aspect of both gaming and craft. Through the amateur craft and game studies of hand-knitting*;* macramé; *Unravel*; and *Mario Kart 8 Deluxe*, discussed in the previous Chapter I demonstrated how sensorial feedback is manifested within each activity. I will repeat the summary table from section 4.2 here for reference:

Table 4.1: Summary of types of feedback discussed

Type of feedback	**Games**	**Amateur Craft**
Visual	-ability to look ahead and back	-ability to look back and ahead
Sound	-responsive sounds	-material sounds respond to action
	-responsive background music	-non-responsive ambient sounds
Haptic	-Rumble/vibration through controllers in some games	-material touch

Game feedback

As a grafted game, *Hazuki Knit* provides the same types of feedback via both the knitting machine and the video game components. The game element (*Hazuki)* provides visual feedback via the connected screen, audio feedback via a speaker within the separate control panel, and haptic feedback via the touch of control panel buttons. The screen displays explicit instructions, such as ‘Press Button to Start’, as well as visual prompts for Player one to respond to in the form of graphic symbols. After pressing a button to start, the screen displays a count down from ‘3’ to ‘1’ followed by ‘Go!’, accompanied by a sound as each is displayed: beep, beep, beep, bing. As Player one responds to the visual prompts through button pressing, if they press the correct button a single tone is played through the speaker and the current symbol disappears from the screen, going blank before the next symbol is displayed. This communicates to the player whether their actions have been successful or not. The control panel also has coloured lights that glow around each button. If the player presses the correct button, this glow changes from white to green momentarily. If Player one presses the wrong button or is not fast enough pressing the correct button, a double-toned low sound is heard and ‘GAME OVER’ is displayed on the screen and the button lights turn to red. Whilst the player presses the buttons, the large buttons also provide a set of sensations (haptic feedback) letting the player know that it has been struck successfully (Parisi, 2009), depressing then lifting again as the hand is retracted.

Craft feedback

Similarly, Player two receives feedback directly from the knitting machine, including audio, visual and haptic. As the player pushes the carriage with their hand on the handle, the carriage responds by moving along the knit bed. When moving across empty needles the carriage moves reasonably smoothly. However, when the carriage meets needles that have yarn on them, the carriage resists. This resistance is felt by the player’s hand and is accompanied by a change in sound which provides feedback for the player. Just as Korn (2015) describes how his hands learnt to ‘listen’ to his tool when developing his woodworking skills in his book *Why We Make Things and Why it Matters*, the player on the knitting machine in *Hazuki Knit* needs to ‘listen’ to the haptic feedback provided through the handle of the knit carriage. These haptic sensations are further supported by visual feedback of the carriage moving across the knit bed and the changing sounds as it moves across the needles. Player two, therefore, is constantly receiving feedback from the knitting machine.

Grafted feedback (game to Player two)

Player two simultaneous to the feedback from the knitting machine also receives the same audio and visual feedback from the screen and speaker of the game as Player one, but not the haptic feedback of the buttons. As Player two moves the carriage along the knitting machine bed it triggers the grafted switch, prompting the next symbol to appear on the screen. This gives Player two feedback on their action, confirming movement of the carriage has triggered a response in the digital game. If the player on the knitting machine moves the carriage before Player one has pressed the appropriate button it triggers the Game Over feedback of the digital game to be displayed and heard. If Player two is moving the carriage slowly or has paused movement after Player one has pressed the previous button, the screen will display as blank until Player two moves the carriage past the trigger. During observations, some participants on the knitting machine would start moving the carriage before the game had started while others waited for the screen to display something, unclear that it was their actions that would prompt the symbol to be displayed. The feedback from the digital game was, therefore, important in communicating to Player two, their role in the grafted game.

Grafted feedback (craft to Player one)

Equally, as Player one watches the screen for prompts and receives feedback when pressing buttons, they can also hear the sound of the knitting machine carriage moving back and forth. The speed of the carriage, and the sound of it, communicates to Player one a sense of pace. The sound of the carriage alone can inform Player one whether they need to respond to prompts quickly or if the game, as controlled by Player two's actions, is moving at a slower pace. A summary of these forms of feedback as received and experienced by each player can be seen below:

Table 5.3: Feedback types experienced in Hazuki Knit

Type of feedback	Player one (at the game controls)	Player two (at the knitting machine)
Visual	Screen displays: instructional prompts, graphic symbols to be pressed, Game Over	Knitting machine: can visually see the carriage moving back and forth and needle responding, knit fabric grows below (one row of knitting with each carriage pass)
	Control panel: responsive coloured lights around buttons	Screen displays: instructional prompts, graphic symbols to be pressed, Game Over
	Both players can also see each other and their body movements	
Sound	Countdown sounds	Countdown sounds from the game
	'Bing' sound with each correct button press, increasing incrementally in pitch as the score increases	Sound of carriage as it move across the knit bed, changing in tone when moving over 'active' needles (those with yarn)
	'Ba Bong' low toned sound when incorrect button is pressed	Carriage and needles make a collective grinding sound if the knitting gets stuck or jammed
	Sounds from the knitting machine are also audible	Sounds from the digital game can also be heard by this player
	Both players can hear each other's audible responses	
Touch	Response of physical buttons under fingers as they are depressed and lift again	Feel of the carriage handle along with vibrations felt through it as carriage moves across the knit bed
	*There was no artificial rumble feature added to the controller	Player will 'feel' some variation in resistance from carriage

Presenting a model of grafted interactivity

Drawing on Chris Crawford's (2003) model of interactivity, Steve Swink (2017) describes real-time interaction with computers as a 'closed loop' in which user and computer are in conversation. Crawford defines interactivity as *"[a] cyclic process in which two active agents alternately (and metaphorically) listen, think, and speak*" (2003:76). Swink provides a diagram of this, shown in Figure 5.6.

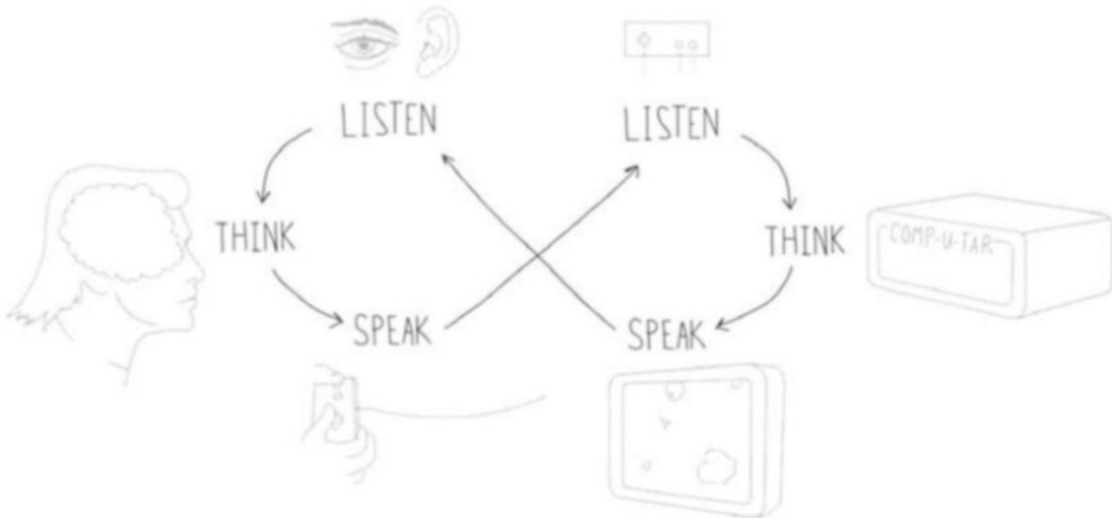

Figure 5.6: "The conversation between human and computer" (Source: Swink, 2008: 4)

This model does not account for the embodied experience of interaction with video games (instead focusing on cognitive thinking in response to feedback), but it does provide a useful base on which to express grafted feedback in the context of *Hazuki Knit*. Adapting this model, removing the cognitive 'THINK' aspect for a whole embodied 'EXPERIENCE' of players, Figure 5.7 below demonstrates the conversation between Player one, the control panel, knitting machine and Player two, during interaction with *Hazuki Knit*. Player one 'listens' to and experiences the audio and visual feedback provided by the game element via the screen and speaker before responding via their hands and fingers on the game controls, which in turn feedback successful button presses to the player via haptic feedback. The game 'listens' to Player one's response inputted via the control buttons, processes the information given before feeding-back to the audio-visual output of the screen and speaker. Simultaneously, Player two also receives the visual and audio feedback from the game element, responding via moving the carriage across the knitting machine, at an appropriate speed and time based on the feedback received. Moving the carriage provides Player two with haptic feedback, prompting an additional 'closed loop' with the Player 'listening' and responding to feedback provided by the knitting machine. At the same time, the input provided by Player two at the knitting machine transfers from the knit carriage to the row counter and switches which the game listens to and responds by displaying the prompt symbol on screen for Player one. Both players are also able to observe each other visually and via audio feedback, although this primarily occurred with Player two visually observing Player one during observations.

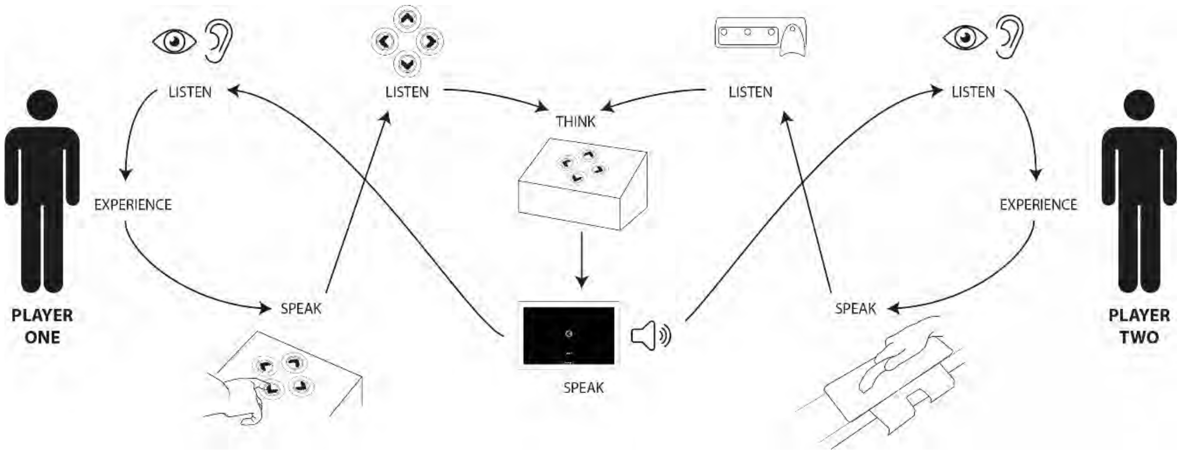

Figure 5.7: Multi-loop conversation between players, game and knitting machine in *Hazuki Knit*

The two-player graft-game, therefore, creates a multiple loop conversation between game, knitting machine and both players.

Balancing grafted feedback

In Chapter 2 I drew on Ingold's (2011) theory of 'perception and action' through which the craftsperson's eyes visually monitor the material while the body makes continual adjustment in response.

> I need more than the saw to cut wood. I need the trestle to provide support, I need my hands and knees respectively to grip the saw and to hold the plank in place, I need every muscle in my body to deliver the force that drives the saw and to

> maintain my balance as I work, I need my eyes and ears to monitor progress (Ingold, 2011:56).

In this description Ingold (2011) not only highlights the role of the whole body in supporting and acting upon the material and tool at hand, but expresses the essential role played by the eyes and ears in monitoring the impacts of those actions. Similarly, Sudnow (1983) discussed how his own hands knowledgeably manipulated game controls leaving the eyes free to monitor the game screen.

> Now the computer. Our organically perfect tool. Seated upright on behinds just made for that, our hands dangle near the lap at their most relaxed point of balance, while these fingers, capable of such marvelous interdigitation, have a territory for action whose potentials and richness are electronically enhanced beyond the wildest dream. And the eyes are freed from hand guidance work, free to witness and participate in the spectacle from above (Sudnow, 1983:22).

During engagement with *Hazuki Knit* the visual feedback from the game element appeared to be more prominent than that of the knitting process. The digital game proved to be a visual distraction for most players controlling the knitting machine with very few participants noticing the knit fabric being produced underneath the knit bed. Many participant's eyes became fixed on the digital screen while others watched their fellow player, monitoring their button presses in order to gauge the timing of their response to the on-screen prompts, often using this to affect the speed at which they would move the knit carriage. In my own experience of using a knitting machine as a standalone activity, the eyes watch the knitting, monitoring the stitches as the carriage moves across the bed, looking up occasionally to check a pattern or monitor how much wool is left on the cone. The eyes also regularly inspect the knitted fabric being produced to look for stitch errors. This is similar to my experience of hand-knitting as discussed in the previous Chapter in which my eyes were mostly focused on the knitting itself. Participants playing *Hazuki Knit,* in the majority of cases, only looked at the knitting when I deliberately discussed it with them before or after the activity, few observed it during gameplay. This outcome is potentially due to inexperience and unfamiliarity with knitting machines, with the majority of participants expressing having not seen or used a knitting machine before, except maybe having seen an older family member use one. The lack of attention given to the knitting being produced could, however, be a direct outcome of grafting with the visual feedback from the game element (via the screen and through observations of the other player) overpowering the game element.

So far in this section I have shown that the act of grafting an existing game with an existing craft process creates additional forms of feedback for the players in control of each element. As discussed, players receiving various forms of feedback from both the knitting machine and the digital game, with Player one receiving visual, audio and haptic feedback from the digital game and vice versa. The audio aspect appeared well balanced but the impact of additional visual feedback in the form of a screen appeared to distract from the visual feedback of the knitting process itself. Later in this section I will come to discuss how this potentially has an impact upon the quality of the craft output, the knitted fabric.

Tracking progress and a loss of 'craft'

Just as quantitative forms of feedback, such as the position in a race on *Mario Kart 8 Deluxe* or tracking stitch count in knitting, were valuable in the case studies of craft and gaming in the previous Chapter, explicit feedback on progress was observed to provide differing levels of motivation during gameplay of *Hazuki Knit*. There were two aspects of tracking progress in the grafted game, both primarily quantitative. Comparable to *Mario Kart 8 Deluxe* that provides explicit feedback enabling the player to track their progress both during and at the end of races, progress in *Hazuki Knit* was tracked and fed-back to the players via an explicit and quantitative score. The players' score was displayed on screen throughout gameplay (see Figure 5.8), counting upwards each time Player one successfully pressed the correct button in time. The sound produced as the player pressed the correct button also increased in pitch slightly each time the score increased by one, communicating progress towards the goal of achieving a high score.

Figure 5.8: *Hazuki Knit* screen display including a live score

The end goal of both the digital and knitting aspect of *Hazuki Knit* were the same, to produce as much as possible, either keep knitting, or get a high score. The knitting in this example, unlike the *MOP Sweater* case study in the previous Chapter, did not have an end item or product as a goal. Tracking progress was, therefore not required in terms of keeping track of position in a list of instructions. Knitting in *Hazuki Knit* could be paused and restarted after any number of rows. The only requirement was to ensure the current row was completed before stopping and to avoid trying to push the carriage in the wrong direction along a row. This would cause the knitting to clog in the carriage mechanism, a limitation that keeps the maker on target towards the goal of producing knitting. This limitation acts in a similar way to the movements of the character in the game *Unravel* being limited to left and right across the screen (see Chapter 4).

Figure 5.9: Knit fabric being produced as result of *Hazuki Knit* gameplay

Comparable with hand-knitting discussed in the previous Chapter, the machine knitting aspect of *Hazuki Knit* provided a tangible means of tracking progress through the knitted fabric being produced which increased by one row each time the carriage moved across the knit bed (see Figure 5.9). This growing fabric reflected the steadily increasing score. Unlike the digital aspect of the game, the physical knitted piece continued to grow from one game to the next unless a new piece of knitting was cast on. Removing a knit piece from the machine and casting-on anew is a slow process and due to the nature of the short-term participatory contexts in which *Hazuki Knit* was played, it was decided that the knitting would be left as a continuous piece in order to not delay participation in the game. The piece of knit being produced, therefore acted as a 'collective' object that all participants contributed to, whereas the digital score was personal to individual or pairs of players. This undefined collective object provides a point of difference from amateur hand-knitting where the fabric being knit is most likely to be for the purpose of a finished object or garment that the knitter may have personal investment in. As noted by Twigger Holroyd, for many hand knitters it is the "anticipation of the use of the items they make" that makes the activity significant to the individual and "legitimates the activity of making it" (2013: 106). The finished output of a wearable or useable item is thus the foal within handknitting. As mentioned in the previous section, few participants engaging with *Hazuki Knit* watched the knit as it was being produced or even realised that the knitting machine was knitting. It appeared that participants related the knitting machine's purpose only as a game input. Of those who did notice it some asked what 'we' (we as 'the facilitators') were knitting, expecting there to be a deliberate output such as a scarf but overall, there did not appear to be any personal connection or expectation of this being a purpose for individual participants. This demonstrates a potential disconnect between making practice and the grafted game suggesting that feedback offered through the grafted game had a negative impact on the craft aspect with feedback provided by the digital game (visual, audio and the progressive score) distracting from and reducing the expected relationship of the maker (Player two) with the knitted output.

'Game Over': feedback on flaws and failure

In previous Chapters, I have established that both craft and gaming involve experiences of failure (Sennett, 2008; Korn, 2015; Juul, 2013; McGonigal, 2011). Having discussed the paradox of video games established by Juul (2013), through the case studies presented in Chapter 4, I demonstrated that the amateur craft practices, like the play of video games, present equal experiences of frustration and pleasure. During the play of *Unravel*, failure was linked to experiences of punishment applied by the game rules, in which the player was forced to try again through either character death or by being prevented from proceeding in the game. Failure during the knitting of the *MOP Sweater* was experienced through physical (and visible) errors in the knitted fabric, such as ladders or incorrect stitches, or through the dropping of stitches from the needles, requiring immediate action in order to recover and proceed. Within knitting, the decision to correct errors was predominantly left to the knitter, with knitting able to proceed if the knitter chose to ignore or keep flaws in the fabric. When playing *Unravel*, however, the game rules that caused instances of Game Over through character death, or the prevention of the player from proceeding, left the player with no choice but to re-play aspects of the game. Through observations of engagement with *Hazuki Knit*, Game Over (where the making and/or gaming would be forced to halt) occurred in two ways, due to the two elements of the grafted game. In the digital aspect of *Hazuki Knit,* Game Over, or failing to succeed is explicit and made clear to the players. As mentioned above, when Player one fails to press the correct button in time or presses the wrong button an audible 'Dun-dunn' tone from the speaker is heard as the screen displays 'GAME OVER' in large text. The coloured lights glowing through the surround of the control buttons also changed to red. There is no doubt, in this situation, that Player one has failed, and the game is over. Many players at this stage would very quickly chose to play again and do so by 'pressing any button'.

Game Over for Player two (on the knitting machine) was experienced a little differently to the player using the control buttons. Just as with hand-knitting, discussed in the previous Chapter, failure when using the knitting machine can occur in the form of stitch errors such as dropped stitches. Dropped stitches on the knitting machine may form 'ladders' in the knitting if left undetected but can generally be fixed using a special tool called a latch hook, that is used to manually pull the dropped stitch up through the ladder, one row at a time, re-looping it onto the hook on the machine bed. In these instances, gameplay had to be paused to make such a correction and this would be enacted by myself. In hindsight this may have distracted from the additional aspects of craft practice. In the majority of cases participants tended not to see the knit errors, and whilst observing gameplay I would choose to intervene if I saw a 'fault' in the knitted fabric that may cause damage to the machine. These errors did not always have to stop gameplay and could be corrected in between games. Full Game Over that prevented either player proceeding further, however, was experienced when the knit carriage jammed. The haptic feedback of the carriage jolting and putting up increased resistance to movement would be accompanied by an audible crunching noise coming from the machine (Appendix B5.8). This occurred several times with jamming generally caused by hanging yarns, called 'floats', getting caught in the mechanism of the carriage. Floats are created in machine knitting either when knitting patterned knits in multiple colours, or when gaps or ladders occur in the knit fabric and un-knitted yarn is left loose 'floating' across a gap or across the back of the knitting. Experienced knitters are able to adjust the speed of their knitting in response to floats that occur in patterned fabric. Participants playing *Hazuki Knit* were not familiar with this experience and so would learn through the machine getting physically stuck that there was a problem with the knitting.

These aspects form part of the wider experience and knowledge of craft practice, the correcting of complex errors, understanding and maintaining of machines. To some extent this could also be said of gaming. In the case of *Hazuki*, the game controller is custom made and powered by a 'Raspberry Pi' computer that sits inside the control panel. The buttons were wired directly to this and, as a custom item, posed a small risk of breaking or needing maintenance during the events. This did not occur, although the Raspberry Pi did freeze a couple of times and required rebooting, an action carried out by us, as facilitators also. This required much less effort than the time and skill needed to fix jams on the knitting machine. This form of Game Over was thus more punishing than the Game Over experience of the digital game because recovery took much longer. When the machine jammed, as a facilitator, I would have to step in and remove the knit carriage, untangle yarn and attempt to rescue dropped stitches. This was a delicate process and if the knitting was not recoverable it would have to be removed from the machine completely and a new piece cast-on. This also would take time. This was the opposite of the recovery from Game Over in the digital aspect of the game. Players would respond to the failure but then move on quickly, either changing places, finishing playing or by playing again. Many participants choosing to play again would start a new game very quickly, pressing a button to start the game countdown almost as soon as screen prompted it. Game Over experienced due to knitting failure was, therefore, far more 'punishing' and harder to recover from than failure of the digital aspect. According to Keogh:

> A playable character’s death is typically inevitable and uneventful in videogame play: a temporal glitch in the system’s efficiency brought around by the player’s incompetence (Pias 2011, 173), an inevitable and intermittent interruption to the player’s experimentation (Atkins 2007, 239), a pedagogical tool used by the videogame to teach the player how they should be playing (Sudnow 1983, 162). Playable character death is a mistake to undo and a lesson to learn (Keogh, 2018:138).

Although *Hazuki Knit* has no playable character, Game Over experienced via the game aspect of the graft-game presented similarly as a temporary inconvenience that provided a chance to learn. As discussed in Chapter 4, such experiences of failure can lead to the repetition required for the acquisition of skill and developing a deeper understanding of material affordances. If recovery from failure is slower, providing more than a temporary inconvenience, the opportunity for repetition is delayed for much longer. This not only delays the opportunity to try again and further embody skills but could act as a de-motivation for players. This was witnessed with *Hazuki Knit*, with players experiencing Game Over due to knitting machine jams, ending their gameplay without waiting to start a new game, far more often than those experiencing Game Over via the game element. This suggests the potential for grafting to impact negatively upon individual aspects, in this case that is that game feedback can overpower and diminish that of the craft which could put the craft at increased risk of unrecoverable failure.

Summary

Throughout this section I have built upon previous discussion around the theme of feedback within craft and gaming to discuss how grafting was observed to have changed and affected feedback during engagement with *Hazuki Knit.* The graft-game provided aspects of visual, audio, and haptic feedback to both players via both the craft and game elements, with individual forms of feedback being received by one or both players simultaneously. In the grafted context, feedback consisted of: game feedback (to Player one), craft feedback (to Player two), grafted feedback (game to Player one), grafted feedback (craft to Player two). Forms of feedback between the two elements of the graft-game, though, were not always balanced. As noted within Ingold's (2011) description of the process of sawing wood, and as observed through my own observations of craft activities in Chapter 4, during making the craftsperson's eyes visually monitor material. In the case of *Hazuki Knit* the visual feedback of the digital game aspect acting as a distraction to the act of knitting with Player two's eyes predominately visually monitoring the screen or the actions of the other player.

Hazuki Knit provided players with two aspects of feedback that enabled progress to be tracked:

- quantitative explicit feedback in the form of a game score displayed live during gameplay and as a final score when each game ends, communicating progress towards the goal of achieving a high score.
- tangible progress tracked through the growing length of the knitted fabric being produced with a single row of knitting reflecting one point in the game score. Unlike the game score, though, the knitted fabric was not restarted with each game so acted as a running total of the score progressed through all games.

This latter aspect of monitoring progress acted as a collective, rather than individual object, creating a disconnect between the craft practice and the grafted game, reducing personal connections to the craft output. In opposition to this, however, the digital output of an individual game score was seen to be highly valued by both players, which could be of value in contexts outside of amateur craft, for example, in manufacturing where skilled makers have no personal connection to the items being produced.

In the last part of this section, I discussed experiences of failure through the grafted game. The digital game aspect of *Hazuki Knit* made no allowance for error with incorrect button presses, or not pressing the correct button within the time limit, resulting in Game Over. This was fed-back to the player(s) via an on-screen display and accompanying Game Over sound. Failure through the craft aspect of the graft-game was experienced differently. Similar, to hand-knitting discussed in Chapter 4, dropped stitches on the knitting machine could lead to holes or ladders in the knitted fabric. More catastrophic failure, that prevented the knitting process from proceeding in the same manner as Game Over halts gameplay, was experienced when the knitting machine jammed as a result of tangled or loose yarn getting caught in the knitting mechanism of the knit carriage. What is significant about the two forms of Game Over is that Game Over due to the knitting machine jamming was experienced by players as more punishing than Game Over experienced via the game element. This is due to recovery from failure taking longer to correct i.e., it takes physically longer to un-jam the knitting machine, often with the length of knitting having to be removed and cast on anew. In the digital game, Game Over was merely a temporary inconvenience. The slower recovery from failure in the craft aspect also had the opposite effect in terms of motivation to play again. When experiencing Game Over in the game element, players were often keen to restart the game quickly whereas, players experiencing Game Over via the knitting machine jamming, tended to end their engagement and walk away. Experiences and impacts of failure as a result grafting should be a significant consideration when planning an intervention with the production setting of a factory. Flaws and errors within the quality of sewing on the production line would be an undesirable outcome, machine faults or jams as a result of grafting would also be seen as having a negative impact on production. As was witnessed with *Hazuki Knit*, failure that results in machine faults requires much more time, and labour, in recovery and would be costly within a production setting. The temporal nature of Game Over experienced via the digital aspect of *Hazuki Knit*, grafting within a production context could provide an area in which failure is less of a risk to production and in turn may have the benefit of encouraging aspects of repetition.

5.4 Optimising Gameplay

In Chapter 2 I discussed the ways that craftspeople and gamers develop methods for minimising risk such as the use of jigs, templates and save points. In Chapter 4 I then went on to evidence the use of the 'body as jig' as a method of limiting risk and increasing certainty on processes in both amateur craft and gaming activities. In addition, through the case studies in Chapter 4, I discussed ways that craft and gamers both optimise their performance, such as game score, and quality of output. In this section I will reflect on methods that participants engaging with *Hazuki Knit* adapted to avoid failure through Game Over and to optimise the overall game score.

Optimising hand positions

In Chapter 4 I discussed how continuous feedback creates a desire in a maker and gamer to improve skill and encourage the development of strategies to avoid failure. *Hazuki Knit* ran only as a short-term participatory activity at events, with participants rarely playing more than two or three games, including switching between the button controls and the knitting machine. This short engagement period did not allow for habitual practice and the embodiment of skill to be developed and observed in any significant manner. It was, however, possible to observe the embodied actions of players with existing experience, with gaming controls in particular, with experienced gamers positioning their hands over the control buttons in a more deliberate way than non-gamers. For example, it was clear that participants who had gaming experience were those who held their fingers poised over the four buttons, many positioning the index finger and middle finger or thumb of one hand over the top and left buttons and the index and middle finger or thumb of the other hand over the right and bottom buttons in a diamond format. Less experienced participants tended to use just one hand, using one or several fingers to press each button as required. See comparative images in Figures 5.10 and 5.11.

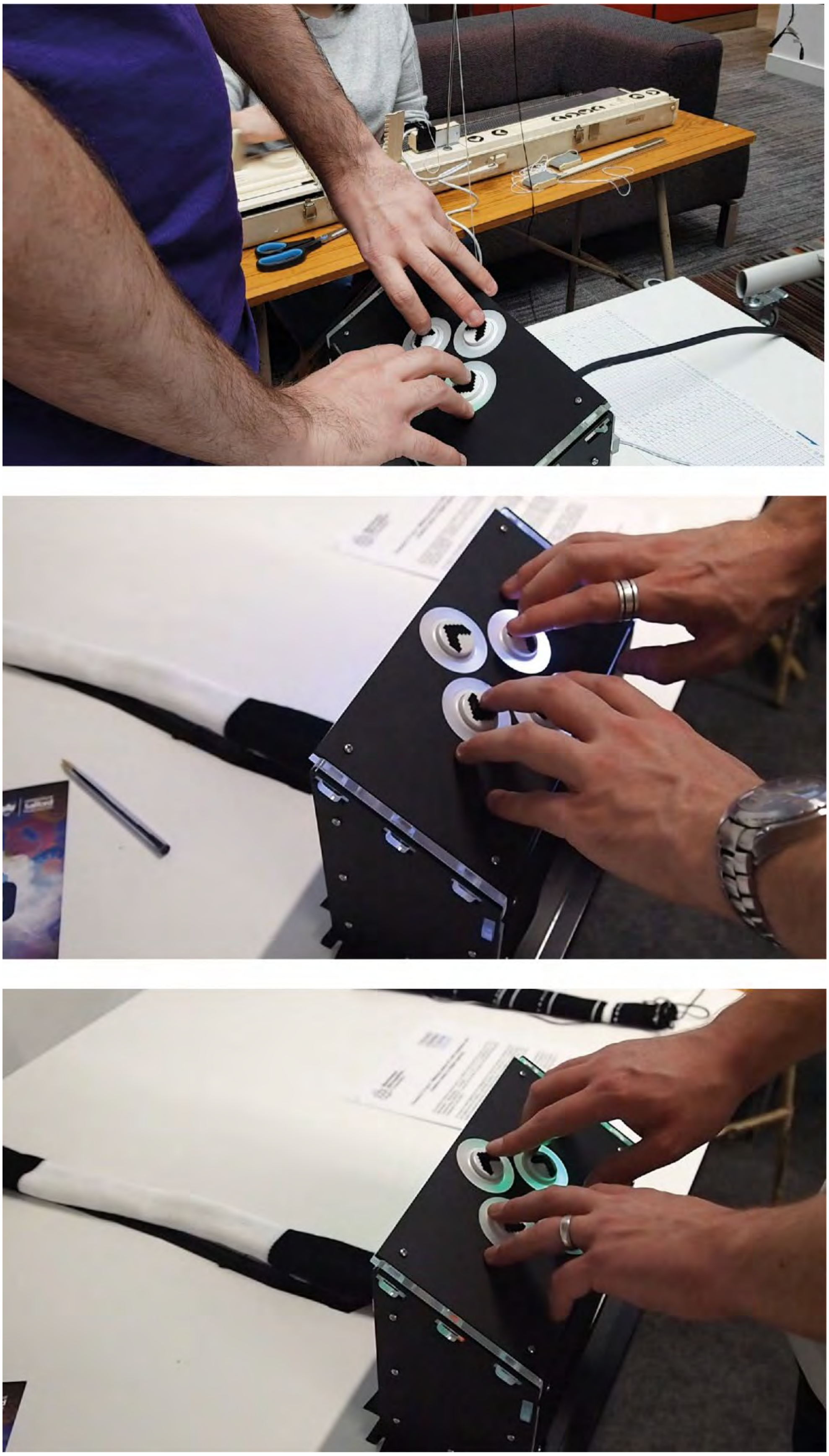

Figure 5.10: Images showing hand and finger positions of participants who presented as experienced gamers

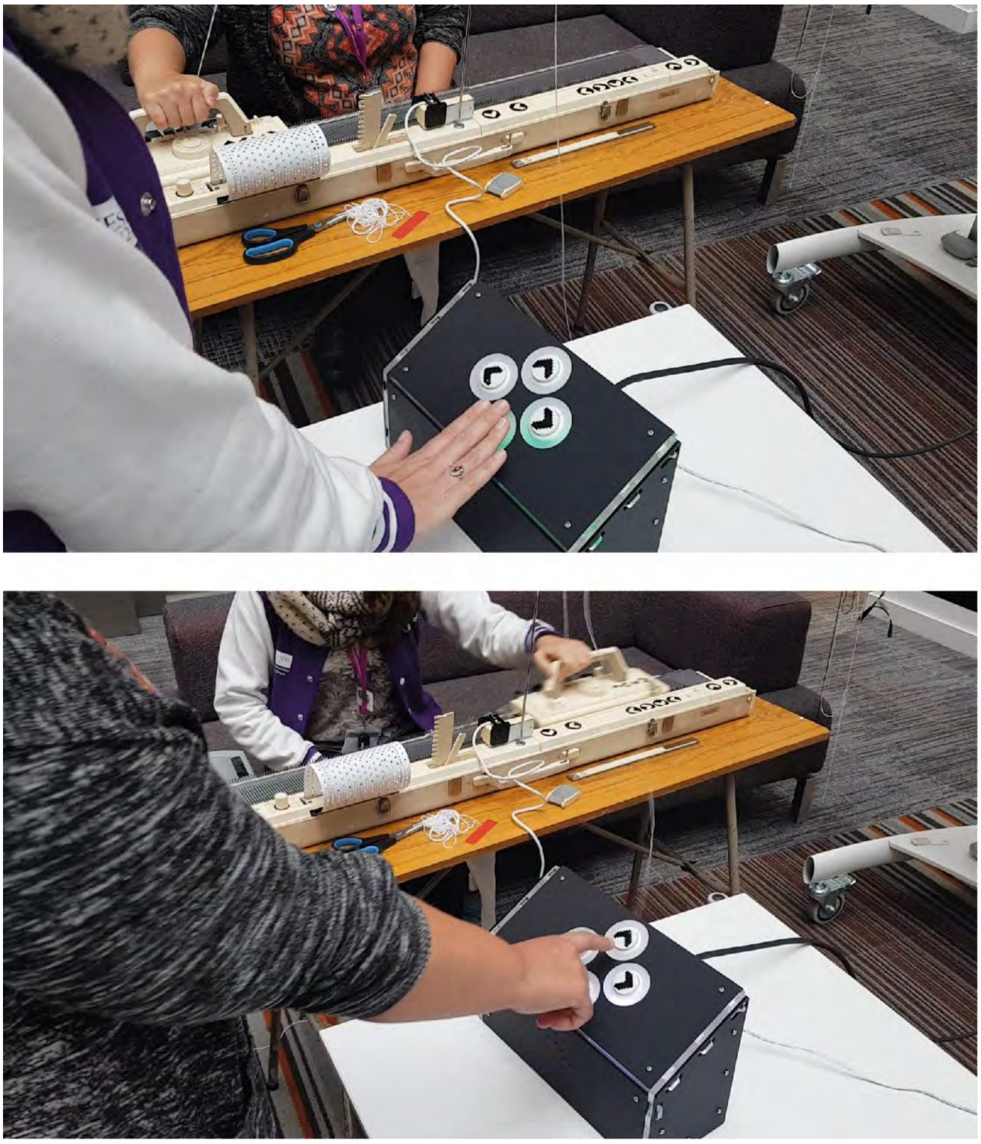

Figure 5.11: Images showing hand and finger positioning of participants less experienced with video games

Players who admitted to being less experienced with playing games tended to position their hands more haphazard, often retracting their hand away from the buttons and hovering in mid-air in between presses. One participant acknowledged their lack of familiarity for the arcade buttons saying “my hands are too small, if only it was a keyboard it would be ok” suggesting that they felt they would manage the controls better if they were using a keyboard. From their comment we cannot assume they had experience of using a keyboard specifically for gaming but perhaps we could assume more general regular use of one and thus recognised their own habitual use of tools.

Outside of existing experience, observations revealed participants optimising their bodily movements through repetitive gameplay. For example, some participants would adjust their hand positions, especially when using the buttons controls as Player one, when playing a second game. Most significantly was that the playing of a second game was, for many participants, driven by the desire to improve the previous score. For example, in video DigiLab_Nov18_v14 (Appendix B5.9) we can see a participant playing their first game as Player one. In this game they position their hands above the controller hovering some distance from the buttons and reactively moving a hand towards a button as a prompt appears on screen. In video DigiLab_Nov18_v15 (Appendix B5.10) the same player is seen playing their second game as Player two on the controls. This time, they position their hands and fingers more deliberately with fingers on their left hand resting on the 'left' arrow button and fingers on their right hand resting on the 'right' and 'down' buttons. This positioning enables them to respond with more considered, less frantic, with movements concentrated to their hand and fingers when a prompt appears. In both games the player finds it difficult to respond effectively to the required additional button presses after reaching a score of 20, and there is still some fumbling of movements to reach the 'up' arrow button with their left hand, but it is possible to see that the participant's hand positioning in the second game is more effective and a slightly higher score is achieved.

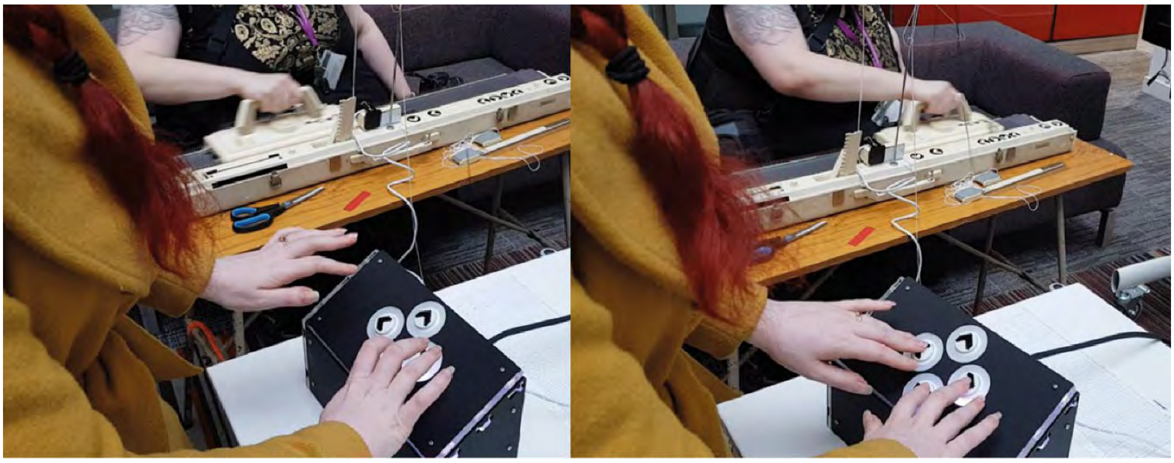

Figure 5.12: Still from videos DigiLab_Nov18_v14 and video DigiLab_Nov18_v15 showing change in hand positions of one participant, showing their first game on the left and second game, with more deliberate finger positioning, on the right

The adapting of more deliberate positioning of the hands supported by the rest of the body, in this instance, demonstrates a similar strategy to the use of the 'body as jig' discussed in Chapter 4. The stance of the body and positioning of the hands, here, reducing 'clumsiness' and increasing efficiency of movements to improve the quality of the performance in being able to respond to the on-screen prompts by pressing the correct buttons in a timely manner.

Competitive and cooperative gameplay

Optimising gameplay to achieve a high score in *Hazuki Knit* was not necessarily dependent upon Player one improving skill at pressing the correct buttons in time, it was also reliant upon the actions of Player two. The pace at which Player two moved the knit carriage along the machine bed determined how fast 'prompts' appeared on the screen, thus dictating how hard the game would be for Player one. Two distinct forms of gameplay in this two-player context were observed as a result of this agency given to the player on the knitting machine. Through observations of participants playing *Hazuki Knit* it was witnessed that strategies and methods for optimising gameplay were driven by opposing motivations: competition and cooperation.

Sennett defines cooperation "drily as an exchange in which the participants benefit from the encounter" (2012:5), whilst arguing that competition and cooperation are not distinct in nature.

> Cooperation can combine with competition, as when children cooperate in establishing the ground rules for a game in which they compete against one another; in adult life this same combination of cooperation and competition appears in economic markets, in electoral politics and in diplomatic negotiations. (Sennett, 2012:5)

As highlighted by Hackney "collaboration might promote positive or negative experiences" (2013a:25) and both were observed during dual play of *Hazuki Knit*. As a single player stand-alone game *Hazuki* has one goal, to achieve as high a score as possible, by grafting the game and adding in a second player the approach towards this goal became altered. Players could either work together towards getting a good score, optimising gameplay through cooperative techniques, or Player two could compete with Player one to make the game harder.

Cooperation

Cooperative gameplay could be defined as mutual support through which both players work together to achieve a high score. In Sennett's thinking, this form of cooperation is "built into the genes of all social animals; they cooperate to accomplish what they can't do alone" (2012:5). In the case of *Hazuki Knit*, Player one is unable to progress in the game without the actions of Player two moving the knit carriage on the knitting machine. This form of play was primarily led by players on the knitting machine. As discussed in a previous example, many players in the position of Player two, would deliberately pause the knit carriage at the end of each row to enable adequate time for Player one to press the correct button. In another instance a group collectively shared playing the different roles of the game, playing in a very careful and considered manner. Having worked out the mechanism that was involved in making the game progressively more difficult, through which additional button presses were required for every additional ten points scored, the group collectively counted button presses at each stage and removed the risk of Game Over by stopping the knitting machine action for as long as required. For example, at a score of 64, the digital game would then display 6 prompts in sequence. With movement of the knitting carriage paused, Player two would count the number of button presses carried out by Player one and not move the carriage again until all required presses were completed. The act of deliberately pausing movement on the knitting machine removes the risk of Player one experiencing Game Over due to being too slow, leaving only the risk of pressing the wrong button. This group of four people changed positions several times and went on to achieve a score of over six hundred. This very high score was a unique instance observed over the series of events, but it did represent a method of gameplay carried out by many players, although it more commonly occurred to a less deliberate extreme. This demonstrates a common desire to achieve a high score with participants working cooperatively to achieve it. As stated, however, this cooperation was mostly afforded by Player two on the knitting machine with Player one responding to their input.

There were no observed interactions that suggested a desire by any participants to improve the quality or production rate of the knit fabric being produced on the knitting machine suggesting that the goal of achieving a high score was prioritised over any perceived goal attached to the act of knitting. The engagement with the knitted output may have been different if the activity had been set up with a more defined output such as producing a pre-determined length of knitting or creating a collective finished object through gameplay. Any knitting that was produced during gameplay was as a biproduct of successive and ongoing gameplay, but with the production of the knit not being as motivating as achieving a high score.

Competition

Competitive games, as defined by Hunicke et al., “succeed when the various teams or players in the games are *emotionally invested* in defeating each other” (2004:3). The pattern of competitive gameplay that emerged during observations of *Hazuki Knit* did so among participants that played the game with a partner that they were accompanied by, as opposed to single players for whom we acted as the second player for. Instead of working together to try and achieve a high score participants would work competitively with players on the knitting machine deliberately making it harder for the player on the control buttons by going fast. In *The Art of Failure,* Juul (2013) describes how such behaviour is seen as completely acceptable in the context of gameplay, expected even, whereas such behaviour in real life might be seen as rude or confrontational:

> Imagine that you are dining with some people you have just met. You reach for the saltshaker, but suddenly one of the other guests, let’s call him Joe, looks at you sullenly, then snatches the salt away and puts it out of reach. Later, when you are leaving the restaurant, Joe dashes ahead of you and blocks the exit door from the outside. Joe is being rude-when you understand what another person is trying to do, it is offensive, or at least confrontational, to prevent that person from doing it.
>
> However, if you were meeting the same people to play the board game *Settlers*, it would be completely acceptable for the same Joe to prevent you from winning the game (Juul, 2013:10-11).

Within *Hazuki Knit,* deliberate actions to prevent another player from winning were carried out by Player two, moving the carriage faster, increasing the pace at which prompts would appear on the screen for the other player and require that player to respond more quickly before the carriage began the next row. The resulting sound of the knitting machine being controlled by Player two also imposed a sense of urgency in the other player.

This approach to playing was often accompanied by expressions of joy rather than frustration and could be seen to align with what McGonigal (2011) describes as 'fun failure'. Participants playing competitively were never observed to be upset or annoyed by this type of gameplay. This form of competitive gameplay could be seen to be combined with cooperation with players, through the act of playing the game, working together to "establish the ground rules" (Sennett, 2012:5). As argued by Sennet (2012), cooperation can also produce destructive results for others, and in *Hazuki Knit* this was observed within these competitive instances where the quality of the knit output was put at risk.

High risk gameplay

Competitive participants shared a desire to achieve a high score, on the part of Player one, but the player on the knitting machine was driven by a desire to prevent Player one from succeeding easily. When this gameplay was witnessed it appeared to be more 'gameful' (McGonigal, 2011). In some instances, we told players whilst introducing the game, "the faster the knitting, the harder the game is for the other player". As suggested above, this often prompted a desire from the player on the knitting machine to go deliberately fast straight away making the game extremely hard for the player on the control buttons. This form of gameplay was often accompanied by laughter as Player one scrambled to press buttons in the short time available and ultimately failed. This would be met with equal joy from Player one, as the paradox of failure (Juul, 2013; McGongial, 2011) was witnessed. McGonigal (2011), cites that such positive feelings experienced when failing in games, as being in contrast to failure in real life through which "we are typically disappointed, not energized" (2011:66). Instead, players fail passively, spectacularly, and entertainingly with 'positive failure feedback' reinforcing "our sense of control over the game's outcome" (McGonigal, 2011:67). The pleasurable experience of failing through competitive gameplay in *Hazuki Knit,* however, despite being easily recovered from in terms of the game aspect, generally had a negative impact upon the craft element. The excessive pace of the knitting machine put the knit fabric at greater risk of jamming, in some instances leading to some needles on the knit bed being damaged and requiring replacement at events. At a lesser extreme faster knitting paces appeared to increase the risk of stitches being dropped, causing holes and ladders in the knitted fabric. The additional excitement and fast playing style also meant that players were more distracted and less likely to notice these errors in action. Cooperative gameplay, on the other hand, put less risk on both aspects of the game but neither made the production of the knitted fabric a priority, either in terms of quality or quantity of output.

Sometimes these two forms of gameplay changed between games in the same paired participants. Just because one participant played cooperatively and paced the knitting machine favourably for Player one, the result when players swapped positions was not always a continuation of cooperative play. Sometimes, when players swapped, the player who had been on the buttons would deliberately knit fast to make the game harder for the other player. This demonstrates that the player on the knitting machine had more agency over the outcome of the game than the player on the control buttons.

In Chapter 1 (section 1.3), I discussed player motivation, citing Schell's view that a "game's success hinges on the players willingness to pretend it is important" (2020:43). Observations of both competitive and cooperative play, participants engaging with *Hazuki Knit* demonstrated a preference for the outputs of the game elements, valuing competitive play and/or a high game score over the knit output. The autotelic nature of craft labour with the "desire to do a job well for its own sake" (Sennet, 2008:9) was not observed to motivate players to produce a quality output in terms of the knitted fabric. Instead, the knitted output had no endogenous value (Schell, 2020) for participants within the context of the grafted game. This is likely to be linked to the framing of the grafted game as 'a game' within the themed events and through our introduction and explanation of the game which focused upon the game score. Perhaps this outcome may have been different if the activity had been framed differently, with more focus upon the craft output as a craft object and/or if we had involved participants in the processes of casting on and correcting errors in the knit fabric. Through including participants in these slower aspects of the recovery of the craft object, participants may have demonstrated motivations relating to ‘pain avoidance’ as well as ‘pleasure seeking’ (Schell, 2020). Motivations and the value of the knit output alongside the game score could also be impacted differently if the quality of the output was linked with external reward or punishment, as would be the case in the production setting of a factory.

Summary

In this section I have discussed ways in which participants engaging with *Hazuki Knit* adapted their gameplay and developed strategies to avoid Game Over and optimize their game score. During observations it was possible to see evidence of previous experience and the embodied aspects of skill in players with previous experience of using game controls through their positioning of their hands and fingers at the buttons on the control panel. Similarly, optimising finger and hand positioning over the game buttons, to improve accuracy and reduce clumsiness, was also observed through repeated gameplay of inexperienced players, resulting also, in slightly improved scores.

As a two-player game, two distinct forms of gameplay were noted throughout observations, with different strategies developed based on opposing motivations: competitive and cooperative gameplay. During observations, players would either work together towards the joint goal of achieving as high a score as possible, or Player two would work competitively to make the game as hard as possible for Player one on the controls. Both aspects were predominantly determined by the actions of Player two on the knitting machine, with knitting faster making it harder for Player one, or knitting more at a more considered speed, allowing enough time for Player one to press the control buttons.

The production of knitted fabric as an output of the game, did not appear to be as motivating for players as achieving a high score. Moving the knit carriage faster would produce more rows of knitting in a shorter time but resulted in more errors within the knit fabric and an increased chance of Game Over through the knit carriage jamming. In some instances, the fast pace of knitting in a competitive game resulted in damage to needles on the knitting machine. This increased risk of errors or failure in the knitting within competitive gameplay is not an outcome that would be desirable in a manufacturing context. Such an outcome could be detrimental to production, especially if competitive gameplay led to damaged machines. Both aspects of gameplay, however, do demonstrate a high value placed on the game score for participants with strategies to improve being motivated by improving this output. This could be of value in a manufacturing context if the ‘score’ related to efficiency and productivity, but competitive aspects would need to be carefully considered.

The discussion on cooperation and competition highlights a tension between the two forms of gameplay but also brings to the fore how both aspects could potentially be useful within a manufacturing setting. As well as value being placed on the game score by players, grafted interventions within a manufacturing setting could impact other aspects of productivity, not just efficiency, through increased worker satisfaction. Outside of the drop-in settings of the participatory events, grafting may pose more potential to build or reinforce a sense of community within a work setting, enabling dialogic and/or dialectic exchanges that may promote greater communication between workers and the sharing of good practice.

5.5 Conclusion

I set out at the beginning of this Chapter that this section of the research sought to explore grafting as an approach in meeting research aim 2: *to identify the relationship brought about through directly connecting craft and gaming*. As set out in Chapter 2, Grafting is a term I have borrowed from horticulture to describe the process of bringing together two individual yet compatible elements to bring about a desired outcome. In this case, I have sought to investigate potential outcomes that could be of value to the manufacturing industry, specifically those that rely on highly dextrous craft skills as part of their production. This Chapter has begun the exploration of this potential through the analysis of observations of participant interactions with prototype graft-game *Hazuki Knit*. Participants were made up of general interest audiences with varied existing experiences with craft and gaming at a series of thematic public events. Using the crossovers identified through Chapters 2 and 4 as a lens to explore and evidence what impact grafting had upon the individual aspects, the following insights have been identified:

- A key insight was that through physically grafting the knitting machine with the digital game not only were the individual elements impacting upon one another, but the two-players experienced grafted gameplay as a result. This was witnessed throughout the thematic crossovers lens but was seen primarily through the creation of additional material affordances that became clear only through direct engagement with the grafted game.
- Feedback given to both players through the individual elements was less cohesive with the game aspect seeming to overpower the feedback of the craft aspect. As discussed in section 5.4, audio feedback provided through the digital game and the knitting machine appeared to be well balanced. Visual feedback, on the other hand, was stronger from the digital game in the sense that the visual screen and the presence of the second player appeared, through observations of gameplay, to distract from any visual attention that may have otherwise been given to the visual feedback of the carriage moving across the knit bed and the knitting being created.
- The score, which could be seen to be linked to both aspects of gameplay as a direct result of both players' input, appeared to be more highly valued by participants than the knit fabric being produced.
- Although unrecoverable Game Over may have occurred more frequently on the digital element of the grafted game, Game Over experienced on the part of knitting required much more time and skill to recover from in order to re-start the game. This suggests that grafting, put the knitting at higher risk of unrecoverable failure than the digital game with Game Over easier to recover from in a digital environment.
- As engagement from participants was generally short-term there was little opportunity to witness the embodiment of skill occurring, although habitual practices of players with existing experience (specifically with gaming) could be observed through hand positioning over the game buttons. With a desire to improve scores, many participants were seen to make efforts to adapt and optimise

their bodily movements through repeated gameplay. For example, adjusting hand and finger positions to make movements more efficient and able to react to the game prompts more quickly.

- Optimising gameplay and the development of strategies to avoid failure were affected by two key categories of grafted gameplay: competitive and cooperative. Direct competition derived from the two-player aspect of the game in some instances led to highly competitive strategies in which participants actions were motivated, as Player two, to ‘knit’ as fast as possible to make the game deliberately difficult for Player one. This resulted in increased incidences of failure, especially unrecoverable failure on the part of the knitting which was put at higher risk of unrecoverable damage. In opposition, cooperative gameplay saw the development of strategies among players working collectively to achieve a higher score. These included participants controlling the knitting machine, carefully pacing their actions in response to those of Player one, using grafted aspects of feedback and their understanding of the grafted affordances of the graft-game.

These insights are summarised in relation to the identified craft and gaming crossovers in Figure 5.13 below:

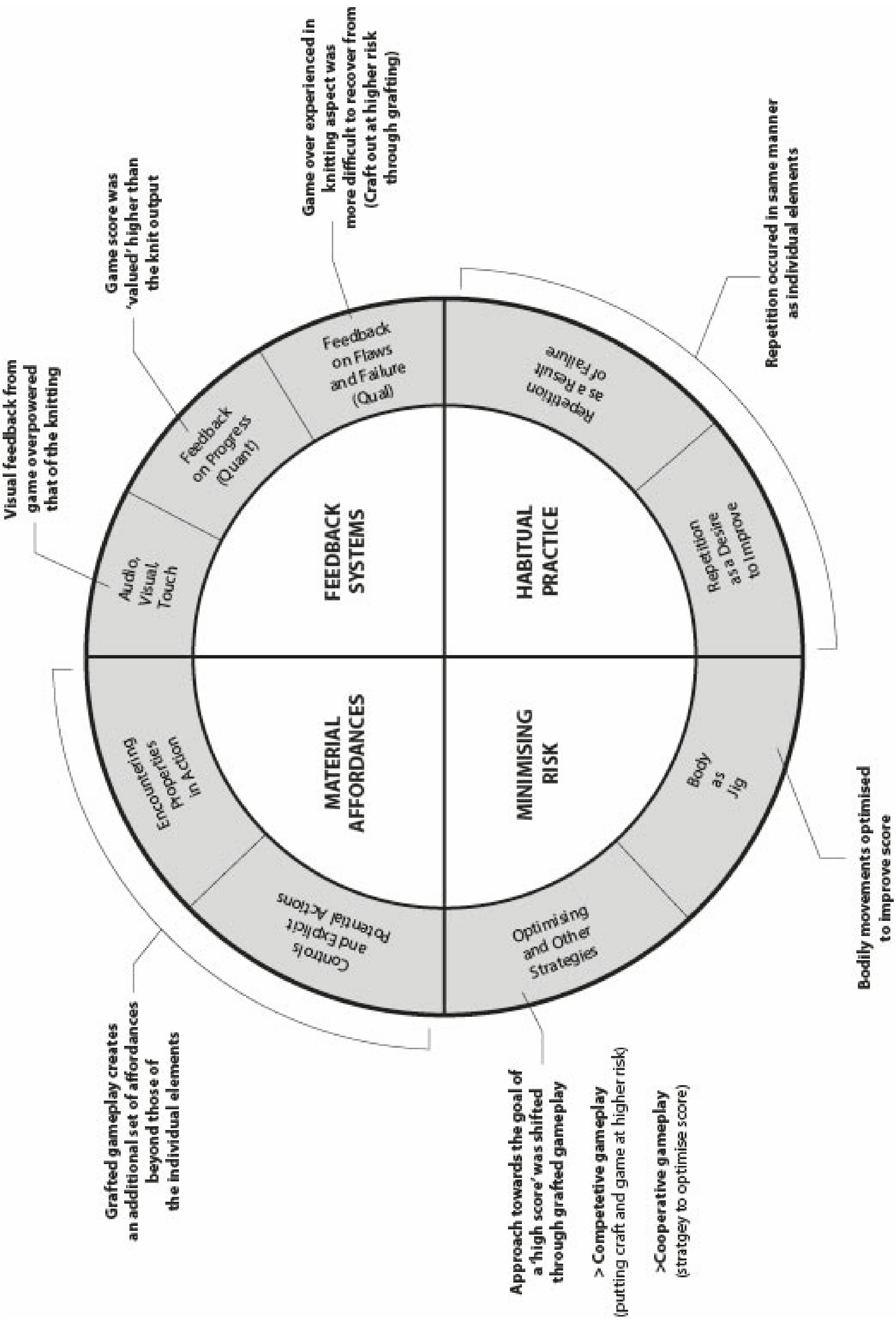

Figure 5.13: Key insights of *Hazuki Knit* in relation to conceptual model of craft and gaming crossovers

Although insights were made within each thematic crossover area not all suggested potential for value within contexts beyond the individual elements. In particular, additional material affordances beyond those of the individual materials, were developed through grafted gameplay but these affordances alone do not stand out as an outcome that may be of potential value within industry. Similarly, existing embodied practices were highlighted in the bodily movements of participants with prior experience but observations of further development of habitual practice was limited due to the short-term format of the events attended. However, repetitive gameplay, driven by a desire to achieve a higher score as a result of experiences of failure within the digital aspect, is likely to have played a role in the adapting of bodily movements observed in repeated gameplay. The thematic crossovers of 'Habitual Practice' and 'Material Affordances' may not have directly revealed potential for value beyond the individual craft and gaming activities but are likely to be linked to those found within the remaining areas.

As discussed within this Chapter, not all of the impacts observed resulted in positive outcomes, some had more negative impacts, specifically those which put the quality of the craft output at risk. Such an outcome would not be desirable in a manufacturing context when quality production is imperative. Negative impacts included:

- Unbalanced feedback with the game aspect overpowering that of the craft, specifically visual feedback.
- Competitive gameplay leading to an increased risk of Game Over in both aspects but with the craft output being put at higher risk or poor quality or damage.

These negative impacts could, however, pose areas for further exploration. Although impacting negatively on the craft in this case, these outcomes do demonstrate that grafting affects how participants approach the grafted elements which could be utilised and accounted for differently in future prototypes.

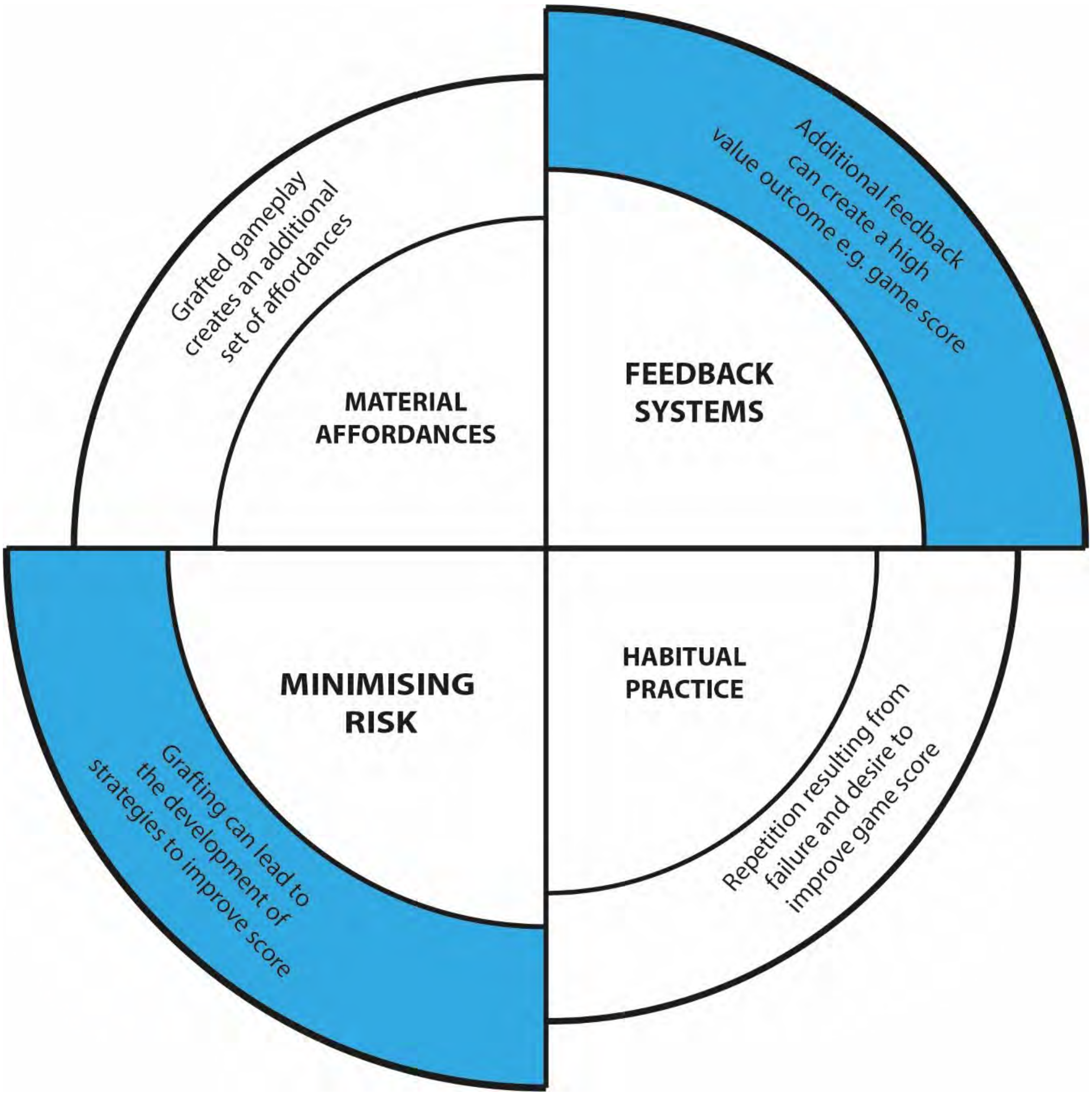

Figure 5.14: Key areas of potential impact indicated through analysis of *Hazuki Knit*

The direct competition of the two players clearly posed the potential to create a highly competitive environment that in this case resulted in the craft output being put at higher risk of failure. The same context, however, in a similar number of instances led participants to develop strategies for gameplay, adjusting their craft actions in particular, in order to maximise the game output i.e., the score. It may be possible that this aspect could be drawn out more in future developments.

6_Cookson & Clegg

Having identified some potential outcomes and areas impacted through the process of grafting via observations of *Hazuki Knit,* the next two Chapters of the thesis will consider potential value of those outcomes in the context of manufacturing. This Chapter focuses on the commencement of Strand Three: ‘Finding value’, aiming *to highlight the potential value grafting could have for and beyond the individual disciplines of craft and games*. In particular, this Chapter focuses on where potential value could arise through grafting in the context of manufacturing. This will be further explored through the development of a second graft-game, *Pocket Racer,* that will be discussed in the following Chapter (chapter 7). First, this Chapter will outline the challenges currently faced by one manufacturer in the North West, project partner *Cookson & Clegg*, discussing the analysis observations of tasks being carried out by skilled machinists on the production line. Observations made will be discussed in relation to the theoretical crossovers identified in Strand One (Chapters 2 and 4) and the outcomes of grafting revealed in Chapter 5. In doing so, this Chapter will highlight opportunities within the current working practices of the factory where improvements are currently desired or that could support the company’s goals for growth. Insights gained through these observations will feed into the analysis of second graft-game, *Pocket Racer*, to follow.

Throughout this Chapter, I will draw on my previous experience as a garment technologist and product developer when discussing garment construction methods.

6.1 Introduction to the Factory

As discussed in Chapter 3 (Methodology), as part of Strand Three of this research, I worked with an industrial partner to assess current challenges faced by them as a business. Through a case study with garment manufacturer *Cookson & Clegg* I will identify areas where value could be added in support of business growth, in terms of insights, interventions and changes to current working practices. As a company, *Cookson & Clegg* has been based in

Blackburn, Lancashire, since it was founded in 1860. The company has produced an array of specialised products over the years, beginning as a leather currier then going on to produce flying helmets and leather products for the British Army in the 1930s. The company now manufactures a range of outerwear, jerseywear and legwear for brands such as Nigel Cabourn, E.Tautz, and Community Clothing (their sister company). As promoted on the company's website, the firm today employs the "same skills essential in the production of military grade products and applies them to the manufacturing of premium quality textile products" (Cookson & Clegg, ND: online). Roles include skilled sewing machine operators, pattern cutters and finishers that require a high level of dexterity and knowledge of material and garment construction. The factory is equipped with advanced sewing equipment including industrial lockstitch machines (such as Juki DDL-9000B-SH and DLN5410N-7) alongside specialist machines including programmable automatic pocket jet sewing machines (that despite involving automated actions require a highly skilled machinist to set up and operate), three needle feed-off-the-arm chainstitch machines and the capacity to tape seams on waterproof garments. The array of machines alongside a need for the production of high-quality garments, as is expected by the market level of the brands they manufacture for, requires machine operatives to have knowledge of multiple sewing techniques and manufacturing processes along with the ability to work accurately in a fast-paced environment. This could be seen to be in stark contrast to the self-led pace of making in amateur craft such as the examples discussed in Chapter 3. Gaming could be seen as a practice that, depending upon the specific goal of the game, encourages skilled work at a pace set by either the game rules (Juul, 2011) or is encouraged through competition in the game. For example, the goal of *Mario Kart 8 Deluxe* (discussed in Chapter 3) was to win races by completing races faster than any other player in that race. *Hazuki Knit,* when played competitively (see section 5.4) encouraged players on the knitting machine to knit at a fast pace in order to increase the speed of the digital game, making it harder for the other player. The desire to increase worker output through increased productivity and efficiency was something expressed by the management team at *Cookson & Clegg* and, like many modern businesses, were drawn to the potential of digital systems to support this. Through working with me they hoped to gain insight into the potential that my research might offer.

Through initial discussions with the management team, it was highlighted that the company faced various challenges. Primarily they wished to improve production processes through the adoption of a *digital workflow* system. The company hoped that the implementation of a digital system that tracked the flow of production through the factory would provide access to data and give insights into areas for improvement including: increased efficiency of production, reducing wastage of time and excess processes; meeting production targets more consistently; allow production costings to be updated and better maintained; better sharing of knowledge across teams; increased motivation for workers with support to hit targets and achieve bonuses. This was later formalised in a Digital Strategy document which can be found under Appendix D1. I will summarise the key challenges here:

Workflow	Production flow is inefficient, with production targets not being met consistently. Production costings, which are based upon estimates of process timings, are considered out of date and inaccurate.
Management	The company, lacks data with knowledge held within the heads of certain staff members. According to the document, this leads to decisions being made based upon individual assumptions.
Control	A lack of control over the delivery of raw materials and visibility of the critical path is cited alongside uneven and unpredictable workloads.
Customers	The customers range from big companies who work within a model of two seasons per year, causing peaks and troughs in demand, and smaller start-ups who have little knowledge of manufacturing, whose orders tend to be smaller and unpredictable.
Employees	The workforce is motivated by money yet disengaged with workers not consistently hitting targets and infrequent bonuses.

Ongoing discussions with the company revealed a desire to adopt a centralised 'digital workflow system' to address these challenges. Long term, the implementation of such a system would be incorporated with some automated machinery, such as fabric cutting plotters, although automation of all processes was acknowledged as being unlikely. The company have a strong desire to employ and retain traditional skills within the local area (to both support the local economy and the region's heritage), and the unpredictable nature of their customers' orders make full automation complex. The need for a flexible production line that could remain adaptive to customer needs as opposed to producing large quantities of like-for-like garments is vital. As proclaimed digital novices, in terms of production, the company had located a digital platform called *Galaxius* which they planned to implement to record and monitor all operations. This system is based primarily around the use of QR codes to track production batches as they move through the factory. The aim for this system was to provide real time data that would assist the management team in assessing operations and to better cost items for their customers. The company is a good example, therefore, of a manufacturer facing the challenges of adopting the use of digital technology in a context where craft skill plays a core role, making this case study well suited to this research. In addition, the company were interested in the dual exploration of gaming with craft in relation to their plans to implement a digital system within their skilled production. This research took place prior to the implementation of the *Galaxius* system with the intention that the research insights could be fed into the potential customisation and development of a digital application within the factory at a later date.

6.2 Methods

As stated in Chapter 3, observations of current practices within the factory have been analysed and will be discussed within this Chapter in relation to the theoretical crossovers identified between craft and gaming: material affordances, feedback systems, habitual practice and avoiding failure. These themes were also cross-referenced with the impacts and outcomes of grafting revealed in the previous Chapter. To recap, the key areas of potential value identified were as follows:

Material Affordances: Grafting creates an additional set of affordances

Feedback Systems:	Additional feedback can create an additional outcome that maker and gamer value, e.g. game score
Avoiding Failure:	Grafting can lead to the development of strategies to improve outcome

This Chapter will consider these areas whilst investigating the existing working practices with the factory, questioning if they may align with current challenges faced.

In alignment with the company's goals outlined above, initial observations of tasks being carried out by skilled operatives in the factory were undertaken prior to a digital system being implemented. Staff members on the production line were assigned numbers (as P number) for the purposes of the research and a total of six workers operating sewing machines across the two production lines within the factory were observed in depth using the methods described in Chapter 3. Observations were documented and data collected through video recordings (ranging from 37 minutes to 1 hour 50 minutes), photography and field notes over four site visits. Observations focused on processes and tasks being carried out along with observations recording aspects of the organisation of tasks, both by the individual machinists and across the production line. Following each session video recordings were fully transcribed by way of description of actions being carried out rather than spoken word. Many staff members did not speak English as their first language and would usually communicate with fellow machinists in their own language. This made full transcription of spoken conversations difficult, but it was felt that, due to the focus on actions being carried out, it would not be necessary for this research.

The factory floor is broken down into two 'lines', although the arrangement of machines within each is not fully linear. The 'jeans line' concentrates on the production of jeans and heavy weight trouser styles, and the 'main line' produces woven garments ranging from shirts and jackets, and jerseywear including T-shirts and sweaters. All orders commence production on the cutting table which is located on a mezzanine level above the factory floor (see Figure 6.3). Once the fabric is cut, orders are split into sizes with all fabric pieces for all of one size, ten size 'Large' shirts for example, placed into a crate. Crates are then hand carried downstairs ready for sewing or collected when needed. Each line has one supervisor who manages the assigning and monitoring of tasks on their line, with every style having a predefined series of processes that are to be completed. Due to the nature of garment construction, processes need to be completed in a particular order, for example a shirt placket is attached before the collar is added, thus requiring the passing of crates from one machinist to the next before garments are fully constructed.

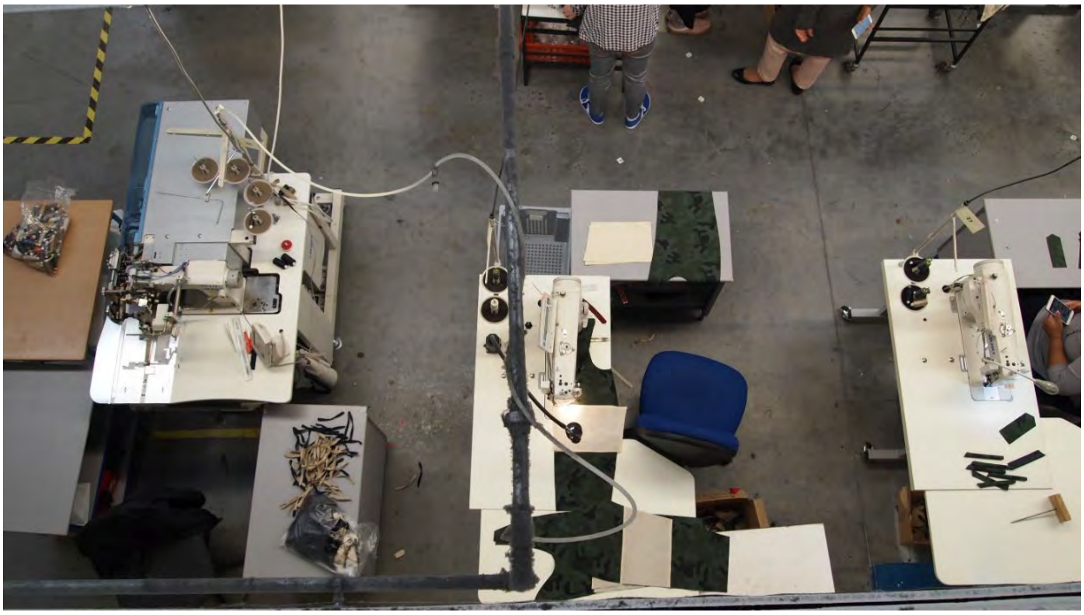

Figure 6.1: Image of machines on 'main line' taken from mezzanine floor

Figure 6.2: Image of some machines on the 'jeans line'

Figure 6.3: Image of mezzanine level with cutting table in the background and crates, where cut batches are sorted, in foreground

6.3 Habitual Practice

As discussed in Chapter 2, the acquisition of craft-based skill is ascribed to learning through habitual practice through which skill is embedded through routinized procedures (Sennett, 2008; Risatti, 2013). Video game players similarly develop high levels of dexterity through many hours of gameplay (Reeves et al., 2009). The existence of habitual practice in both craft and gaming also leads to the embodiment of tools to the extent that they become an extension of the hand (McCullough, 1996; Pallasmaa, 2009; Keogh, 2018). Overtime the gestures of both the craftsperson and the gamer thus become habitual to particular tools. When observing machinists working within the factory, I observed standard working practices making no interventions at this stage, including the use of existing tools. Just as it could be assumed the staff within the factory had a good knowledge of the materials being used due to ongoing everyday practice, I did not witness any instances of machinists stumbling over habitual action (Tanaka, 2013) that may have resulted from any changes to tools or practices. This lack of evidence supports the evidence of habitual practice and embodied tools being present with all participants working seamlessly and un-hesitant in their tool use. The existence of habitual practices is further supported through the dedicated use of single machines by certain workers. Across multiple visits it was also possible to see that the machinists each had a dedicated machine that they sat at consistently for basic sewing (lockstitch), only moving to use another machine for a specific purpose that it was set up for e.g. lockstitch machine set up for binding only with a specialised attachment (see Figure 6.4).

Figure 6.4: Binding attachment

Some machinists worked predominantly on specialised machines such as button-hole machines, overlockers or a 'run and fell' machine specifically designed for sewing side seams together with a flat twin needle finish (see Figure 6.5).

Figure 6.5: Run and fell machine

In Chapter 4, through amateur craft and gaming case studies, I demonstrated how feedback from material on quality and performance leads to repetition which enables the acquisition of skill and the embodiment of tools. Factory staff observed are assumed to have been working on the production line daily for some time, if not years, and must have already reached a particular skill level to have been deemed employable. Skill acquisition has thus, likely, already taken place but may be further supported by the repetitive nature of the production environment where the same tasks are carried out many times for each order. In Chapter 4, I further identified two ways in which repetition occurs: firstly, as a result of failure, and secondly as a desire to improve quality. Whilst making observations within the factory, I witnessed a minimal number of occasions where an error, or poor quality of a finished garment was picked up during quality check at the end of the line. In these few instances the item was taken back to the machinist who carried out the task where the error or poor finish may have occurred and given to them to correct it. On the odd occasion this also occurred further down the line where one machinist would spot an error made by a previous machinist and return it to them for correcting before carrying out their own designated process. I must emphasise how few of these instances occurred though, based on the number of items being processed whilst observations were carried out. I would not expect to witness regular mistakes or errors in a production setting where skilled machinists are employed. High quality is a clear expectation of the role and poor quality finishes on a regular basis would not be accepted.

As stated, repetition is an inherent aspect of bulk production and observations made within *Cookson & Clegg*, demonstrated repetition driven by this nature rather than as a result of failure or any personal desire to improve as had been observed of amateur craft and gaming practices. With craft skill already acquired to a certain level for employment on the production line to exist repetition may support the ongoing maintenance of skill levels and habitual practice clearly exists within the working practices of the production line. A desire to improve performance, however, could be fostered through grafting, where, as seen during observations of *Hazuki Knit* (in Chapter 5), a higher game score becomes a valued output. If this score was linked to productivity, a grafted intervention may have the potential to be of value to the company by reducing sewing time and increasing production output.

6.4 Material Affordances

In Chapter 2 I outlined how both craft and gaming practices involve an encounter with material (Risatti, 2013; Tanaka, 2013; Harrod, 2015) and that each material has a unique set of properties (McCullough, 1996; Adamson, 2007, Juul, 2011) that define what a material can and can't do (affordances and limitations). In Chapter 4 I discussed how material knowledge can be expressed through explicit instructions, tutorials and control lists, through a series of amateur craft and gaming case studies. Even when made explicit, however, these case studies demonstrated that potential actions are only truly understood when experienced directly.

The machinists observed in the factory generally had a good understanding of what actions were required for styles and fabrics produced on the line and I did not witness any specific evidence of machine operatives encountering material affordances anew. Although styles being produced in the factory vary, fabric types observed tended to sit within particular categories: jerseywear (such as knitted T-shirt and sweatshirt fabric); denim and heavy weight twills and cottons on the jeans line; and various weights of woven shirt and jacket fabrics. It could be assumed that for staff working on the factory floor on a daily basis, handling these regular categories of fabrics and using the same machines, will have gained a certain level of knowledge of the affordances and limitations posed by materials commonly used for orders. The factory does, however, often produce small orders with few styles being made in large quantities. These styles are often produced in familiar fabrics but do still require new knowledge of what is needed for new styles to be made explicit. During observations, there was some evidence around the factory floor of such instructions or required actions being made explicit for machinists. For example, signed off sample garments, sometimes with notes attached, were positioned close to workstations to act as a reference (see Figure 6.6).

Figure 6.6: Garment sample with notes for production attached

These completed garments provided a reference point for garment finishes and required quality thus making explicit the required outcome with notes highlighting any changes that were required to be made in production. During one visit, the factory manager mentioned that the line was under pressure with an urgent sample order. A sample order is a very small order of garments that may be used for promotion and marketing purposes, as salesman samples for example, as opposed to bulk orders for sale. I observed during this session the supervisor on the 'main line' handing out tasks to staff and in some instances demonstrating specific processes. This was different to the activities observed for non-sample orders when staff would, in the majority of cases, organise themselves, collecting crates of items, and seemingly proceeding with tasks without the need for additional instruction.

As demonstrated through the analysis of interactions with *Hazuki Knit* (in Chapter 5), grafting can provide an additional set of material affordances. Unlike the machinists observed in the factory setting, participants engaging with *Hazuki Knit* were generally engaging with two sets of new affordances, with little existing knowledge of knitting especially. For any future grafted intervention within the factory, the materials used in production cannot be changed, so new material affordances would be added in the form of affordances of the game that is grafted. Later in Chapter 5, analysis demonstrated that grafted gameplay required direct and repeated engagement with the grafted material affordances in order to gain an understanding of them. Could grafting, in this context, provide an additional set of affordances via the game elements that link to desired outcomes for increased efficiency in production? In the next section I will discuss existing feedback systems observed within the factory and open up the potential space for grafted feedback to provide a new high value outcome for staff.

6.5 Feedback Systems

As discussed in previous Chapters, both craft and gaming involve an implicit conversation between maker/gamer and material in which material and tool provide the maker/gamer with continuous feedback that the maker/gamer responds to (Korn, 2015; Ingold, 2011; Parisi, 2009; McGonigal, 2011). As established in Chapter 4 both games and craft provide feedback through visual, audio, and haptic forms. This process was observed to be no different in the factory setting with machinists receiving feedback from material, both directly and via their tools including machines being controlled. Feedback was received in the following ways:

Visual – Machinists were able to visually monitor fabric pieces moving through the machine and under the sewing foot, continuously checking the position in relation to the sewing foot. The quality and success of stitches being produced was also monitored, checking it remains in-line with seam edges and for signs of errors in individual stitches.

Audio – The sewing machine provides audio feedback via the sound of it running, with the pace and volume directly affected by the machinist's foot on the foot pedal which determines the speed. This sound also changes subtly for different points on a stitch-line and when the machine moves over different thicknesses of fabric, all of which the machinist has learnt to recognise.

Haptic – With their foot on the machine's foot pedal and their hands and fingers holding and guiding the fabric pieces through the machine, the machinist receives haptic feedback through the body and are able to adjust their movements in response.

These aspects of feedback from the material and machine enable the machinists to respond to, and adjust, their actions to control the quality of the output. All these aspects relate to individual skill and quality of overall production. Based on observations made, the feedback provided via the sewing machine, material and related tools, gave adequate information to the machinists for them to be able to control the quality of their output. As discussed at the beginning of this Chapter, quality is an important aspect of production that needs to be maintained. This is not the only concern of the factory. Production flow is currently deemed to be inefficient with costings based on potentially out of date process timings and production targets not being consistently met with individual bonuses given infrequently. With the desire to implement a digital system to track workflow, attention was given during observations to ways in which progress was tracked both by individual machinists and collectively across the production lines.

Feedback on progress

In previous Chapters, I have discussed ways in which an individual maker and gamer tracks progress towards a particular outcome. Whilst knitting the *MOP Sweater* in Chapter 4 and the knitting aspect of *Hazuki Knit* in Chapter 5, the counting of stitches and rows and the visual feedback of a tangible piece of knitting growing was tracked as progress was made. Similarly, the game aspect of *Hazuki Knit* provided feedback on progress via a constantly updating score displayed on screen, as play progressed successfully, the score got higher just as the piece of knitting grew longer. When playing *Mario Kart 8 Deluxe* progress was fed-back via on screen displays showing the players race position throughout, whereas progress towards completing the game of *Unravel* was fed-back via the 'home' screen showing which levels had been completed. Through various methods, individual machinists within the factory were observed to be able to view the progress of both individual pieces being constructed and that of the current batch they were working on. Audio, visual and haptic aspects of feedback described above enable machinists to track progress through individual tasks, for example, via visual monitoring of completed stitch-lines and the position of a fabric piece as it moves under the 'presser foot'. The sound of the sewing machine also continuously responds to the actions of the machinist's foot, controlling the speed of sewing (via the foot pedal), and confirming successful action of the back stitch function, where required, at the start and end of stitching a piece.

Alongside monitoring progression of individual pieces, observations and analysis of recordings suggested that individual machinists tracked the progress of batches, consciously[9] or otherwise, in the following ways:

> -movement of items via the use of piles to arrange work around the machine area as completed (visual indicator)
>
> -crates with batches are used similarly to transfer uncompleted and completed items (visual indicator)
>
> -counting of items and potential tracking against crate info sheet and/or personal notes (quantitative/written)

I will discuss observations of these methods being used before highlighting what was not seen to be tracked or monitored on an individual level.

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[9] by consciously I mean that these actions were observed as commonalities in the working process of the participants, but it was not expressed explicitly by participants that these methods/approaches were being used deliberately to monitor progress.

Visual indicators

All participants were observed to organise fabric pieces and completed items into various piles or work. For example, Participants **P4** and **P1** were seen to take items from a pile of work they had placed to the left side of their machine table and, once sewn, placed it on a pile to the right of their machine. The position of piles and movement of items between them varied between participants with some placing smaller fabric pieces, such as trouser fly's, in one area and large panels on larger table areas. Whatever the method of organisation and movement between piles, getting to the end of a pile of items seemed to indicate to the machinists that they were to move onto another task. The next task depended upon the particular styles and stage of construction, but completion of piles generally led to the machinist collecting a new pile or taking the completed items to another machine to commence another process. One participant (P10) even gave me a thumbs up when he had completed a pile.

As previously described, garment orders are transferred from the cutting area to and around the factory floor via crates in which orders are divided up by size. During observations, machinists were seen to use the crates as a means of organising their workload and to track progress as an extension of the use of piles around their work area. All participants observed positioned crates around their work area removing items, individually or in piles, periodically to process them and returning completed items to the crates when done. The act of returning completed items was often accompanied by neatly folding the pile together, perhaps to reduce movement of individual items in the crate.

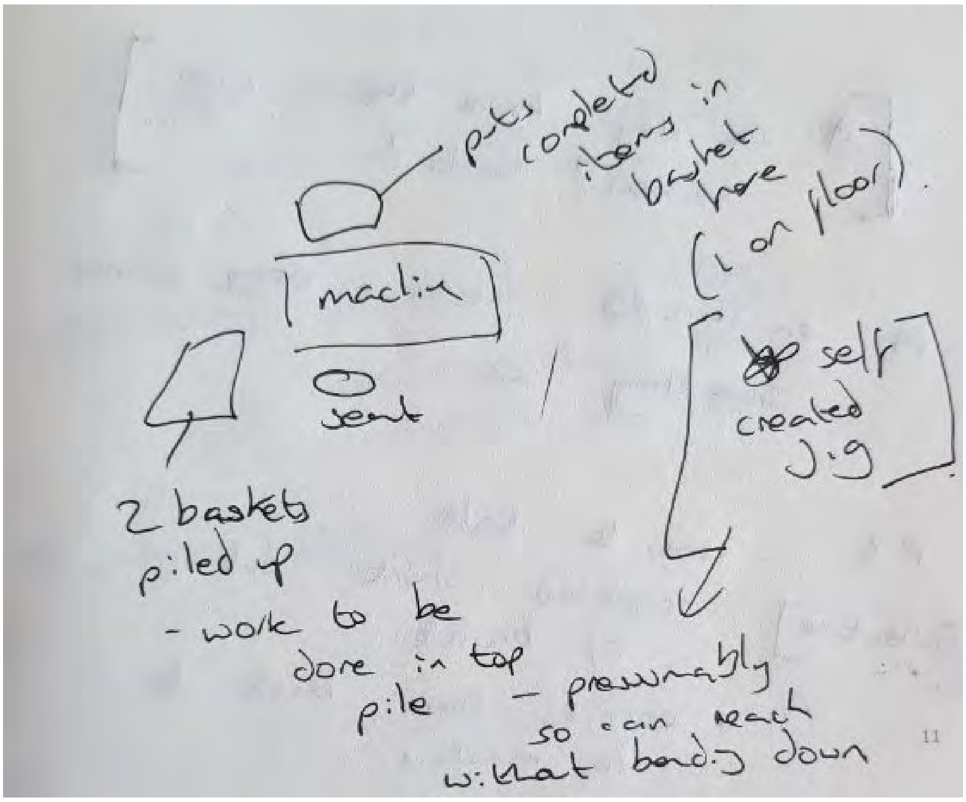

Figure 6.7: Diagram of crates around workspace of P10 taken from field notes

Figure 6.8: Crates positioned around workspace of P10

These crates of batches of items were seen to move between machinists throughout the production line as tasks were completed. Many participants were observed to collect crates from the back of the factory floor, where they had been brought from the cutting area, ready to commence a task. After completing piles of a particular process, the machinists were then often observed to move crates to another machine, either to process a different task themselves, or to pass onto another machinist. Other crates were moved to the front of the production line, perhaps once all tasks were completed or to wait until another machinist was ready to collect it. This movement of batches along the production line (although often not a distinct linear direction of travel), acted as a means of assessing the progress of an order. Piles of crates building up in one particular area, for example, could indicate a back log of work at particular task.

Written and quantitative tracking

Explicit tracking in the form of written notation, that had been observed within amateur practices, was observed to a lesser extent in the factory. Each crate had with it a docket that listed the style, size, colourway and quantity of garments within it i.e., all the necessary pieces to complete that many garments. For example, the crate pictured in Figure 6.9 contained five of every fabric piece, enough to complete five complete garments in size 8/XS.

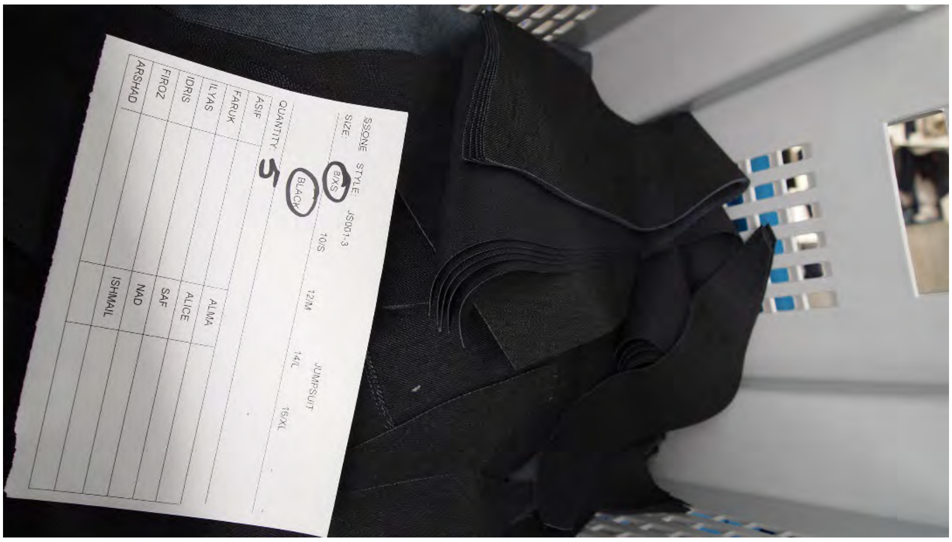

Figure 6.9: Crate with docket

Machinists did not appear to annotate or add to the information of these dockets as crates are moved around the production line, but it would certainly have given each machinist coming into contact with that crate, guidance of the number of items to be completed. Besides these dockets, it was not clear as to whether individual machinists had any awareness of targets beyond the number of items within each crate, especially the target (or costed) task timing.

The supervisor of the main line kept track of work across the line through a written list of crate numbers, including the garment size and number of pieces within them. Another machinist was seen to count items in a completed task pile before writing something in a personal notebook at the side of her machine. It is possible that this participant was keeping track of how many items she had completed but this was not confirmed. Of the six participants observed these written forms of tracking were only observed in two instances so potentially a minimally used method but one that could still be of value to those individuals using it.

A duo of large white boards was positioned at the front of the factory floor, visible to all machinists. The white boards appeared to display a series of production targets.

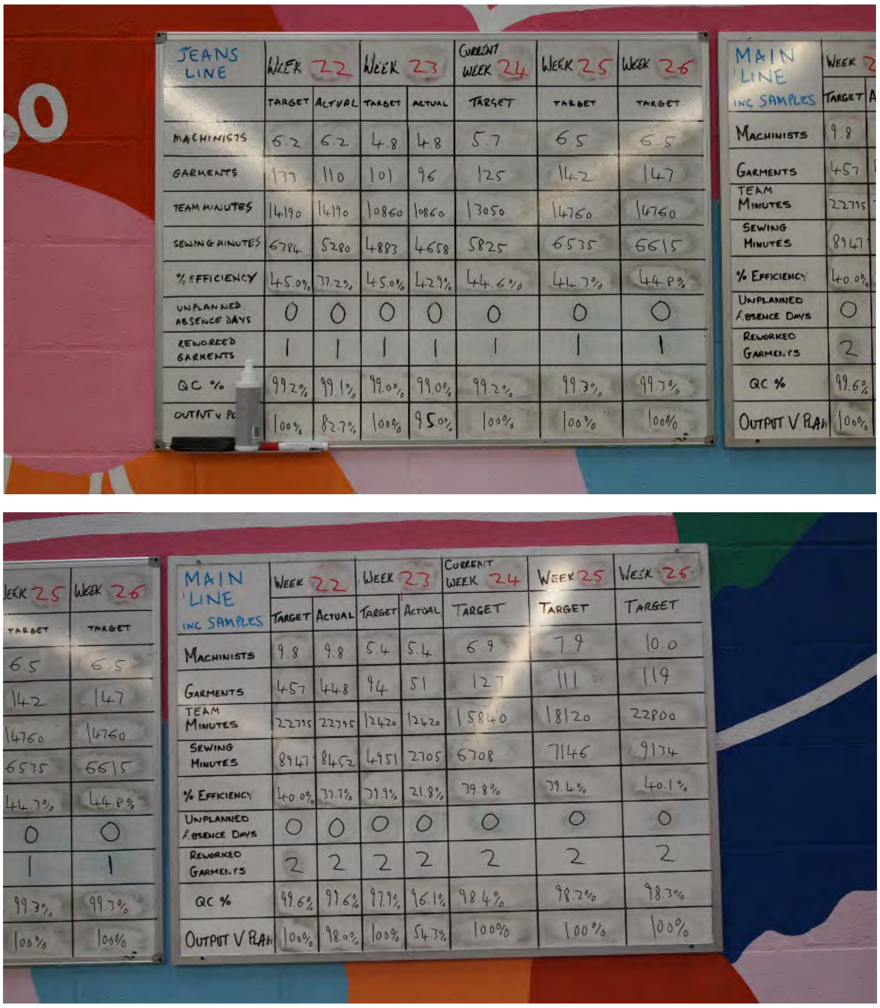

Figure 6.10: Production targets displayed on whiteboards at the front of the production lines

These displayed a series of targets for the previous two weeks, the current week and the next two weeks, with actual figures achieved written against past weeks. Despite the prominence of this information, it was unclear as to how much machinists on the line referred to it, having not witnessed any participants engaging with it during visits. The value of this information to individual machinists is unknown.

Awareness of progress

As discussed, the above methods may or may not have been activated consciously as ways of tracking progress of individual and collective tasks. As forms of feedback though, it is likely that the use of piles and crates to organise items and the more explicit written measurements inform the machinists of their progress towards completion of tasks and batches on some level. Unlike observations made during my own craft and gaming activities or those of participants playing *Hazuki Knit,* however, there was no evidence of machinists in the factory celebrating moments of completion. When finishing tasks or batches all participants observed simply moved on to the next activity or took the pause as an opportunity to break from tasks, for a bathroom break for example. This suggests that other than marking the passing of time and marking physical progress through their workload, the machinists observed did not seem to value these moments with a sense of achievement. One participant (P10), who seemed to wish to converse with me whilst I observed their activities, made mention of their progress. Whilst attaching belt loops on a pair of trousers, at one stage they said to me “still one job left” after completing a pile, thus demonstrating an awareness of their progress. This conversation, however, occurred after I had earlier asked them how many items they had done, to which they responded by showing me the docket in the basket, so their explicit awareness could have been prompted by my question.

Analysis of observations made suggest various ways in which individual and collective progress of items and orders are made on the production line. Individual machinists were able to monitor progress of individual tasks on the sewing machine, via the feedback offered from both the machine, tools and material. Observations of machinists’ activities also suggested that individuals may track progress through a batch of tasks through the movement of items via arranged piles of items and crates used to hold the full batch. All of these methods (explicit and implicit) track progress towards completion of either items or batches, thus progression through the workload. Individually this suggests that machinists are able to understand what work they have completed and what is left outstanding. Collectively this demonstrates an ability to track progression of orders that will ultimately be packaged and shipped to customers. What was not observed as being fed back to or tracked by individual machinists, however, was information relating to efficiency of tasks being completed i.e., the time taken to complete, a figure upon which styles are costed. This highlights an area for potential value to be added through grafting. As discussed in Chapter 5, grafting creates an exchange in which additional feedback can create an additional high value outcome, which in the case of *Hazuki Knit,* was a game score. Grafting, therefore, could provide an opportunity to give the factory machinists consistent feedback on their progress or achievement of targets relating to their efficiency, for example if the feedback related to the time taken to complete individual tasks at the sewing machine.

6.6 Strategies

In previous Chapters I have discussed the use of tools and jigs that makers and gamers use to both access and manipulate their materials (physical and digital) and to aid control over processes. As discussed in Chapter 2, a *tool* is "part effector, part probe", enabling the maker to "work a medium" (McCullough, 1996:63). Material specific tools are often complimented by *implements* that measure and assist observations as well as the use of *jigs* and templates that increase certainty in a particular process. Collectively, these can be seen to improve quality and reduce risk. Practices observed within the factory were no different with many different tools and implements seen to be in use by all participants. Through the discussion of observations of engagement with graft-game *Hazuki Knit* in Chapter 5 we saw that the players of the game, within a relatively short time, adapted their gameplay and developed strategies driven by a desire to improve their game score. These methods included adapting bodily positions and movements to maximise efficiency and the development of cooperative gameplay with some players working collectively to maximise their game score. In this section I will discuss the analysis of observations of specific tasks being carried out by machinists in the factory, seeking to identify strategies that participants might already be using. In addition, I will highlight areas where there may be potential for grafting to promote the further development of strategies to improve efficiency. Specific tasks being carried out during observation sessions tended to vary from machinist to machinist, so it was not always possible to directly compare tools and techniques. But through a series of examples of commonalities I will outline how observations suggest that an awareness of different methods could impact upon production time.

Common practices

Just as participants were seen to use similar methods for tracking their progress through their current batch of work (see section 6.4), machinists were seen also to use common methods for organising their tools to maximise the efficiency of tasks. For example, positioning hand tools close to the working area of the sewing machine. During observations many standard tools, you might expect to see being used in garment sewing, were seen. These included: scissors or ‘snips’ (see Figure 6.11), used for trimming thread ends or fabric edges; rulers for measuring seams or item placements (a care label position for example); and tailors chalk to temporarily mark such positions on the fabric. More production specific tools were also observed, both standardised in the form of attachments for sewing machines that assist particular processes, and in some cases, non-standard implements and templates.

Figure 6.11: P9 tools at side of machine - scissors and ‘snips’

Figure 6.12: P15 scissors at machine

In the factory the use of tools and implements appeared to be two-fold in purpose:

1) to improve quality or ensure consistent quality
2) to make processes more efficient

both of which, include minimising risk and avoiding failure.

The practice of tool ownership and efficient placement or trimming tools specifically appeared common across the production line. More specific common tasks were observed across some participants with techniques used varying between different machinists. I will now discuss an example of a specific task that was observed being carried out by more than one machinist and discuss the potential impact of the varied techniques on overall production time.

Belt loop attachment

During observations P1 was completing the task of securing belt loops to the waistband of a Men's woven short style (on the main line). On the same day, P10 was observed completing the same task on the jeans lines for the 'Finisterre Jeans' style. Although the two styles being produced were different, the beltloop construction at each trouser/short waistband was the same, each style having five beltloops. In both cases the beltloops were already secured into the bottom edge of the attached waistband and the machinists were required to fold and back-tack each beltloop at the top and bottom of the waistband to secure them in place. The diagram below (Figure 6.13) summarises the steps involved.

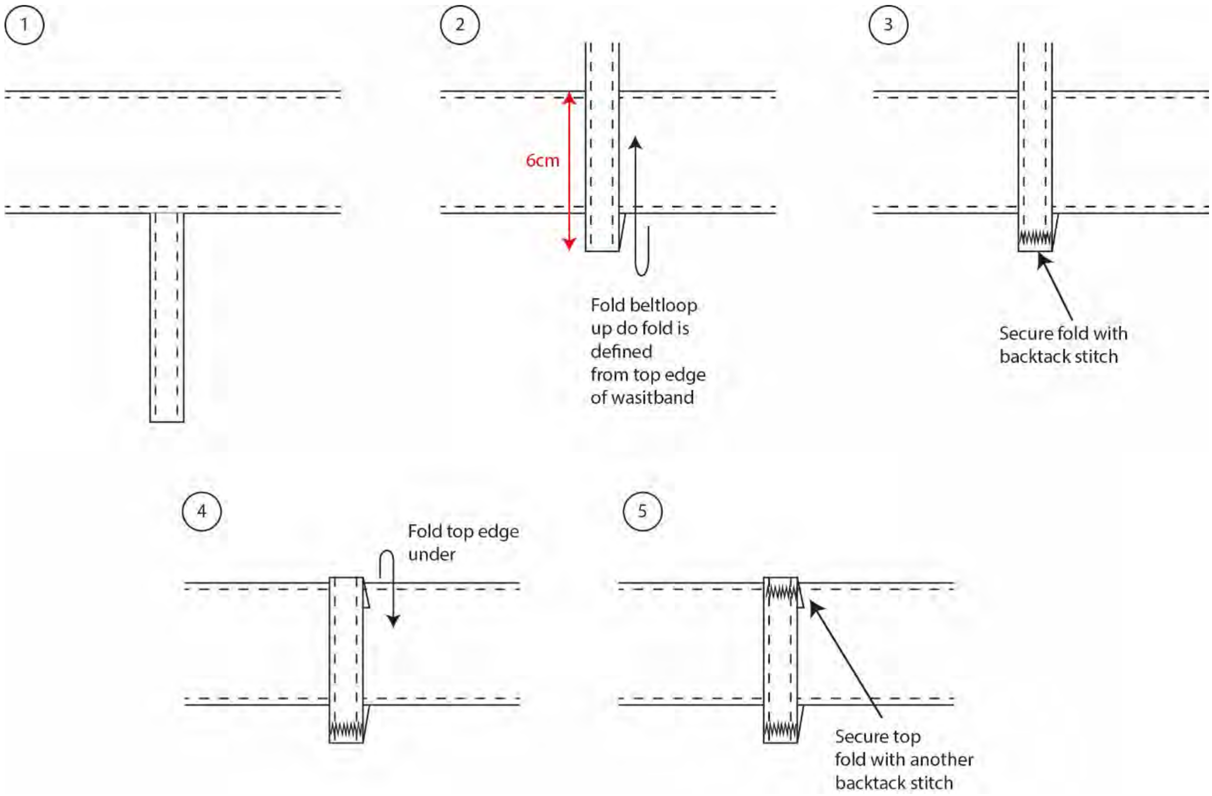

Figure 6.13: Diagram showing steps involved in securing belt loops

Both P1 and P10 carried these steps out in this same order but there were some differences in their techniques for completing the task. During step two, P1 used a small ruler to measure the distance of the fold from the top of the waistband, P10 on the other hand had created their own measuring implement from an old credit card cut to the correct size. This made the process of folding and measuring quicker for P10 and potentially more consistently accurate with the pre-cut template acting as a jig. At step four, P1 found the beltloops of the shorts to be too long and had to cut the top down before folding under the top edge for the final back-tack. The beltloops on the jeans that P10 was working on appeared to be the correct length with no cutting required. Stopping to cut the beltloop length definitely slowed down the whole process for P1 and is perhaps something that could be avoided in a previous production stage when the beltloops are prepared. Both machinists completed all five beltloops on one garment before checking for any thread ends that needed trimming. The video of Appendix B5.11 shows the two techniques side by side for direct comparison. From the video it is also possible to see, and hear, that the semi-automated backtack function on the sewing machine worked slightly faster on the machine of P10 than on that of P1. Having discussed this function with the factory manager, this process is apparently customisable and each machinist ‘should’ know to optimise this. The manager’s suggestion was that some machinists were reluctant to use the faster function.

Having discussed the variation in the approaches of these two participants for completing the same construction process I will now examine how this might impact upon production times. Every style produced by the company is currently costed according to the estimated length of time each process takes, referred to as ‘standard minute value’ (SMV), an example of which can be seen in Appendix D2. As highlighted in the company’s digital strategy document, as well as during initial discussions, these estimated timings (SMVs) are based upon knowledge held in the heads of a few members of staff and are not always documented or checked against actual sewing times. As outlined, the company had a desire to improve the accuracy of the costings by increasing and making more explicit knowledge of task timings. The *Galaxius* (digital) system was expected to go somewhere to tracking this more accurately once implemented, documenting completion times of whole batches on the line via scanned QR codes. These could then be tracked by the management team and line supervisors but not individual machinists. Using the video recordings collected during observations, I analysed tasks to compare them with documented SMVs and explore if they were accurate. In doing so, I also sought to gain insight into what impacts these timings and where there could be potential to improve them and thus add value to the business through increased productivity. For many tasks observed, timings were either inaccurate or not found to relate to any existing documentation but the task of securing beltloops was documented for both styles observed and posed an opportunity to directly compare the effectiveness of each technique.

Times recorded for P1 to secure all five beltloops on a garment ranged from 3 minutes and 9 seconds to 3 minutes and 59 seconds. The documented SMV available for the ‘short’ style they were working on was 2 minutes, significantly faster than the times carried out by the machinist. The average time taken to complete the tasks by P1 was 71% slower than the current SMV. The same task on the ‘Finisterre’ jeans lines, completed by P10 had a documented SMV of 1 minute and 2 seconds, faster than the SMV for the shorts despite the process being the same with the same number of belt loops per garment. I was, however, told on several occasions by the factory manager that the 'jeans line' generally performed much more efficiently than the main line due to more consistent styles and order quantities. P10 took an average of 1 minute 58 seconds to secure all five belt loops per garment, with times ranging from 1 minute 34 seconds to 2 minutes 9 seconds. This average time is 89% slower than the SMV for this style and is in fact closer to the SMV documented for the short style completed by P1. From the recorded timings, P10 worked faster than P1 on this particular task, completing the task, on average, 1 minute and 27 seconds faster. If each machinist processed this same task on one hundred garments, P10 would complete their quantity almost one and a half hours faster. It is possible, therefore, to see that accumulatively, if P1 were to use the same method for securing the belt loops as P10, production time would be reduced overall.

This poses a clear opportunity for adding value to the company through improving efficiency and reducing task timings (SMVs). As revealed in Chapter 5, grafting craft with a game has the potential to lead participants to develop strategies to improve an outcome. If that outcome, which in the case of *Hazuki Knit*, was the game score, was linked to the time taken to complete individual tasks, could grafting encourage the exploration of techniques that would reduce this time. This could be further supported through improved knowledge sharing among machinists to allow them to compare methods and techniques for comparable tasks. The two machinists in this example (P1 and P10), however, did not appear to be sharing best practice in terms of techniques being used. In the next section I will highlight the lack of knowledge sharing among staff.

Knowledge sharing

During observations across all sessions, it was noted that in the main, the machinists tended not to communicate with each other during working time. The factory working day is split into slots with official breaks marked by the sound of a bell. Staff would interact during these break times, many using a dedicated break room to do so, some gathering around machines, but during the set work times, it was noted that on the whole staff would generally concentrate on their tasks. My attention was drawn, therefore, at moments when staff would appear to confer during designated working time. The majority of occasions when staff were seen in discussion was between the supervisor and other machinists on the main line. These conversations, although often carried out in a different language, appeared to be regarding a technique or required finish, often bringing work in progress to the supervisor's machine. Sometimes the supervisor would unpick or correct items, or even demonstrate a particular technique to another machinist. Demonstrations seemed to relate to new or sample styles, with the supervisor seen to be checking against an approved sample. All other conversations appeared to relate either to quality (pointing out and correcting mistakes in construction), or general organisation (where items are etc.). The supervisor on the 'jeans line' did not get interrupted during the particular days I was observing. This could relate again to the jeans line having more consistent style lines so that workers are more familiar with the required techniques for particular styles. Non-supervisory machinists were seen interacting on some occasions too. These interactions were generally restricted to the passing of items and crates from one machinist to another, with little conversation (see Figure 6.14 of mapping movements during one session).

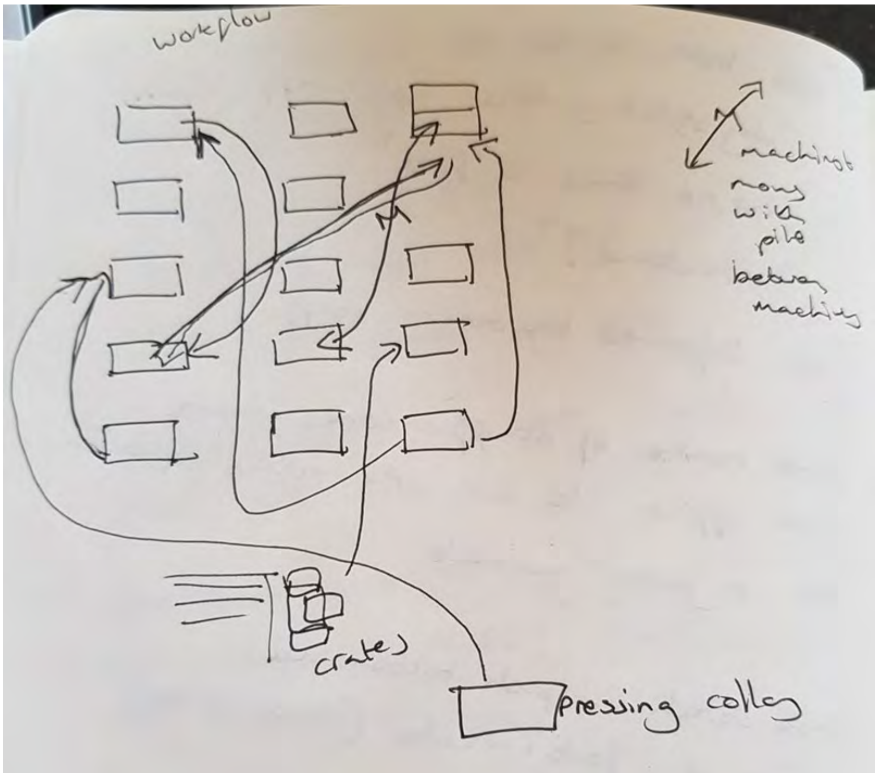

Figure 6.14: Spaghetti diagram of movements of machinist between machines on the 'main line' during one observation session

Sometimes, in the transition of batches, a machinist would find an error or inconsistency in the previous task completed and would either shout over to the previous machinist or take the item to them to discuss. However, what was not seen was any knowledge sharing or direct comparison of techniques or methods for completing similar tasks. This is perhaps an example of knowledge being held within the heads of certain members of staff and not made explicit for all. In the belt loop example above, the sharing of techniques and methods used by P10 could assist the slower machinist (P1) in adapting similar methods to make the task performed by them more efficient and therefore more productive. The promotion or encouraging of practice sharing techniques could thus be a potential area for improvement.

6.7 Conclusion

As discussed at the beginning of this Chapter, the management team at *Cookson & Clegg* have a desire to implement a digital workflow system to respond to current challenges including: an increased efficiency of production, reducing wastage of time and excess processes; meeting production targets more consistently; allow production costings to be updated and better maintained; better sharing of knowledge across teams; increased motivation for workers with support to hit targets and achieve bonuses. At the core of these goals is a desire to increase knowledge of individual task timings upon which garment styles are costed for customer orders. More accurate, up-to-date timings for all processes would provide more accurate costings but also poses the potential to see where timings could be improved through increased efficiency.

Through the development of an initial graft-game, *Hazuki Knit,* in Chapter 5 I identified three areas where value may arise through grafting:

Material Affordances:	Grafting creates an additional set of affordances.
Feedback Systems:	Additional feedback can create an additional outcome that maker and gamer value, e.g., game score.
Avoiding Failure:	Grafting can lead to the development of strategies to improve outcome.

Through observation and analysis of tasks carried out within the factory, discussed within this Chapter, areas where grafting could offer potential value have been highlighted. Machinists observed used two key areas for tracking progress of their work: the use of piles and crates to visually monitor progress through batches and monitoring quantitative progress via the use of batch dockets held within the crates and on lists collated by line supervisors. What became apparent, however, was that individual machinists received no feedback on the time taken to complete tasks, which as outlined, is the core aspect upon which production is costed. The proposed *Galaxius* system has potential to offer some insight into this, but data is not expected to be fed back to individual machinists and would certainly not be provided live. Instead, data is more likely to be summative, reviewed as orders are completed. This poses an opportunity for adding value through providing additional feedback, such as live times to machinists that may then become a valued outcome in the same manner the game score became valued by players of *Hazuki Knit.* Secondly, a desire to improve such an outcome could be fostered through where a game score (related to task timings) becomes a valued output. In previous Chapters, I have discussed ways in which makers and gamers develop strategies to avoid failure and optimize performance through improved skills and the use of implements, jigs (including bodily movements). Similar strategies in the form of particular construction methods and techniques were seen among the actions of participants in the factory. Through the comparative example of two machinists securing beltloops to trouser and short styles (see section 6.6), demonstrated how differing techniques for carrying out the same construction method can have a significant impact on time taken to complete individual tasks. If the knowledge of more efficient tasks was shared and used by multiple machinists, production times for tasks such as this could be significantly reduced. As discussed, there was little evidence of knowledge sharing among machinists on the factory floor beyond supervisors demonstrating techniques for newer sample styles. In Chapter 5 grafting was shown to lead to the development of strategies of the game score that the player had valued, it could therefore be possible that similar could occur within the factory. In the next Chapter I will discuss the development and analysis of second graft-game *Pocket Racer*¸ developed in direct response to the challenges and opportunities found within the factory, exploring the potential impact grafting could have on production tasks.

7_Pocket Racer

As discussed in Chapter 3, Strand Three of this research explores the potential value of outcomes brought about through grafting craft and gaming for and beyond the individual disciplines. This Chapter combines the findings discussed in the previous chapter that are part of this strand and combine them with the aims of Strand Two: to investigate the relationship brought about through directly connecting craft and gaming. Here, I will discuss the development of a second graft-game that responds more directly to challenges faced by the project partner, *Cookson & Clegg*. Having discussed observations of practices within the factory setting, several potential areas where value could be added were identified. In summary, key findings were:

1) Machinists in the factory were seen to track progress through bulk orders and individual batches through the use of 'piles', and organisation of crates. Individual tasks could be tracked to completion visually but feedback on efficiency of those tasks in terms of task timings, upon which all orders are costed, and productivity measured, was absent during observations. I proposed that value could be added through the addition of live, continuous feedback in the same manner as feedback had been offered to players of graft-game *Hazuki Knit.*
2) Adaption of construction methods and techniques were witnessed of comparative tasks carried out across different lines for example, different methods used by two machinists to secure belt loops on trouser waistbands. These differing approaches were seen to have an impact on task timings with one machinist performing much faster than the other. Best practice, in terms of the most efficient techniques, are currently not seen to be actively shared among machinists, if there is any awareness of them at all. I proposed that additional aspects of feedback could encourage the further development of such strategies through a desire to improve a game score as was seen in *Hazuki Knit* grafted gameplay.

This Chapter continues to investigate the potential impacts and outcomes that could be developed through a second graft-game and seeks to align them with the challenges currently faced by project partner. I will begin by outlining the development of the graft-game before outlining analysis of observations of interactions with it. In the first instance, observations were made of engagement, this time, at a single public event. This proceeded in a second iteration of the prototype with observations made in a trial batch production setting. As discussed in Chapter 3, the original research plan was to carry out an intervention with a graft-game within the factory setting. Due to restrictions imposed during the COVID-19 pandemic in 2020, an alternative approach was used in which a small group of domestic machinists (including myself) were recruited instead. In this final stage, the prototype was used by three machinists employed to complete a batch production process for a one-off project for art collective, *The Lost Running Club,* in Manchester. Analysis of both phases of observations will be discussed collectively, building upon the themes developed in Chapter 5. These themes include: the impact of previous experience of gameplay, grafted feedback, and competition and the desire to improve.

7.1 Prototype Development

Iteration One (v1.1): Festival of Making

Led by the need for productive construction of garments within the factory, graft-game, *Pocket Racer,* was developed by grafting a re-iteration of an existing game onto a domestic sewing machine. A first iteration of *Pocket Racer* (v1.1) was born through initial discussions had with the factory management team and trialled with members of the public at a participatory event just as had been the approach with *Hazuki Knit* (Chapter 5). I was invited to take an activity to the Festival of Making in Blackburn in June 2019, one that would open-up discussions around my ongoing research with *Cookson & Clegg*. The festival is an annual two-day event taking place in the town centre of Blackburn in Lancashire and celebrates all forms of making "from the factory floor to the kitchen table" (festival website, accessed 7.6.21). Being located within the same town as the *Cookson & Clegg* factory, this presented as an opportunity to engage with the local community, some of whom may have connections to the manufacturing industry within the area.

As with *Hazuki Knit* discussed in Chapter 5, *Pocket Racer* was developed through the grafting together of an existing game with an existing craft process. As outlined in Chapter 3 (Methodology), the research plan at this stage of the research was to develop a prototype graft-game that could initially be tested in a public setting before refining it for intervention within the factory setting. As the intention of this game was to directly explore what potential impacts and outcomes of grafting could have in the setting of the project partner's factory, it was important that the 'craft' process being grafted was led by the processes being used within that setting. Of the machinists observed within the factory, the majority were operating industrial standard lockstitch sewing machines (by JUKI). Previous discussions on habitual practice and the embodiment of tools would suggest that any interventions within the factory should not alter existing tools and machines to any great extent. Doing so, could cause experienced machinists to stumble over habitual actions (Tanaka, 2013) and increase the risk of mistakes being made in production. This initial prototype was, therefore, developed to closely replicate the tools and machines of the working practices found within the factory. Industrial sewing machines are costly and very heavy items, often attached to a specialised flat-bed table, which would have been difficult to transport and set up in the public settings of the festival. Instead, a domestic sewing machine, which shares many features with industrial models but with the advantage of being more portable, was used for this stage of the research. The intention was that any intervention to graft a game onto the machine would later be translatable to an industrial machine as used in the factory. Domestic sewing machines bear many resemblances to industrial sewing machines with many core mechanics of the machines working in a similar way. For example, both machines use a foot pedal to power the machine, and both use a top and bottom thread that are stitched through fabric as it is fed under a presser foot. The main differences are speed (with industrial machines generally operating at a higher speed) and that industrial machines offer additional features appropriate for production settings such as automated back stitch and thread trimmers for the end of a stitch-line. Such features may relate to the acquisition of higher skills and habitual practices of machinists in the factory setting but were not deemed as essential to replicate in the public event setting where skill sets were expected to be broader.

Figure 7.1: Industrial (left) and domestic (right) sewing machines

Based on initial discussions with the factory management staff and observations of production activities that had begun alongside, it was deemed appropriate to try and set participants with the challenge of completing a set task and for that task to be carried out by all participants for comparison. Observations made of *Hazuki Knit* (see Chapter 5) suggested that participants had little connection to the knitted fabric being produced which may, in part, have been a result of the knit being undefined in terms of a completable craft object. This disconnect from the craft output was also considered to have potentially played a role in the digital Game Overpowering the craft process through which the knitting was put at higher risk of failure. In response to this, I decided to define a specific outcome for this graft-game that each participant could complete (as opposed to a collective object) to try and avoid focus being removed from the craft output. I was also conscious that the festival would be attended by all ages and a variety of existing skill levels, and so it was important that the set task would be achievable for a range of participant abilities. Informed by some of the trouser, jacket and shirt designs seen in the factory, I decided on 'sewing a patch pocket' as a specific task that posed as a completable activity. Patch pockets generally consist of a flat pocket piece, with seam edges pre-pressed under to conceal the raw fabric edges, which is then stitched onto a main garment (a shirt front for example), with the stitching following the outer edge shape. The top edge, stitched flat before attaching, would be left open, forming an accessible pocket.

Figure 7.2: Example Community Clothing jacket style (men's chore jacket) with patch pockets (Source: Cookson & Clegg, ND: online)

A patch pocket would act as a small-scale task that would be simple to manage, in terms of time and physical resources, in a public setting where a large number of participants were expected. When stitched in fabric, a patch pocket requires only two fabric pieces, the patch and the main body, for example, the shirt front. This would be simpler to prepare and recreate at the event than a more complex area of construction such as a shirt collar that is made up of several complex shaped patterns. Such complex construction methods would require a lot of prior instruction before engagement with the graft-game could commence and would thus delay observations. The public setting of the proposed activity posed an additional challenge, in terms of safety. All sewing machines have a sharp metal sewing needle, through which the sewing thread is threaded. When the machine is powered this needle moves up and down through the fabric at a fast pace. This action posed a risk for anyone using it and great care would need to be given to all participants to ensure that their fingers and hands were kept away from the needle during sewing. As with development of *Hazuki Knit*, I did not want the need for extensive machine instructions to dominate what would potentially be a short activity for participants. I was also aware that young children may wish to partake in the activity and did not want this safety issue to remove this potential engagement (although I would not be recording participation of anyone under the age of eighteen). The decision was made to adapt the machine so that it would use a felt tip pen instead of the sewing needle. The machine would therefore be used to 'draw' around a pocket shape with the sewing machine instead of sewing it with thread. This would closely replicate the sewing process whilst minimising safety risks. The use of a felt tip pen and lack of thread meant that fabric was not essential as the pen could draw on paper instead. The use of paper also eased the production of materials for the event for which hundreds of participants were expected. A simple printed pocket template was designed and printed prior to the event (see Figure 7.3 below and Appendix C1). The template featured a dashed line, representing the desired stitch-line with a shaded grey region either side of it. The aim for each participant was to 'sew' (draw) with the pen as closely as possible to the dotted line and ideally stay within the grey region. Any pocket 'sewn' (drawn) outside of the grey region would be rejected for quality, just as inaccurate sewing in the factory setting would not be acceptable in production.

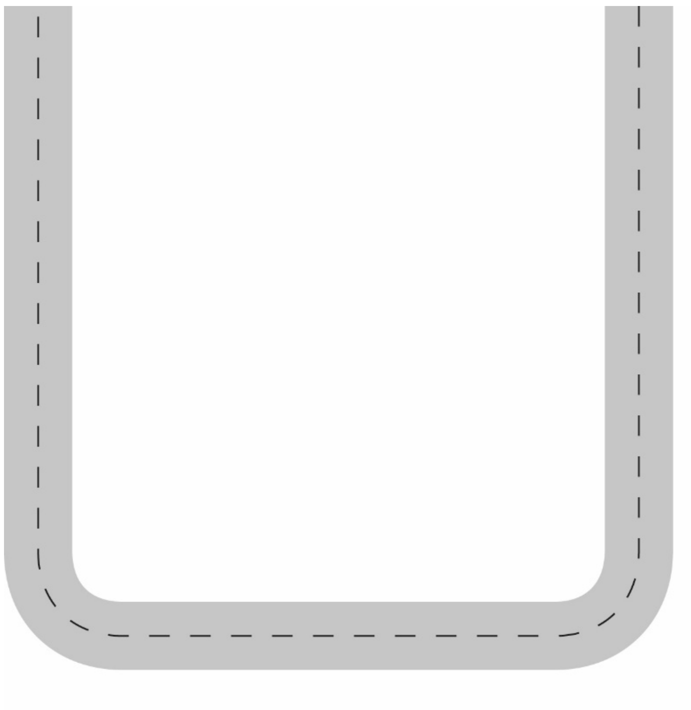

Figure 7.3: Pocket template

As with *Hazuki Knit*, the approach to grafting a game with a craft concentrated on utilising an existing game. I again worked with artist and technologist James Medd for technical support and selection of an existing game. Considering the core challenges outlined by the factory (see section 6.1), it seemed important to draw upon a game that related primarily to speed. James had previously developed a game called *The Mashing,* inspired by frantic 'button-mashing' that is required in some arcade games. James describes the game as follows:

> The game is *very* straightforward: two teams of up to five players each have a designated button to press. On-screen are two coloured bars that increase in height with every press. Once a team's bar reaches the top of the screen, they win the game. I made a couple of controllers specifically for playing the game, built to take a good mashing (Medd, 2015: online).

Gameplay, and the accompanying player interactions, can be seen in the following video:

Video 7.1: Clip of *The Mashing* being played (Source: Medd, 2015: online)

A key insight provided by observations of players engaging with *Hazuki Knit* (as discussed in Chapter 5) was that some aspects of the game distracted from the knitting element with knit players watching the other player or the screen far more than the knitting progress (see section 5.4). This resulted in many errors in the knitted fabric being produced and was thus deemed to be a potential negative impact of grafting. To improve the balance of feedback between the craft and game elements of *Pocket Racer,* it was decided that any screen feedback should be kept to an absolute minimum to allow the player to focus their view on the sewing machine and the visual progress of the drawn stitch-line of the pocket. As can be seen in the above video, *The Mashing* uses only a very simple on-screen graphic throughout the game, consisting of two bars that increase in height with each button press. The game also includes a set of feedback sounds that inform the players of different stages in the game: a countdown sound at the start of the game; an end sound when the fastest team reaches the top; and a 'bing' noise that increases incrementally in pitch as the bar gets higher. *Hazuki Knit* had a similar mechanism and seemed to balance with audio feedback from the knitting machine, distinctive but not overpowering as the visual feedback had been. These simple audible aspects of feedback were thus seen as appropriate to use alongside the sewing machine without the need for an additional visual on-screen marker of progress. By removing visual feedback from the game element and focusing on audio aspects, it was hoped that the increased risk of failure or poor quality of the craft output observed with *Hazuki Knit* would be avoided.

It should also be acknowledged that *The Mashing,* in its original format, was a ten-player game, with two teams of five. Direct competitive gameplay in the two-player aspect of *Hazuki Knit* was seen to increase the risk to the knitting and was a situation wanted to be avoided in a future factory setting where quality of production was important. Other forms of competition could be relevant to productivity in the factory, but I wished to observe how this may occur through a single player game that avoided the direct competitive gameplay. It was therefore decided that *Pocket Racer* would take the form of a single player game for this iteration.

Creating the graft

In order to link the sewing machine with the game a mechanism was required that would be able to track the progress of sewing along the pocket line. Through setting a standard stitch length on the sewing machine the number of stitches required to complete the full length of the pocket was measured. To capture the number of stitches in real time, two areas of the sewing machine were considered. As the machine stitches the sewing needle moves up and down and although the needle itself was being removed for this game, the post that holds it in place would still move during sewing. As this movement occurs a hand-wheel at the right-hand side of the sewing machine rotates, one complete rotation per stitch. Either of these movements were considered as potential areas to track stitches using a sensor, the simplest position, however, was the latter. A 'Hall Effect' sensor (which detects the presence and magnitude of a magnetic field) was temporarily mounted onto the top right of the sewing machine, positioned over the top of the hand wheel. A small magnet was then attached to the outer edge of the hand wheel. As the hand wheel spins the magnet passes the sensor which in turn sends a signal to an attached Arduino controller. The digital game was then adjusted to look for this signal instead of a button press with the in-game sound triggered when a stitch is completed. The starting count-down sound was retained from the original version and accompanied by an on-screen countdown, and the end sound triggered when the specified number of stitches were completed, indicating that the pocket should have been completed. A series of external buttons were connected to 'start' the game and at the end to either 'accept' or 'reject' the quality of the completed pocket. The pocket would then be 'judged' for accuracy with a button to be pressed for 'accept' or 'reject'. Once the pocket has been judged the game would then display the player's score: the time taken to complete the pocket.

Figure 7.4: Sewing machine with sensor positioned above hand wheel, external Arduino and 'reject'/'accept' buttons

The goal of the game was thus set: 'sew' around the pocket template as fast and as accurately as possible.

As outlined at the start of this Chapter, the completed prototype was trialled at the Festival of Making in Blackburn where participants were invited to play *Pocket Racer*. It was a very busy event with over three hundred people engaging with the grafted game in total. As with observations of *Hazuki Knit,* a small indicative number of participants contributed to data collection, being asked if they would consent to their interactions being recorded for the research. A total of twelve participants were filmed during their engagement with recordings later analysed along with field notes made over the course of the two-day event. Participants were given a code number for anonymity and shall be referred to by those throughout this Chapter. Analysis of these observations will be discussed in the sections to follow (7.2 through to 7.5) along with observations of the second iteration of the prototype, v1.2, the development of which I will discuss now.

Iteration Two (v1.2): Batch Production

Following observations of public engagement with the first prototype of *Pocket Racer* and completion of initial observations within the factory, the original research plan was to further develop the grafted game as an intervention with the production setting. Observations would then be carried out again and comparative analysis would assess what impact may have been had on working practices to determine what value any outcomes of grafting may have on productivity and efficiency of tasks. As outlined in section 3.3, the proposed intervention was planned to be carried out in the summer of 2020. This was sadly impacted upon by the COVID pandemic and national restrictions meant that in person observations would not be possible. The implementation of a physical intervention on the sewing machines within the factory, using the same sensors used within prototype one of *Pocket Racer,* also proved complex and remote observations felt like they would pose ethical concerns regarding the confidentiality of participants. The research plan was thus adapted, and I was able to take advantage of an opportunity to work with a small group of domestic machinists (with some industry experience) in the completion of a batch order of t-shirts. The order was for an artist collective based in Manchester who needed some custom patches sewing onto the outer side hem of approximately three hundred T-shirts for a one-off project, *The Lost Running Club*. The work was divided between three machinists (including myself) who each worked from their own home using their own domestic sewing machine and tools. Each machinist was given a ‘sensor kit’ to attach to their own sewing machine, consisting of a ‘Hall Effect’ sensor (as used in the first prototype) with Velcro attachment, a magnet with large silicon band to temporarily attach it to the hand-wheel of their machine, and a *Seeeduino XIAO* microcontroller to harvest the digital signal received from the sensor. For this prototype, and with the original intention of devising an intervention for the factory setting, using a laptop to run the digital game for grafting the sewing machine to seemed inappropriate as it would be too costly and bulky to install in the factory setting. Instead, a mobile ‘App’ was developed based on the previous game software with the expectation that staff in the factory would be able to use company mobile phones they had been issued in anticipation of initial tests being carried out with the proposed *Galaxius* system discussed in Chapter 6. With the adaption to observations taking place in domestic settings, participants were given the option of using the app via their personal mobile or via a web browser on a computer dependent upon their own preference. The app version of the game had the same mechanics and feedback systems as that of the first prototype: a minimal visual '3', '2', '1', 'Go!' countdown reinforced with 'Bing' sounds; a consistent 'Bing' sound each time the sensor picked up the magnet thus representing the completion of a single stitch; and an end sound followed by the display of the players 'score', I.e., the time taken to complete the task. The 'judging' system of accepting or rejecting completed pocket was removed from the first prototype as quality checking was deemed to be a sufficient existing process in the factory setting. As the second prototype was intended for use in the factory where many different sewing tasks are carried out, the pre-set stitch count given to the pockets of the first prototype would not have been adequate. Instead, a new function was added that enabled users to record the stitch count of a new task, after which the game could proceed as before with the 'end sound' triggered at the measured stitch count. The stitch count was measured simply by recording the task being carried out on the machine with the software recording and saving the number of stitches used. This recording was intended to be measured for the first item in a batch from which the rest of the batch could be compared to, with the expectation that participants would be motivated to improve their 'score' I.e., reduce the time taken to complete each task. As observations were to take place remotely, the app was also equipped with the ability to save each participant's scores (anonymously) on a server so that they could be analysed without the need for participants to keep a record of their scores themselves.

Observations of participants were carried out remotely using many of the same methods used for the previous strands of the research including video recording and reflective notes. Due to COVID restrictions direct observations were not able to take place of machinists in their own homes so video recordings became vital to the observation of others. Each participant recorded their activities on their own device (usually a mobile phone) and transferred the recordings to me at the end of each session. Taking part in the batch production myself, as one of the three machinists, I was able to make reflective notes of my own processes and reflect upon the remote interactions and conversations with fellow machinists regarding the production methods and progress. I recorded my own sewing activity using the same GoPro camera used for observing amateur craft and gaming activities discussed in Chapter 4. For anonymity, participants were advised to focus recordings on their hands at the sewing machine. Recordings were transcribed, omitting any conversations with non-research participants in the home, and aligned with game scores captured via the game server. Each participant was assigned a code name (a colour) and linked with a serial number assigned to each sensor kit in order to match game data with participant recordings. The full batch of approximately three hundred t-shirts was divided between all three machinists (including myself) and work commenced at our own pace, fitting the work in and around personal commitments, but taking place across the same week. Two participants completed their batches across three sessions, the third completing theirs across two sessions.

In the following section I will begin an analysis of observations of both instances of the prototype graft-game by discussing the impacts of previous experience upon the experience of engaging with the game.

7.2 Previous Experience

As discussed in Chapter 2, the development of craft skill is generally attribute to habitual practice (Sennett, 2008; Risatti, 2013) and the embodiment of skill through repetition. Such practice includes the embodiment of tools which extend the hand as part of habitual practice (McCullough, 1996; Pallasmaa, 2009). As outlined earlier in this Chapter, the development of *Pocket Racer* took into account the potential habitual tool use in anticipation of creating an intervention within the factory setting. Previous experience with sewing and sewing machines in particular was also revealed to have an impact within the participatory public setting. During observations of *Hazuki Knit* (see Chapter 5) many participants had expressed or demonstrated having some previous gaming experience but few to none had used a knitting machine before, although some recalled memories of family members using one. For experienced gamers it was possible to see evidence of habitual practice and strategic positioning of bodily movements, specifically finger positions over button controls to make movements more efficient (see section 5.6). A good proportion of participants playing *Pocket Racer* v1.1 at the Festival of Making, expressed having previous experience of sewing, either domestically or within industry. With that came some expectation, either from the participants themselves or people accompanying them, that they would perform well in the game making comments such as “I should be good at this” and “you’ll nail it”. This, however, was proven not to be guaranteed with some of those who expressed having previous sewing machine experience were being shocked if they were inaccurate in their ‘sewing’ of pockets. A possible reason for this may be due to habitual practice, which some players acknowledged, for example the following that I recorded in my field notes:

> “One girl suggests it’s because she would be looking at the seam edge not the needle” (exert from field notes)

As discussed in Chapter 2 (section 2.5), the embodied knowledge of an experienced craftsperson includes the embodiment of tools associated with the skilled activity (Tanaka, 2013). The pre-reflective body moves to act even before we consciously ‘think’ to do so (Merleau-Ponty, 2012). Participants approaching the unfamiliar sewing machine used in this version of *Pocket Racer (v1.1),* acted with the embodied actions associated with their previous experience. This includes the body acting based on experience of using their own, or another more familiar sewing machine. In *Phenomenology of Perception*, Merleau-Ponty describes the body’s knowledge of key positions in touch typing, explaining that knowing key positions does not provide an objective position of objects in space:

> One can know how to type without knowing how to indicate where on the keyboard the letters that compose the words are located. Knowing how to type, then, is not the same as knowing the location of each letter on the keyboard, nor even having acquired a conditioned reflex for each letter that is triggered upon seeing it. […] It is a question of a knowledge in our hands, which is only given through a bodily effort and cannot be translated by an objective designation. The subject knows where the letters are on the keyboard just as we know where one of our limbs is – a knowledge of familiarity that does not provide us with a position in objective space (Merleau-Ponty, 2012:145).

The ‘knowledge of familiarity’ (Merleau-Ponty, 2012) thus suggests that despite objectively being aware of the machine set up being different, the body will ‘know how’ to act at the sewing machine based on the embodied knowledge that has been developed through repeated bodily practice of working with a familiar machine with a sewing needle in place. Thus, the participant with embodied knowledge of working with a more familiar sewing machine that has a needle in the expected position, would not automatically be able to adjust their bodily actions to the new machine and repositioned felt tip pen. The response of the participant described at the beginning of this section demonstrates an awareness of habitual practice with the participant recognising, upon conscious reflection, how the graft-game, affected the unconscious embodied movements.

Players with previous experience also tended to have additional questions, often seeking to familiarise themselves with any specific technique required for the activity and the particular machine. For example:

> Exert from PR6972 [Player "so is this… have you got to drop the feed dogs, no you haven't" (answering her own question as she inspects the machine). "You don't drop your feed-dogs, so I just need… I just want to know what I'm working with."

This player clearly wants to have a better understanding of the machine being used before she starts sewing. I offer her a piece of scrap paper to practice on first.

> Continued [Player: "Am I turning this way, this way and this way, or will the machine do that?" I say the machine won't do that.]

Similarly, another player is also curious about which way to turn the pocket:

> Exert from PR6963 [Player asks "Does it have to go that way?" I say "you can go from the other way if you prefer." She says "I'm left-handed so think I'd prefer that way."]

Through these comments the participant is expressing a preference for the side of the pocket they wish to start sewing from, aware it will impact how they turn the paper for the corners, which may be based upon habitual and embodied actions from previous experience.

Some participants who had previously used a sewing machine also mis-aligned the pocket template at the start, due to their previously embodied actions. The sewing needle would usually be positioned in the centre of the presser-foot and it is usual to align the position of a desired stitch-line with the centre of the presser foot. For this activity the desired line needed to be positioned slightly to the right. Those with existing skills who mis-aligned the pocket thus demonstrated their habitual practices and embodied familiarity (Merleau-Ponty, 2012) when aligning to the foot rather than the pen. This is an example of stumbling over habitual practice identified as a key crossover between craft and gaming as discussed in Chapter 2. As suggested previously, such habitual actions should be accounted for in the development of any future interventions as causing users to stumble over these actions could cause undesirable errors.

In the second iteration of *Pocket Racer (v1.2),* habitual practice and embodied tools were accounted for with participants using their own sewing machines for which each already had experience using. In addition, the second phase of testing, involved sewing with fabric and thread with the needle remaining in place, unlike the simulated activity of prototype v1.1. Participants were thus able to work within the embodied actions of previous practice and no impact on this was observed.

Having discussed the development of *Pocket Racer* prototypes through two iterations, including adjustments made for the embodied actions of experienced machinists, I will now consider the impacts and outcomes of grafting through observations of both iterations and consider these in relation to the potential areas for value to be added within the factory setting as outline in Chapter 6.

7.3 Material Affordances

Early Chapters of the thesis established that both craft and gaming involve an encounter with material of which the quality and potential of each is understood through explicit instructions and further understood when encountered through repeated action. Participants engaging with *Hazuki Knit,* discussed in Chapter 5, encountered additional sets of affordances via the graft-game and came to understand them through repetitive grafted gameplay. As a two-player game, the knowledge and understanding of affordances was gained in a shared manner. Following observations within the factory setting of *Cookson & Clegg*, it was acknowledged that any future interventions would need to involve the use of existing materials as dictated by production orders. Grafting would provide an additional set of affordances to those of existing, familiar materials through the game aspect and understanding of these would need to be understood through direct and repeated engagement.

In Chapters 4 and 5 I discussed the explicit instructions and controls that were provided to makers and players prior to commencing amateur craft and gaming activities or engaging with *Hazuki Knit.* Participants engaging with *Pocket Racer* were also provided with explicit instructions before starting. When approaching the graft-game (v1.1), participants were given verbal instructions by myself, beginning by asking if they had used a sewing machine before. This was followed with direction on using the foot pedal, with the chance to test it quickly (especially for inexperienced machinists), before introducing the paper template and instruction on guiding it through the machine. I directed all players to note the position of the felt tip pen as I positioned the paper template underneath it and explained that the aim was to keep the desired stitch line in-line with this throughout, ideally staying within the grey border. Once the participant was in position and ready, I would move to the computer and say that I would count them in, counting along with the game sounds.

Participants using v1.2 were given full instructions, that included the set-up of the sensor attachment and installing of the *Pocket Racer* app, via a video call. In doing so, I talked each participant through the process of measuring a new task using the app and checked the sensor was working correctly and feedback sound appropriately, responding to the machine being powered and sewing. This gave the participants some initial familiarity with the basic actions involved in the grafted-game and thus some knowledge of potential affordances before batch production commenced. Alongside the game aspect, an example finished item was provided to each participant along with instructions of the basic requirements for the sewing task for completing the batch order.

Following provision of initial instructions, as outline in earlier Chapters, material affordances came to be further understood through action and direct engagement with material and associated tools (McCullough, 1996; Pye, 1995; Juul, 2013; Keogh, 2018). Participants engaging directly with *Pocket Racer* also came to further understand the affordances and limitations of the grafted aspects in action. With v1.1, some, especially those with no previous experience of using a sewing machine, demonstrated a sense of shock when the machine first started 'sewing' as the pace of movement moved quicker than they may have expected. This was usually expressed verbally or through an expression of sound with the hands remaining steady as they held the paper template in position. Bodily control over the movement of the pocket template became tested the most upon meeting the first pocket corner at which point many participants struggled to turn the paper adequately enough during their first try. Participants engaging with v1.2, as had been observed of machinists in the factory (see section 6.4), having previous experience of using a sewing machine, were generally familiar with the materials being used in terms of the craft aspects of the graft-game. As a result, there was no evidence of participants having to excessively adapt to or add to their existing understanding of the badge and t-shirt materials.

As established in Chapters 4 and 5, repeated actions enable material knowledge to be expanded through the process of problem finding and problem solving (Sennett, 2008). Little repetition of the pocket sewing task was observed at the Festival of Making, driven by the short-term nature of the event. Engagement with v1.2, however, predisposed the need for repetition of tasks. In this case, knowledge and understanding of grafted material affordances were understood through the repetitive nature of batch production which represents the repetitive nature of work within the factory setting. The repetitive nature of learning links to the acquisition of skill, recognition of feedback systems of the graft-game and enables the development of and refining of techniques and strategies to improve efficiency as will be discussed in the following sections.

7.4 Grafted Feedback

As discussed in Chapter 2 and 4, in both craft and gaming, an active conversation occurs between material, tool and maker or gamer with feedback given in three forms: visual, audio, and haptic. These inform the player/maker of their progress towards the goals of an activity (quantitatively), and on the quality of their performance (McGonigal, 2011), including confirmation of failure and flaws. In Chapter 5 I discussed the impacts that additional and grafted forms of feedback had upon the craft and gaming elements in *Hazuki Knit*. A key observation was that feedback from the game aspect overpowered and distracted from that of the knitting, especially in terms of visual feedback. The additional feedback created did, however, create additional outcomes that were valued by the players. For example, participants engaging with the graft-game demonstrated a desire to improve the game score, including players controlling the craft aspect of the grafted game. It was also observed that Game Over experienced via the game element was much easier to recover from than that of the craft aspect with recovery of failure in the knitting delaying and discouraging repeated gameplay. Following observations of participants within the factory of *Cookson & Clegg* (see Chapter 6) I proposed that additional forms of feedback could provide machinists with a way of tracking their progress and efficiency in relation to task timings, which was observed to currently be lacking. In this section I will outline the forms of feedback offered by *Pocket Racer* before discussing their impact on the sewing activity at each stage of prototype development.

Forms of feedback

The primary form of feedback of *Pocket Racer* was audio feedback. *As* outlined earlier in this Chapter, the core component of the game aspect, once grafted onto the sewing machine, was a series of sounds played in conjunction with sewing progress. These sounds consisted of:

-An audible countdown of four ‘bing’ sounds, representing a ‘3’, ‘2’, ‘1’, ‘Go’ count.

-A ‘bing’ noise for each stitch completed, increasing incrementally in pitch.

-An end sound triggered when the correct number of stitches had been completed.

Each of these elements fed back to the player the current position or state of progress in the game I.e., getting ready to start, sewing progress, and finish. In addition to audio feedback, visual feedback was provided by the sewing machine and the item being stitched as well as the screen connected to it, although as discussed this was kept to a minimum. The start screen displayed instructions for starting the game ('Press the button to start'), once the start button was pressed a countdown was displayed ('3', '2', '1', 'Go') to link with the audio countdown and when the game ended a score, in the form of the time taken, was shown. Graphics for each of these were kept simple with predominantly white text displayed against a black screen. During actual gameplay, the screen remained blank so as not to distract from the sewing process. Once the set number of stitches were completed and detected by the 'game' via the sensor, an end sound was fed back. During prototype v1.1 the facilitator (myself) would then 'judge' the completed pocket for accuracy and input a result using the 'accept' or 'reject' button. This would then be displayed via the screen (visually) along with the game score (time taken to complete) with the option of adding the score to a leader board. In the second iteration of the prototype (v1.2) it was deemed that the experienced machinist could manage and judge the quality of outputs required so the 'judging' element was removed.

Through gameplay, other than the pressing of a key on the keyboard to start the game and using the judging buttons at the end, haptic feedback was solely provided to the player via direct touch with the sewing machine and the item being moved through it. Through the sense of touch the player could sense vibrations of the machine as it sped up or slowed down, with the hands also receiving an awareness of the position of the item as it moved through the machine. The players foot also received haptic feedback as it interacts with the foot pedal underneath the machine, controlling the speed of the machine as it does. Visual and audio feedback from the sewing machine and movement of the item being sewn contribute to an awareness and understanding of progress and success of the 'stitching' being produced.

As given for *Hazuki Knit* in Chapter 5, table 7.1 below shows a summary of the types of feedback provided by *Pocket Racer* to the player:

Table 7.1: Feedback types experienced in Pocket Racer

Type of feedback	**Game element**	**Craft element**
Visual	Screen displays: instructional prompts, countdown (3, 2, 1, Go!), game score No in-game feedback	Sewing machine: can visually monitor the item moving through the machine including the 'sewing' appearing and its position/accuracy
Sound	Countdown sounds	Sound of machine, changing in tone depending on the speed
	'Bing' sound with each stitch made, increasing incrementally in pitch as the sewing progresses	
	End sound heard when correct number of stitches is reached	
	Sounds from the knitting machine are also audible	
Haptic	Response of physical buttons under fingers as they are depressed and lifted again (pressed to start game and 'judge' pockets)	Feel of the material as it passes through the machine, including directional senses
		Feedback from foot pedal as player presses it control the speed of the machine

Building again on the previous adaption of Swink's (2017) model of interactivity of a user in a closed loop conversation with a computer (see section 5.4) below is an image representing the conversation occurring between the player and the aspects of *Pocket Racer* (see Figure 7.5). The diagram demonstrates the player 'listening' to feedback from both the sewing machine and the game (visual, audio and haptic) before responding via their foot on the foot pedal to start the sewing machine. This, in turn, causes the hand wheel on the sewing machine to rotate as the machine begins sewing. The sensor positioned above the hand wheel then receives a signal from the magnet attached to the hand wheel, transferring that signal to the game on the computer (or mobile phone in v1.2). The game responds by producing the appropriate sounds, closing the loop.

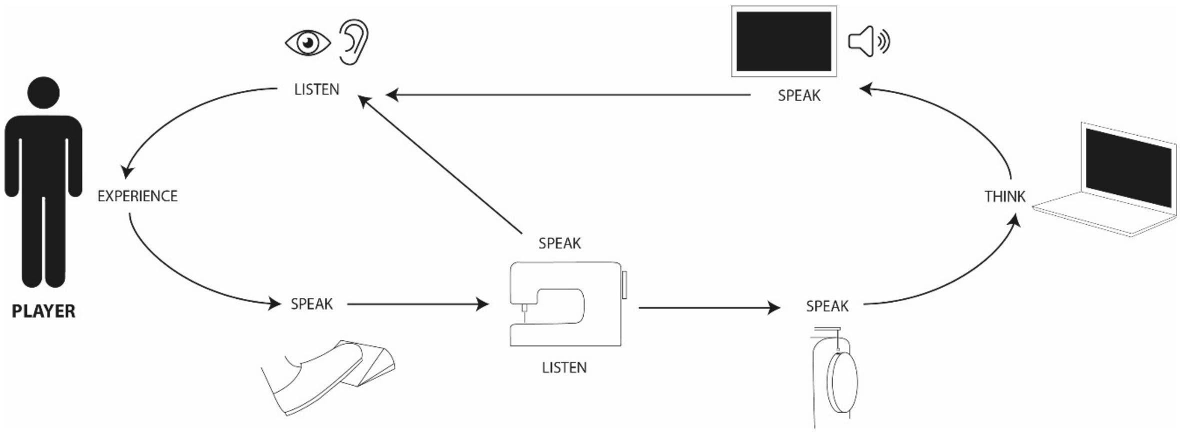

Figure 7.5: Conversation between player, sewing machine and game aspects in *Pocket Racer*

Balance of grafted feedback

Observations of *Hazuki Knit* grafted gameplay revealed that the visual feedback of the game aspect dominated and distracted from that of the craft element. This was linked to an increased risk of failure to the craft, with few participants monitoring the knit output at all during gameplay. Development of *Pocket Racer* sought to address this by reducing visual distractions so that the players eyes could remain on the craft material during grafted gameplay. A resulting outcome of this was that grafted audio feedback became the most significant form of feedback received from the game aspect with haptic and visual feedback forms remaining predominantly focused on the craft element. Unlike visual feedback from the game element in *Hazuki Knit*, however, the dominance grafted audio feedback did not overwhelm or distract from the craft activity.

The first iteration of *Pocket Racer (v1.1)* was trialled, as discussed, at the *Festival of Making* where the activity took place in an empty shop space as part of the festival along with several other activities. Due to this and the many other festival activities happening on the street outside, the game sounds often had to compete with the general sounds within the space. The countdown sound seemed the hardest to be clearly heard in this context, so I counted out loud along with the game. Sometimes observers, often friends of participants, would countdown aloud with me. The majority of players listened expectantly to the countdown before starting to sew, some glancing momentarily at the screen as they did, but most kept their eyes on the sewing machine and their hands, that were generally positioned ready to sew. Of the twelve participants recorded, two started sewing before the countdown was completed. Both stopped when they realised I, or the game, was counting down, the feedback thus confirmed that play was yet to commence. This demonstrates that, despite beginning before the countdown was completed, the audio feedback from the game was subsequently heard, recognised and acted upon by the participants. If the sound had been ignored when starting prior to hearing it, it would suggest that the audio feedback was being ignored or had no impact upon participant actions. In both cases the premature start was acknowledged by the players either by smiling, as was the case with PR6963 or by panicking then apologising as in the following example:

> Extract from PR6972 [I explain “I will count you in”. Player starts sewing as I say “3…”, player stops in a panic realising she has started too early and says “oh sorry”].

In addition to the ‘start’ sound, as described in the previous section the game aspect also provided an end sound. This again was acknowledged by players but did not dominate or overpower the craft process. Due to this being the first prototype, the number of stitches being measured proved to not always be accurate or the sensor did not catch every stitch, particularly if the player was sewing very fast. This resulted in the end sound sometimes being triggered before the player had completed the actual pocket template. In the main this did not seem to affect sewing with the majority of participants not responding the game’s end-sound and continuing to sew to the end of the pocket. The feedback from the sewing process in this case, thus provided a stronger indicator as to when the pocket, and the game, were completed. This is further evidenced in participants responses and actions who looked to visually see when they had completed the pocket. PR6964, for example, when reaching the end of the template, simply took their hands off the paper and sat back. Others, such as PR6968, stopped sewing and looked around the machine to the assess the completed pocket visually, confirming “it’s not a very good pocket”. One player did respond the game sound ending:

> Extract from PR6961 [In response to the game ending too soon, I say “Oh man!” and someone watching says “ah too slow” (almost laughing). Players asks if he was too slow but I explain it may be an error with the sensor].

In this instance it is possible that the player was reacting to myself and an observer responding to the end sound rather than the end sound itself. This observation was made during one of the first games played at the event and so my reaction of “Oh man!” was due to concern about an error with the sensor and the game. Following this game, I was careful to not respond to the end sound if triggered early so as not to impact on participant’s actions in this way.

In summary, the start and end sounds provided by the game aspect of *Pocket Racer* were both acknowledged by players with participants demonstrating an awareness of them, but there was no evidence that either dominated or distracted from the craft process.

Feedback on progress

Observations within the factory (discussed in Chapter 6) revealed a practice among machinists to track progress through an individual batch (held within individual crates) through the use of piles assigned to completed and incomplete tasks. The same organisation of items was seen within my own approach to working through the t-shirt production. As items were removed from the ‘to do’ pile, placed to the right of my machine, I moved completed items to either a ‘finished’ pile or an ‘unpick’ pile for items I have deemed to be of poor quality, or I had made a mistake on. This organisation felt intuitive but may have been influenced as a reflection of the observation made within the factory setting. Due to recordings focusing on the hands of other participants at their sewing machines, I was unable to see if they organised their spaces in the same way, but their movements appear to suggest taking new items from one side and placing them on the opposite side when complete. The grafted game appeared to have no effect on this approach to tracking progress visually through batches of items.

The additional audio feedback provided by the grafted game did, however, contribute, to tracking of progress of individual tasks. As discussed in previous Chapters, consistent feedback was identified as a key crossover between craft and gaming and feedback on progress towards a macro (Liboriussen, 2013) or transient goal (Juul, 2013) can lead to a desire to continue. Just as Keogh's (2018) example of *Audiosurf* discussed in section 4.2, audio feedback has the ability to induce a sense of pace and urgency in a player. The game sound within *Pocket Racer*, with its incrementally increasing pitch, not only indicated a level of progress towards completion, but the consistent 'bing' played with each stitch added to a sense of pace during sewing, with fast sewing resulting in fast paced feedback from the game. The increasing pitch also enabled the player to gain a 'sense' of progress towards the completion of the specific task (sewing a patch pocket in prototype one and attaching the patch in prototype two) contributing to the feedback provided through the craft process. In both contexts the 'bing' sound with each stitch increases in pitch, subtly inform the player of the approaching end point. Having facilitated many complete 'games' using prototype one at *The Festival of Making* I was very attuned to this sound when taking part in the batch production task using v1.2 and as a result felt very aware of it during sewing with prototype two. Over time I was able to sense how this feedback related to the speed at which I was progressing and got a feel for if I was sewing faster or slower than my previous try. In contrast, participant 'Pink' acknowledged that they had turned the game sounds down after a little time which could suggest they found it distracting or unhelpful to their process or that it just did not add anything to the monitoring of progress for them. This prompts the question as to whether the audio feedback would be useful as an option in a factory setting. These two different experiences are inconclusive of the impact of the incrementally increasing tone on the efficiency of the craft task.

Feedback on quality and performance

Having discussed the potential, but inconclusive impact of grafted feedback of monitoring progress, I will now discuss feedback on quality and performance offered by the grafted game to the sewing process. As discussed, during sewing, as the player pressed the foot pedal the machine moved into action giving feedback in the form of haptic vibrations through the fingers and hands as they guided the paper through the machine, the movement of which also provided constant information of its position to the player. The whirring and rumbling of the machine matched the speed of the sewing, sometimes even causing the table beneath it to rumble if particularly fast. Then of course, as the paper pocket moved under the felt tip pen in place of the needle, a drawn line appeared on the paper allowing the player to gauge their ongoing success or failure at staying on the desired stitch-line. Just as the craftsperson continual monitors their “material through its response to hand and tool" (Korn, 2015:55), this ongoing information enabled the player to make adjustments to their actions. This included the continual adjustment and correction to the position of the paper as it fed through the machine or changing the speed at which they were sewing by changing the pressure that their foot was applying to the machine’s pedal below. All these aspects of feedback were continuous with players responding to them as would be the case for anyone using a sewing machine without the game attached.

Alongside the audio feedback provided by the game element, grafting also offered additional feedback on quality. As observed of interactions with *Hazuki Knit* grafting offered an outcome that was found to be valued by participants in the form of the game score. Once participants had completed their pockets all were observed to wait for their results both in terms of quality and speed. After each player finished, the drawn line would be looked at for closeness to the desired stitch-line and deemed either ‘acceptable’ or ‘rejected’ based on whether the player had stayed within the outer grey border. The decision was made by myself through visual inspection but often involved discussion and agreement with the participants themselves. The decision was confirmed verbally to the player and through the pressing of the external ‘accept’ or ‘reject’ buttons. Players would then wait patiently for their game score to be displayed. The score represented the total time it had taken for the player to complete a pocket, measured from the end of the start sound to the end sound. All players were observed waiting for their score to be revealed which suggests a desire to receive feedback on their performance in terms of speed. Game score and accuracy of 'stitching' were thus equally valued by participants. This is a positive outcome. In *Hazuki Knit* the game score was seen to be valued with many participants demonstrating a desire to improve their score, but this was to the detriment of the craft output. With visual feedback of the game overpowering, knitted fabric being produced was generally not visually monitored as would be expected of craft practice. This result in flaws and errors being overlooked. This would be undesirable in the factory setting and could result in quality of production diminishing. *Pocket Racer*, on the other hand, was more balanced in terms of feedback, with visual attention kept on the craft aspect throughout the sewing process. Quality was not consistent, and the majority of participant's pockets were 'rejected' for going outside of the acceptable border, but participants demonstrated a concern for quality and an awareness if the stitch-line went beyond the acceptable limit.

The judging of finished pockets as inaccurate led many participants to want to improve quality, a desire that I identified as leading to and necessitating processes of repetition linked to the acquisition of skill (Sennett, 2008; Juul, 2013) in section 4.3. Within *Pocket Racer* this was seen to be linked to feelings of disappointment when failing to produce an accurate pocket as the following example suggests:

> Extract PR6962 [I say "ok, judging…so you've gone outside the grey line which means I'm afraid", looking at the finished pocket again and pointing to the reject button on the controller. I explain this is the quality control element to the game. Player makes "oh" noise in slight disappointment but also laughing. She asks to try again].

This desire of participants to improve their accuracy is further implied in their response to an improved outcome on a second try. For example, player PR6964 who previously compared the quality of her fast sewing of her first pocket to off-road driving, asked if she could try again (this time recorded as PR6965):

> Extract PR6965 (second try) [Stops like last time and sits back them says "it's a bit better", referring to the accuracy of her line.] [I press the 'accept' button and the player cheers] clearly pleased to have improved enough to pass.

A competitive drive to achieve a 'high score' and 'beat' their own score, or someone else's, also appeared to be a strong motivator for some participants. High-score chasing is an aspect of dominant in early arcade games and persists today in mobile videogames (Keogh, 2018), a feature which creates no end point. Juul (2013), defines such games, of which *Pocket Racer* could be categorized, as game with an 'improvement goal'. The primary goal of such games is to complete your personal best, a goal which once achieved "is immediately replaced with the goal of beating the new personal best" (Juul, 2013:85). Within observations of *Pocket Racer* gameplay, this goal was accompanied by a desire to beat others', as well as participants own scores. The first participant to take part at the event jokingly commented at automatically achieving the highest score saying, with slight amusement, "I wanted to get the high score". Other players directly express the desire to do better than their friends making comments such as "as long as I beat them". The following example demonstrates the competitive desire leading also to a desire to have another go of the game:

> Extract PR6963 [I say time is… 12:03". I look for the fastest time in the pile, the player sees the time and says "7:89" and immediately asks "how was that?" indicating with her hand that she wants to see the quality of the line. "Aw pretty good". She asks "can I do another to try and beat that?" and laughs. I say "you can" and she seems surprised. Player: "Can I?" Me: "Yeah, dive in".
> Player: "was is it, 7:89?, checking the score she wants to beat for her 2nd game, "not that I'm competitive" she jokes.
> After finishing the second pocket - Player removes paper from the machine and places it down on the table - glancing to check the quality before looking to the computer to wait for the score to be revealed. I say "10:02". Player sighs disappointed, "ahh, flipping heck". I say "close" and she laughs.]
> *Note: both pockets are accepted as accurate.

What seems significant about this example is that the participant improves their own time by more than 2 seconds on her second try but is still disappointed. The desire to get 'the best' score in this case is stronger than one of self-improvement. The desire to be competitive does not seem to overpower the drive for a quality output as it did in Hazuki Knit where the physical knit was put at risk when competitive play was prioritised.

In the next section I will discuss how the desire to improve the game score, either to compete with yourself or another participant, led to the adaption of techniques to improve efficiency in the sewing process within observations of prototype v1.2.

7.5 Strategies and Techniques

During observations of machinists' carrying out tasks in the factory (Chapter 6) it was seen that some participants adapted their own jigs, tools or techniques to perform particular tasks with increased accuracy. This was identified as an area for potential value, where the encouragement of machinists to develop more of these techniques and share them amongst their fellow machinists, could lead to improved efficiency in production, reducing time taken to complete individual tasks. In interactions with *Hazuki Knit*, it was observed that the desire to improve the game score led to either competitive or cooperative gameplay (see section 5.6), the former of which put the knitting at increased risk of failure through dropped stitches, sometimes resulting in the machine jamming and/or needles breaking. Failure in the form of Game Over was not experienced as an outcome of *Pocket Racer* and was not a feature programmed into the game element. Instead, failure or error, was 'judged' against the subjective accuracy of the finished item i.e. the closeness of the drawn line to the desired pocket shape in proto v1.1, and the quality of the finished patch stitching in v1.2.

In contrast to experiences of failure through *Hazuki Knit,* a desire to improve the game score was demonstrated by many participants through the development of strategies including cooperative gameplay and adjusting bodily movements. In *Pocket Racer* a desire to improve was reflected in both the game score (speed) and quality of the craft output (accuracy).

Very few participants engaging with the first prototype of *Pocket Racer* played more than one or two games so the development of any particular strategies to improve their game score, the time taken to complete the sewing, was not observed. Repetition was necessitated by the batch production requirement when using v1.2 of *Pocket Racer* and so there was more opportunity to observe the development of particular strategies. Through the game data collected and video recordings it was also possible to analyse any changes to task timings as individual participants progressed through their batches. All three participants, myself included, expressed having experienced a desire to improve their score and reactions to their game score suggested this too at some points. For example, during recording participant 'Pink' deliberately reads their score allowed each time (for the purpose of the research), on their fifth T-shirt, 'Pink' says "ooh 41.167" in a tone that suggests pleasant surprise. Their previous score was above 50 seconds, so this was quite an improvement upon that. The game data collected via the game server showed that the general trend through each participants' batch was that of improvement with times reducing on average (see Appendix E2).

As one of the machinists, I was able to reflect on my own desire to improve. I felt particularly driven to improve my score once I knew the other participants' scores, which could be in part due to my role in the research as well as a participant. An additional factor involved in my own approach to the activity was that as the other participants shared their recordings with me and as I monitored their improving scores, I became even more focused on improving my own score. Having access to the ongoing video recordings I was able to directly observe the actions of the other participants and compare it with my own sewing technique. My initial scores (during my first session) ranged between 67 and 95 seconds, whereas the other participants scores were lower, 'Pink' in particular was achieving scores between 37 and 57 seconds. By observing the other participants' techniques for attaching the woven patch and loop to the t-shirt hem, I was able to see where my method could be improved to reduce time. Even though sewing on the patches was a relatively simple application of sewing round the four sides, I was able to reduce my sewing time by making some small changes. When I first started sewing the patches on, I began part-way along the hem edge, sewing a back-tack at the start, then continuing to sew along all four edges, turning at all four corners then overlapping the end of the stitch-line slightly at the start point, with an additional back tack. The back tacks, part automated in function by the sewing machine, is an important element that secures the sewing ends preventing the stitching from unravelling and is thus a step that could not be omitted to save time. Having watched the videos of the fellow participants though I was able to see that they both started and ended stitching at the fourth corner, keeping the back-tacks but not attempting to overlap the start and end of the stitching. In essence this enabled the last corner movement to be removed from the process. I also noted a difference in when I trimmed the thread (that is left by the machine at the start of the stitch line) compared with the other machinists. I was pausing sewing after the first/second corner to grab my scissors and trim the long thread end from the start. The other machinists simple waiting until the patch was completely sewn and trimmed the start thread along with the end thread once the task was complete. The combination of reducing these two elements reduced sewing time almost immediately. Further comparison also highlighted a subtle difference in how the other machinists approached sewing the corners of the patch. The woven patches were rectangular in shape but with very slightly round corners. To sew them with a single 90-degree turn in the stitching would not have matched the edge of the patch closely enough and would have looked like poor quality on the finished garment. Instead, the corners required a slightly angled approach. When first sewing the patches of my own batch I did this using two-part turns, leaving the sewing needle down, so that the fabric could be pivoted around it and to ensure that the final stitch-line remained continuous in appearance. I was able to see from the video recordings that the other machinists were only turning on the needle once at the corners and sometimes manoeuvred around any remaining curve of the corner whilst sewing. The video in Appendix B5.12 shows examples of the progression of techniques used.

This links to observations in the factory of different techniques being used for comparative task of securing belt loops by machinists on different lines. The different techniques and strategies used (including the use of a custom jig by one participant) affected the time taken to complete the task on average, one machinist performing significantly faster than the other. P2 showed an increased awareness of time and access to comparative techniques enabled improvement of techniques to reduce time without reducing quality. Significant that this was a self-led/motivated action as a result of game feedback and access to wider data.

Following observations of practices within the factory discussed in Chapter 6, I proposed that additional aspects of feedback could encourage the development of strategies through a desire to improve the game score, resulting in faster, more efficient task timings. The grafted feedback offered *Pocket Racer* in the batch production of items, demonstrated this outcome within my own sewing processes. This outcome could thus have implications within the factory setting in improving production efficiency, but this would of course need to be fully tested within that setting.

It is important to note that unlike observations of competitive gameplay with *Hazuki Knit,* the desire to improve score in *Pocket Racer* did not appear to impact negatively on the quality of the output with participants showing care to ensure a quality finish was achieved. I have already mentioned, the 'accept' and 'reject' buttons of the first prototype were removed from v1.2. Instead, the judgement of quality became self-actioned with all participants demonstrating an accepted quality level beyond which each chose to correct any perceived errors. Within the organising my own batches, as I completed items, I moved them from 'to-do' to 'completed' and also designated a pile for items which needed unpicking having thus decided they were unacceptable. This is comparable to processes of quality checking witnessed in the factory and the demonstration of consistent care taken in quality of batch produced items suggests the desire to improve the game score and reduce sewing speed would not overtake existing quality assurance processes.

7.6 Conclusion

Having discussed the development of the two iterations of graft-game *Pocket Racer and the* analysis of observations made of participant interactions with them, I will now summarise the findings. As stated at the beginning of this Chapter, this final stage of the research brings together Strands Two and Three. Building upon the findings discussed in Chapter 5, I have further investigated the potential impacts and outcomes of grafting, aligning them with the challenges currently faced by project partner, *Cookson & Clegg*, as identified in Chapter 6. Before I bring together these various threads of the research, I will first re-cap on the aims of Strands Two and Three, and highlight the relevant findings of Chapters 5 and 6:

Strand Two: **Grafting potential**

The aim of this strand was to investigate the relationship brought about through directly connecting craft and gaming by 'grafting'.

Strand Three: **Finding value**

This strand sought to highlight the potential value this relationship could have for and beyond the individual disciplines, including potential impacts for the industrial partner setting.

In Chapter 5, as part of Strand Two of the research, I discussed observations of the first prototype graft-game *Hazuki Knit* which revealed the potential for grafting to have a negative impact on craft processes through increased risk of failure to the knit output. Potential positive outputs were also discovered. Namely:

- Grafted feedback systems can create outcomes that participants value and work towards. In the case of *Hazuki Knit*, this was that players on the knitting machine valued the digital game score in addition to or above that of the knitting output.
- Grafting can promote the development of strategies by participants to achieve a higher score and avoid Game Over, for example through cooperative play and adjusting bodily movements to maximise efficiency.

Through observations of skilled practices and processes taking place in the factory setting of *Cookson & Clegg* (as discussed in Chapter 6) I identified two key areas where value could be added to improve production efficiency. I proposed the following:

1) With factory machinists currently receiving no feedback on the efficiency of individual production tasks, productivity through the addition of live, continuous feedback in the same manner as feedback had been offered to players of graft-game *Hazuki Knit.*
2) There is currently little to no awareness of best practices, in terms of the most efficient construction techniques and supporting methods. Additional aspects of feedback provided through grafting could encourage the further development of

such strategies through a desire to improve a game score as was seen in *Hazuki Knit* grafted gameplay.

I will now summarise the areas discussed within this Chapter before discussing how findings demonstrate alignment with these proposals.

Prototype development

The first iteration of *Pocket Racer* (v1.1) was developed in response to initial discussions with the factory and then trialled with members of the public at the *Festival of Making* in Blackburn. The prototype was planned to account for existing tool use and habitual practices consisting of a domestic sewing machine, connected with an adaptation of an existing game, with the challenge set to 'sew' a pocket as fast and as accurately as possible using a paper template. Pockets were 'judged' based on the quality of the sewn line (i.e. whether it stayed within the designated area either side of the desired line) and a final score, in the form a of the time taken to complete, was measured by the game.

The second iteration (v1.2) was later developed with the intention of being used as an intervention in the factory setting of *Cookson & Clegg*, adapting the sensor attachment for temporary use on machines in production. The game aspect was developed further into a mobile app to take advantage of mobile phones that had been deployed to staff on the production lines for the new *Galaxius* system. An additional function was added to the app to enable a variation of tasks to be measured, not just the setting for the pocket template used for the first v1.1. In light of the pandemic and local restrictions, the research had to be adapted due to not being able to access the factory for observations. Instead, a small group of domestic machinists (including myself) were recruited to work on a one-off batch production process, attaching custom badges and loops to an order of T-shirts. To assist with remote observations of these machinists, a game server was set up for the monitoring of game scores alongside video recordings submitted by the participants.

Previous experience

In section 7.2, I acknowledged that prototype development took into account the potential embodied actions gained through previous experience with sewing and sewing machines.

Players of v1.1 that commented on having previous experience generally expected to be ‘good’ at the game yet found using a different machine with the needle position adjusted and replaced with a felt tip pen, proved to impact on their expected performance. Knowledge of familiarity (Merleau-Ponty, 2012) was seen to out-way any conscious awareness of changes to the sewing machine. No such issue was observed to be an issue with v1.2 because participants used their own machines with no changes to the sewing needle position. These aspects have thus been demonstrated to be important for consideration for any future interventions.

Material affordances

In section 7.3 I discussed how participants engaging with *Pocket Racer* v1.1 at the *Festival of Making* were each given a set of verbal instructions and sometimes a brief demonstration alongside the aim of the graft-game (to ‘sew’ a pocket template as fast and as accurately as possible). These instructions included a brief overview on how to control the sewin machine using the foot pedal for those who had never used a sewing machine before. Participants engaged with v1.2 were given full instructions on set up and how to manage the grafted aspects (recording a task timing etc) during a video call. As experienced machinists, these machinists did not require an instruction on the use of the sewing machine and were provided with a sample finished garment to show the desired finish for the patch to be sewn to each T-shirt. During engagement with prototype v1.1, inexperienced participants often displayed some unease at the initial movements of the sewing machine upon starting and struggled to match their bodily movements with controlling the movement of the paper template through the sewing machine effectively throughout the grafted gameplay. All the experienced machinists engaging with prototype v1.1 displayed no evidence of coming into contact with new material affordances, as had been expected. Repetition, upon which material knowledge is expanded, was observed very little at the *Festival of Making* due to the short-term nature of the event. Within the batch production setting of engagement with v1.2, however, the repetitive nature of tasks mimicked that of the factory setting discussed in Chapter 6. Here, the repetition of tasks was linked to an increase in awareness and understanding of the grafted affordances provided by prototype v1.2, enabling the development of strategies and refining of sewing techniques discussed in further sections of this chapter.

Grafted feedback

In section 7.4 I outlined the forms of feedback offered by *Pocket Racer*, specifically focusing on those that the game aspect offered to the craft process i.e. sewing. Audio forms of feedback were predominant with start and end sounds, and incrementally increasing in-game sounds. Development had been cautious not to create overpowering elements of visual feedback as had been observed to distract from the craft process of *Hazuki Knit*. Observations as the *Festival of Making* showed participants were aware of and responsive to the start and end sounds but they did not dominate over feedback and indicators from the sewing of the pocket template, specifically the finishing of the pocket.

Continual audio feedback in the form of a 'bing' sound, increasing in pitch with every stitch completed, was observed to potentially add to a sense of place in sewing. Participants received feedback on quality and performance via the 'judging' of pockets/items as acceptable or rejected (by the facilitator in v1.1 and self-judged in v1.2) and via the game score represented. Both aspects were seen to be equally valued by participants, thus well balanced, unlike observations of *Hazuki Knit* where the game score was seen to be valued over the knitting output. The judging of the quality of pockets in v1.1 as 'rejected' led participants to want to try again and improve. This was equally through a desire to improve the game score i.e., the time taken to complete the pocket, which could be a significant desire to promote in the factory. The desire to improve was seen not only to be a desire to self-improve but also as a competitive need to achieve the highest score and to 'beat' others.

This supports the proposal that the addition of live feedback on task timings in the factory could be of value, which has been demonstrated to encourage a desire to improve both speed (score) and accuracy (quality).

Strategies and techniques

Through engagement with prototype v1.2 it was possible to observe the development and refining of strategies and specific techniques through repetition of actions that resulted in the same desire to improve the game score whilst maintaining consideration of the quality of workmanship. This was supported, in my own experience, by an ability to compare game scores and related techniques used by other participants. This further supports the proposal that grafting could add value in production with the potential to create a desire to improve a game score and seek out methods and techniques to improve productivity (second proposal). Further research would be required to investigate how knowledge sharing of specific techniques between machinists could be achieved in the factory setting.

As outlined throughout this Chapter, in the implementation or development of grafted interventions, care would need to be given to ensure the following:

- That habitual practices and tools are taken into account and allowed for.
- That grafted game feedback, specifically visual feedback, should not overpower and/or distract from any craft feedback.
- Competition of multiplayer aspects should be kept indirect to avoid increased risk to any craft output, as witnessed in *Hazuki Knit.*

As acknowledged in the introduction to this thesis (Chapter 1), the application of an intervention that combines craft with gaming within the work setting of a factory could be linked with gamification. With this comes the potential for exploitation of workers (Bogost, 2011; Seaborn & Fels, 2015). Woodcock and Johnson suggest that gamification "ignores the power dynamics in both the workplace and society", replacing "older forms of labour surveillance and oversight" (Woodcock & Johnson, 2018: 544). A recent increase in digital management technologies has seen a rise in new modes of workplace surveillance (Yu Liu, 2022; Altenried, 2020) which “a small but growing number of academic and journalistic work” (Alternied, 2020:149) has begun to term as ‘digital Taylorism’. In 2015, *The Economist* posed that this “modern version of ‘scientific management’ threatens to dehumanise the workplace” (Schumpter, 2015:online) and suggested that multinational technology company *Amazon* is the embodiment of this emerging trend. As a revitalisation of Taylorist principles, recent technology has enabled workers to be connected to and observed by their managers in “increasingly complex and invasive” (Yu Liu, 2022:2) ways. Such digital management systems have the potential to extend beyond productivity in the workplace to affect worker behaviour during unpaid time (Yu Liu, 2022), with digital

Taylorism "set to be a more powerful force than its analogue predecessor" (Schumpter, 2105:online). Through the linking of performance to pay in work settings such as factories, any intervention that utilises digital management systems has the potential to be intrusive and exploitative.

This research was driven primarily by the framing of the Transformation North West programme with the funding requiring a focus on the government's *Industrial Strategy*. Within this research this resulted in tensions towards a view of productivity, significantly in responding to the business needs of the partner company Cookson & Clegg. With the focus on speed and quantity in the planned implementation of a digital system within the factory any additional introduction of a gamified application would need to be done with great care. Having been unable to carry out a direct intervention of *Pocket Racer* within the factory setting as part of this research, it was not possible to directly observe any impact of the extra layer of surveillance upon workers. Further research would be required to fully understand these aspects.

_8 Conclusion

In this concluding Chapter, I will give an overview of the main areas covered in this research, discuss its original contribution to knowledge, and outline research limitations before suggesting possible areas for future research and practice.

8.1 Summary of the Research

This research has investigated the crossovers between craft practice and the play of video games in order to explore potential insights that could be brought about through directly connecting the two areas. It has done this through the use of creative practice, specifically in the development of two custom graft-games.

Three aims were specified for this research. I will revisit them, one by one in order to outline my findings:

To identify existing crossovers between craft and gaming.

Through the literature review in Chapter 2 I determined that both craft and gaming required the acquisition of embodied forms of skill through repetitive practice and identified four key areas of thematic crossover through an analysis of existing literature including: material affordances, feedback systems, habitual practice, and minimising risk. In Chapter 4, I further explored these areas through a discussion of auto-ethnographic observations of amateur craft and gaming activities, focusing on four case studies: play of video games *Unravel* and *Unravel Two* on the PC, and *Mario Kart 8 Deluxe* on the *Nintendo Switch,* alongside amateur crafts of hand-knitting and macramé. I established a conceptual model that expanded upon the identified thematic crossovers through reflections of amateur practice. Having established that both physical and digital materials pose a set of limitations and affordances, direct engagement with these materials revealed that these affordances are presented to a maker/gamer via explicit controls or instructions and are further understood through encountering them in action. Having identified that both craft and gaming involve an active conversation between material, tool and maker/gamer, observations of amateur practice enabled three types of feedback to be outlined (visual, audio and haptic). These feedback types were further understood to provide explicit and quantitative information on player and maker progress alongside qualitative feedback including confirmation of flaws and failures. The acquisition of skill acquired through repetitive action and habitual practice, including the embodiment of tools, was identified as a third crossover in Chapter 2. The amateur craft and gaming case studies provided detailed reflection upon the role of repetition both as a result of failure or error and as a desire to improve as a direct result of feedback received. The final crossover identified that within both practices, elements of risk are controlled through the appropriation of jigs and skilful action. Direct engagement recognised specific approaches to minimising risk that included the use of the body as a jig, and the optimising of actions and other strategies to both avoid failure and maximise the chances of success.

To investigate the relationship brought about through directly connecting craft with gaming.

In Chapter 5 I described the development of prototype graft-game *Hazuki Knit* and came to understand the impacts grafting had upon the individual elements. Through observations of participants engaging in grafted gameplay at a series of public events, I found that grafting had the potential to impact negatively upon the craft activity, knitting in this instance. As a two-player game, *Hazuki Knit,* saw participants engage in two distinct forms of gameplay: cooperative play in which players used refined bodily movements and optimised their actions to achieve a higher score, and competitive gameplay in which players deliberately set out to make the game difficult for the other player. The quality of the knit output was prioritised in neither instance and competitive gameplay in particular, increased the risk of flaws and errors in the knitting.

In Chapter 7 I discussed the development two iterations of second graft-game, *Pocket Racer,* and connected insights of participant observations with the areas of potential for value to be added within the factory setting. Observations of interactions with the prototype at the Festival of Making revealed that grafting encouraged a desire to improve the game score. In this graft-game, the game score was linked to, and representative of the overall time taken to complete a particular sewing task. The desire to improve this was not seen to overpower the desire for accuracy in sewing i.e., the quality of the output was not put at an increased risk.

To highlight the potential value that a direct relationship between craft and gaming could have in contexts beyond the individual disciplines.
In Chapter 6 I described working with project partner, garment manufacturer *Cookson & Clegg*, identifying current challenges faced by the company, especially in terms of production. Through direct observation of activities and practices taking place on the production line of the factory I was able to identify areas where value could be added to improve productivity. I discovered that self-initiated jigs and variations in techniques being used across production lines impacted upon individual task timings. I also highlighted that machinists working on the line had little to no clear awareness or means of tracking efficiency of individual tasks. I proposed that additional feedback of task timings may promote the further development of strategies to increase efficiency and reduce overall production times.

Observations of graft-game *Pocket Racer* (discussed in Chapter 7) revealed that well balanced grafted feedback had the potential to increase a desire to improve the game score and develop strategies to optimize this. In this instance the game score represented the time taken to complete a particular sewing task and desire to improve the game score, actually resulting in improved sewing times without the quality of the output being put at risk. This reconnected with the overarching purpose of the research, in that directly connecting craft with gaming through grafting had the potential to be of value to the project partner. I summarised that the additional feedback provided through grafting could encourage the development of strategies to improve efficiency of sewing processes.

8.2 The Research Process

Having revisited the aims of the research and its key findings, I will now reflect on the overall research process and its effectiveness.

As outlined in Chapter 3, the study employed a mixed methods approach incorporating methods braiding, with research methods applied across three strands. The autoethnographic observations carried out within Strand One proved highly valuable in accessing inarticulable embodied actions. Full transcription of all actions would have been lengthy and excessive, but the video recordings captured proved crucial in supporting analysis of reflective field notes, providing clarity and additional detail post-observation. The direct interaction with amateur practices and the tools and materials required, enabled a deeper understanding and questioning of the theoretical crossovers being explored through craft and gaming literature.

Within Strand Two of the research process, I drew heavily on the participatory approach already used within my practice. Prototype 'graft-games' developed in collaboration with artist and technologist James Medd, were closely linked with the participatory contexts within which they were showcased. Through embracing an investigative designing approach (Durling & Niedderer, 2007) the prototypes developed acted as probes that enabled the interrogation of craft and gaming actions. In this context participants acting as co-developers, their actions and responses feeding into the ongoing iterative research process. The open nature of the graft-games presented as experimental prototypes as part of a wider research project, was crucial to the success of data collection at the series of participatory events.

Observations and data collection within the factory setting as part of Strand Three, were a different experience to those at the participatory events. This was in part due to the setting and caution being required to build a sense of trust with the machinists working on the factory floor. Carrying out initial visits to the factory and ensuring I was introduced to key members of staff went some way to dismantling any suspicions. The use of video recordings to support the capturing of individual production actions was successful in supporting field notes and enabled observations to be carried out in a non-invasive manner.

In practical terms, I feel the research design was successful, with the multi-stranded approach allowing for interconnected themes and reflections to occur concurrently as aspect of the research overlapped at some stages. In particular, the research design allowed for a responsive and flexible approach that embraced opportunities to engage with members of the public at a variety of events, and in particular to adapt research methods in the light of COVID restrictions.

8.3 Research Contribution

This study makes several contributions to the related fields of design practice and the emergent interdisciplinary field of craft theory and games studies. Key contributions have arisen through the immediate context of the research, I will outline, however, that there is scope for the research insights to be translated to related areas of academic enquiry and creative practice.

Firstly, a new conceptual model of crossovers between craft and gaming as developed. In the introduction to this thesis, I identified that there is extensive existing research on the collaborative nature of craft and the relationship between work and play yet little empirical research to date has directly explored the link between craft expertise and the play of video games. In Chapters 2 and 4 I developed a new conceptual model of existing crossovers between craft and gaming was developed, contributing to emerging theoretical research across the fields of craft theory and game studies. I have begun to bridge these currently distinct disciplines and contribute to the convergence of craft and games studies both academically and in practice. Within the research, the conceptual model developed contributed to the analysis of observations of interactions with the experimental graft-games, using the thematic lens to discover impacts and outcomes of combining craft and gaming practices. This work will be of value to those working within the fields of craft and game studies, both academically and practice-based, who wish to further interrogate the linked relationships between the two, bringing these two currently distinct fields further together.

The identified thematic crossovers also fed into prototype development with the acknowledgement and awareness of existing habitual practices becoming of key importance. This was particularly relevant in contemplating grafting interventions in settings where prior experience may lead to stumbling over embodied actions (Tanaka, 2013; Parisi, 2009) if changes to tools or processes were to be changed significantly. This highlights the importance of assessing the compatibility of individual aspects to be grafted if the approach were to be applied to say combine gaming with another material practice. The conceptual model of identified existing crossovers between craft and gaming provides a suitable basis for exploring grafting as a method in other contexts where craft and games might be combined, outside of manufacturing.

Secondly, this research has demonstrated potential value for grafting craft with gaming within the context of manufacturing. This research was instigated by the aims of the Transformation North West AHRC funded doctoral training program which sought to unlock creative intelligence within the region in response to the Government's Industrial Strategy. Whilst the white paper focused on digital skills, this research has investigated how linked conversations between craft expertise and video gameplay could support growth within manufacturing contexts where production relies on more traditional craft skills. The experimental prototype graft-games developed, enabled insight into the potential value of joining the two practices, particularly in the context of applying digital applications within manufacturing contexts where craft skills are dominant. The outcomes of these investigations are of specific value for the project partner, *Cookson & Clegg*. Since the completion of the final stages of the research, the proposed digital *Galaxius* system has begun to be implemented in the factory setting. As the system rolls out, the management team are looking for how to more consistently get data from the application and how it can be better understood by supervisors and machinists on the line. Grafting as an approach has enabled me to make recommendations to *Cookson & Clegg* for improvements that could be made to the *Galaxius* system going forward.

Although the insights found through *Pocket Racer,* in particular, are aligned with the challenges faced by the project partner, they have wider implications for manufacturing contexts where craft skill plays a significant role. The graft-games developed were not designed as solutions to be rolled out, but the act of grafting has demonstrated itself to be an approach that provides a 'quick' method for exploring and investigating potentialities brought about through directly developing a relationship between craft and gaming.

Thirdly, the research contributes grafting as a model that is both adaptive and responsive to different settings and contexts. During the research, two prototype graft-games were developed, *Hazuki Knit* and *Pocket Racer* through which there was some continuation and development of insights. As well as the cumulative effects of these insights within this research study, the prototypes offered differing, individual outcomes. For example, the impacts of direct competition on the craft output in *Hazuki Knit* was driven by the two-player aspect of the game, an aspect that was not observed through engagement with *Pocket Racer,* a single-player game. These varying insights were provided through observations of the participatory contexts used as part of the research methodology, and without excessive prototype development. This demonstrates the value that grafting as a process provides, enabling insights into the impacts and outcomes of different combined elements with some speed.

Finally, in the introduction to the thesis I acknowledged that the study could be seen to be synonymous with the growing field of gamification but that this would not be a focus on the research as it was felt the political aspects of gamification might detract from the intended aims. Whilst I hold the position that issues around power and possible exploitation of users, especially workers within the partner factory, were not a desired area of focus for this study, having completed the research it is reasonable to reflect that the insights gained do have implications for the gamification field. Through the development of custom, experimental graft-games, this research offers a new approach by using creative practice to contribute to the existing theoretical and practical approaches. The investigative designing approach in which prototypes act as a probe is an approach that is not currently used widely. As discussed in Chapter 2, current 'craft games' that combine craft with gaming, tend to use craft as an input or output device games that remain for the use of leisure. In the respect of being used within non-gaming contexts, the graft-games developed within this research could be likened to examples of gamification. Having rapidly gained traction in recent years, gamification is generally utilised to motivate and increase user activity and retention (Deterding, Dixon, et al., 2011), whether those users be customers or employees. Despite this, critics and proponents alike call for the careful application of gamification to existing systems with no single method appropriate for all contexts. Woodcock and Johnson suggest that gamification is “increasingly - and uncritically - being applied to new fields” (Woodcock & Johnson, 2018:543) with little research being carried out in cross-disciplinary contexts. With little existing research that directly explores links between craft and gaming, especially from the perspective of creative practice, this research contributes new knowledge through the development of custom ‘graft-games’. This approach of grafting has enabled craft and gaming to be explored in direct relation to one another in an experimental and creative manner.

8.4 Limitations

No research is without its limitations and this study is no exception. Research insights have hypothesised the potential value that grafting could have upon efficiency of production within the factory of the project partner, *Cookson & Clegg*. As direct interventions were unable to proceed as planned due to COVID-19 restrictions, the research plan had to be adapted to intervene within a small batch production process amongst domestic sewers. The research findings were not compromised due to this change and, due to taking part myself in the production process, the approach enabled greater access to reflective moments -in and -on-action. Nonetheless further research could extend the scope of the study and test the methodology. Outcomes may suggest further research within the factory environment around aspects of motivation and hierarchies of power between machinists and management, may affect desires to improve efficiency as different to those of the participants within the research. Further research could apply the approach of this study against economic considerations, such as wages and economies of production. In addition, as this research focused on working with just one industrial partner, particularly in the outcomes of *Pocket Racer* which were aligned directly with the challenges faced in this setting, the research methods and findings could be adapted to other manufacturing settings. The approach of grafting, however, could be directly transferred to other manufacturing contexts, especially in settings where craft skills play a core role within production. Grafting, as seen within this research, provides quick insight into the impacts of combining gaming with craft processes to assess potential impacts and outcomes without the need to develop fully fledged applications from scratch.

Another potential limitation of the project could be the decision to limit observation of craft activities to those of textile making. This was deemed appropriate for this research both in terms of my own experience and interests as an artist and amateur maker, and in relation to the specialist skills employed within the production setting of garment manufacturing within the project partner setting. However, the conceptual model developed within Chapters 2 and 4, considers theoretical perspectives from broad craft literature taking a non-specialists view of craft practices. Grafting as an approach would always be dependent on testing with individual crafts and games to assess specific impacts.

8.5 Recommendations for Further Research

Due to the limitations imposed by the pandemic, the final insights of this study highlight potential impacts of grafting upon practices within the partner factory. This provides an ideal basis for a follow up study in which the hypothesis could be fully tested within the actual work setting. This could also be expanded to apply the same research methods to test out the potential for grafting in other manufacturing contexts. This research offers a base for further investigation into the suitability of applications in contexts where game interventions, including aspects of gamification, are being considered. Through a creative approach to prototype development, the study suggests that grafting could be used as a method to shortcut to the development of fully fledged applications which require large teams and generous budgets.

Within observations of two-player graft-game *Hazuki Knit* (Chapter 5) cooperative and competitive forms of gameplay strategies arose. As discussed, competitive motivations had the potential to have destructive outcomes for the quality of the knit output which was put at high risk through direct competition between players. This was not considered desirable in the context of the factory setting and direct competition was removed from the development of the second graft-game *Pocket Racer*. As acknowledged in Chapter 5, cooperation and competition can combine in the negotiation of gameplay and in the potential to lead to the sharing of good practice. This reveals a tension between cooperation and competition in relation to the crossovers between craft and gaming that would warrant further research. Within this research the final intervention was shaped according to the needs of the partner factory and the requirements of the PhD funding. The research would benefit from further investigation into the tensions between cooperation and competition outside of these contexts.

As I have discussed, there is currently a lack of empirical studies that explore similarities and crossovers between craft and gaming, aside from theoretical work by authors such as Brock and Fraser (2018), Reeves et al (2009), and Nørgård (2012). There is great scope for further work that directly investigates the similarities and potential relationships between the two practices. It would be interesting to explore other craft disciplines and materials and observe the potential spaces grafting could bring about within them. I also believe there is great potential to further explore the production of tangible outputs that use digital outputs from game aspects, such as game score, to affect the physical craft objects being produced.

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_Appendices

Please note: This research project produced an abundance of data, of which a representative sample has been included here.

Research Project: **Making sense of craft expertise and creative value in digital gaming**

This activity is being used as part of a research study which forms part of my PhD at Manchester Metropolitan University. It is one of 12 studentships of the Transformation NWCDTP, funded by the AHRC as part of the National Productivity Investment Fund (NPIF).

The study is interrogating and investigating the cross overs between traditional craft and digital forms of making, specifically gaming. The overall aim is to consider the impact of computer gaming on the future of industry, its qualities as a transformative digital technology with craft practices seen as reciprocal positive characteristics. This activity aims to observe the making processes of amateur and experienced crafts people, and gamers.

All participants (over the age of 18) are invited to take part by being filmed whilst taking part in the making/game activity. The aim is to capture your engagement with the activity, but your participation is purely **voluntary** and if you do not wish to be recorded you may still take part in the activity. All data captured (video and written notes including quotes) will be saved anonymously and will be stored securely in digital form.

Video recordings will be used for analysing making processes and will contribute to research outputs of the study including PhD thesis. In addition, recordings may be documented and disseminated in by myself, Graft Games and/or as part of the Transformation North West programme to be shared online, at conferences and through group progress reports and/or publications

Many Thanks
Gemma

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THE MANCHESTER METROPOLITAN UNIVERSITY
LEGAL DEPARTMENT

VIDEO CONSENT FORM

I consent to the use of videos of **myself**, taken by members of the University or by agents authorised on behalf of the University such as the research student **Gemma May Latham** and **Graft Games**.

I understand that the videos will be used for the following purposes(s):

Video recordings will be used for analysing making processes and will contribute to research outputs of the study including PhD thesis.

In addition, recordings may be documented and shared via Graft Games and disseminated as part of the Transformation North West programme online, at conferences and through group progress reports and/or publications

Name of person being filmed: …………………………………………………………………..

Signature: …………………………………………………………………………………………….

Address: ………………………………………………………………………………………..………

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<u>For office use</u>

Campus: Department:

Project Name: Job Number:

Photographer: Notes:

Data Protection Policy
Manchester Metropolitan University

Manchester Metropolitan University

TRANSFORMATIONW
A DOCTORAL PROGRAMME IN DESIGN & CREATIVITY

Participant Information Sheet

Making sense of craft expertise and creative value in digital gaming

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Email: gemma.m.latham@stu.mmu.ac.uk

I would like to invite you to take part in a research study. Before you decide you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. Ask questions if anything you read is not clear or would like more information. Take time to decide whether or not you wish to take part.

This research project forms part of my PhD at Manchester Metropolitan University. It is one of 12 studentships of the Transformation North West (TNW), funded by the AHRC as part of the National Productivity Investment Fund (NPIF). TNW is a fully-funded doctoral training programme that applies design and creative techniques to maximise new product and service opportunities for business in the North West.

What is the purpose of the study?
The study will interrogate and investigate the cross overs between manual and digital forms of making, specifically craft skills and gaming. The overall aim is to consider the impact of computer gaming on the future of industry, its qualities as a transformative digital technology with craft practices seen as having reciprocal positive characteristics.

Currently, the value of gaming as a digital form of craft labour is difficult to translate to non-gamers, especially policy makers. A series of projects with Industry partners (cultural and commercial) across the NW will map the parallels between digital and analogue forms of craft labour, exploring ways that digital technologies are shaping perceptions of making. In support of these projects this particular study aims to observe the making processes of workers within manufacturing contexts.

The findings, including video and audio recordings, and written reflections will primarily be used to contribute to my PhD study but may be shared through research publications, public reports produced in collaboration with Manchester Metropolitan University and the Transformation North West Program. All data will be anonymised.

Why have I been invited?
As part of the study, I wish to observe manual skills being used in manufacturing contexts. I am working with 3 organisations across the North West and have invited 6 participants at each location to take part, based upon their particular job roles and following discussion with stakeholders within each organisation.

Do I have to take part?
Your participation is voluntary. While I would be pleased to have you participate I respect your right to decline. It is up to you to decide and your decision has no bearing on your relationship with your employer. I will describe the study and go through the information sheet, which you will receive a copy of to keep. I will then ask you to sign a consent form to show that you have agreed to take part. You are free to withdraw at any time, without giving a reason. You are under no pressure to take part and you can stop at any time.

What does the study involve?
I will arrange a series of dates and times to come and observe your work tasks over the course of 6 months. Each observation session will last 1 to 2 hours including set up and I would like to collect data across 3 sessions if possible. These observations and data captured will take place in your normal place of work and during your usual agreed working hours. All session will be agreed in advance with your manager to ensure minimal disruption.

During agreed observation sessions, a combination of methods will be used to capture working processes. These will include video capturing using a Go Pro camera (potentially with a chest harness), a second camera capturing a third person view and screen recordings for any digital work; along with audio recordings and written field notes.

The observation sessions and the data collected will give me insight into your processes and allow for the interrogation of cross overs between physical and digital forms of making such as gaming. The video recordings captured will be used to reflect upon and discuss your making processes in more depth during a follow up interview, this may be done individually or I may invite you along to a session with other research participants within your organisation where we can discuss the data captured as a group. All sessions will be audio recorded so that I may type out the material afterwards – this is a process called transcription. The recording and the typed document will not be marked with your name and both will be securely stored.

All data captured (video, audio and transcribed data) will be saved anonymously and will be stored securely in digital form.

You are under no pressure to perform in any particular way during these observations. The aim is to capture information and insights into your working processes. The session can be stopped at any time.

Expenses and payments?
Your participation in this study is voluntary and as observations will be made at your place of work, no additional expenses will be required.

What will I have to do?
I wish to capture your experiences during your carrying out of your normal working tasks so do not require you to do anything different. I will try to remain quiet during observation so as not to disturb whatever usual routines you have during these times.

What are the possible disadvantages and risks of taking part?
The research activity should provide no more risk or discomfort than your day to day work tasks. You will be given a Go Pro camera with chest harness to wear and I will assist with placement of this if needed. I will spend time during set up to ensure that this is comfortable but if at any point you are unhappy with you can tell me and it can be easily and quickly removed.

Any risks associated with the common tools and equipment relating to you own job remain the responsibility yourself and your place of work. Please could you make the researcher aware of specific elements of your process that could pose a risk to the observer e.g. Hazardous chemicals or dangerous equipment, prior to the sessions so that any further risk assessments may be carried out.

What are the possible benefits of taking part?
I cannot promise that the study will help you but the information I get through observing your activities will increase the understanding of physical and digital making processes and raise the value of the skills involved.

What if there is a problem?
If you have a concern about any aspect of this study, you should ask to speak to myself (the researcher) and I will do my best to answer your questions (07786076483).

Please direct any complaints to MMU Research Centre Director, Professor Martyn Evans
email: martyn.evans@mmu.ac.uk
telephone: 0161 247 129

Will my taking part in the study be kept confidential?
All information which is collected about you during the course of the research will be kept strictly confidential and any information about you which leaves the university will have your name and address removed so that you cannot be recognised.

Your data will be collected in written forms and/or electronic mail and via video and audio recordings described.

- individual participant research data, such questionnaires/interviews/data from audio/video recordings will be anonymous and given a research code, known only to the researcher
- A master list identifying participants to the research codes data will be held on a password protected computer accessed only by the researcher
- hard paper/taped data will be stored in a locked cabinet, accessed only by the researcher
- electronic data will be stored on a password protected computer known only by the researcher

Identifiable data may be shared with project supervisors for the ongoing development of the research.

What will happen if I don't carry on with the study?
If you withdraw from the study all the information and data collected from you, to date, will be destroyed and your name removed from all study files.

What will happen to the results of the research study?
Following the study, results will be analysed and compiled into a format to contribute to the PhD thesis. The results may also be used to contribute to group reports through the Transformation North West program. No individual respondent will be identifiable from this information unless you have given consent for this. Copies of any published reports will be available on request.

Thank you very much for your time and consideration in taking part in this study.
Gemma May Latham
PhD Candidate
Manchester Metropolitan University

Appendix B1 Example field notes from participant observations of Hazuki Knit

Hazuki Knit

Game Lab – Science Festival

Salford Uni 21st/22nd October 2018

Observation Notes

Day One – 21st Oct

“You naturally want to go faster” – lady on knitting machine who said her nan had one

-Her daughter on knitting machine went slower when eyes were on the screen

-2 men, both were cautious at first on the knitting machine, taking care to swap hands in between rows (*maybe worried arm would get in way of the yarn coming down from top*)

-James on knitting machine: sound went odd and we both instantly took it as an indicator that it was getting stuck – sound in game lets you know when its game over – knitting machine does the same

-Boy on knitting machine going fast pace – James on game buttons finds it hard to keep up – James says “its hard mode” – what if could select game mode/level by person on the knitting machine (their skill level) – easy, medium, hard

-“my hands are too small”…”if only it was on a keyboard it would be ok” woman on game buttons

-Girl says to her brother “do you know what the trick is, you look up”…pointing at the screen, indicating better not to look at your hands on the buttons

Day Two – 22nd Oct

start to implement marking scores on the knit by adding in line of white knit for each new player/turn (one player may try several times in a desire to improve). White yarn begins to get clogged up in machine so we stop using it after a couple of hours*

-Machine getting stuck/clogged/jammed a lot more today. Takes much more time to fix this version of ‘game over’. Is there an equivalent in games? Maybe when game glitches or controller breaks? Is the maintenance of tools and machine more complex with knitting? Unlikely to get this issues with hand knitting. During the course of the weekend the game does seem to fail to display the game over screen so to correct we reset machine by turning off and on again – rebooting the raspberry pi(the computer). This is much quicker than unjamming the machine, or hooking back on dropped stitches or casting on new knit. What if buttons on game broke? Would a gamer repair the buttons on their own machine like a knitter may fix the mechanical aspects of a knitting machine or at least take it to someone to repair it. What role does maintenance of tools/equipment play in gaming and craft?

-James says “I’ll have a scarf by the end of the day”, another man asked me in the morning “what are you knitting for me today?” ***focus on the output/object from the knitting machine as evidence of activity

-Many people ask “what is the highest score of the day?” – and then showing a desire to want to beat it

-The ‘scarf’ being produced is a collective object produced by people taking part, doesn’t seem to be a sense of ownership, a couple of children ask if they can take it home but no adults. Wonder what would happen if we offered for them to sit long enough to produce a scarf or object to take home

-A score is a very individual item. Even without a clear leaderboard on show. People in groups compare their scores with each other….who had higher score…would they compare scarf lengths?

-Man asks “can I have another go?” desire to get better/beat own score – to which James responds “practice, practice”

-Many children on the game buttons tended to watch their hands, moving between screen and hands to find the right button to press. Adults would have eyes on screen/the material. The knitter often watched the screen too. Perhaps more experienced would watch the knitting more? Or does sound and feel play more of a role?

Appendix B2 Example video transcript from participant observations of Hazuki Knit

Hazuki Knit

Game Lab – Science Festival

Salford Uni 21st/22nd October 2018

File: Game Jam_Oct18_v3

Single player on game controls

One hand hovering over left and the other over the right button, index finger pressing button. On 11th turn, hand (right) has to react to move to up to the UP arrow/button but isn't quick enough and gets game over. Hands pull away from buttons as he says "aar…shhh…oooooo..." then laughs.

File: Game Jam_Oct18_v5

Same player on knitting machine

Moving carriage quite fast, using his whole upper body to rock side to side, one hand on carriage handle (right), other arm resting on left knee. Games ends and player on buttons says something (cant make it out) then there is laughter.

File: Game Jam_Oct18_v6

Same player back on game controls

Hands positioned diagonally, left hand index finger on UP, thumb on LEFT, right hand index finger on RIGHT, thumb on DOWN buttons. Minimal movement of hands beyond finger and thumbs. "aah…." When game over…James (on knit) can be heard saying "oooooooh", player then says "ah, man"

Player has adjusted his hand positions since previous turn

File: Game Jam_Oct18_v7

New player on game controls

Left and right hands hovering directly over left and right buttons, each index finger resting (tip) on the buttons. Right hand moves up to top button when UP arrow comes into play, uses index finger, then stretches index finger down to DOWN button, leaving middle finger over the UP button. Moves middle finger back down to RIGHT button when needed. Right hand is controlling 3 buttons, left hand just one. Laughs quietly when game over.

File: Game Jam_Oct18_v8

New player on game controls

Index fingers resting over left and right buttons again, smaller fingers resting on controller box. Position of arms gives impression player is leant over controls, poised, feet positioned slightly back. Right index finger moves down to DOWN button. Moves left hand and index finger up to UP button but isn't quite quick enough. There's a low sounding "oooh" from James, players right hand stays over controls then he says "let me go again, let me go again", then before restarting says "its hand placement, its hand placement". Starts game and keeps hand position similar but seeming to have both index and middle fingers on left and right buttons. Moves whole left hand to UP button and right hand to DOWN button, still using two fingers on each button. Stays on up and down buttons for a little while. Gets gamer over. Payers says "what?(sounds surprised)....oh right, ok" then laughs. Moves hands away then brings them back over buttons for another go. James tells him its double prompts after 20 (which must have been the realisation at end of last go). Finger/hand positioning the same, except can see the left index finger reach twice for the DIWN button (without pressing) in anticipation of up and down controls coming in to play. When they do come into play, he moves whole hand to UP button (using both index and middle fingers) but only moves right index finger to DOWN button leaving right middle finger on RIGHT button. Left hand scrambles a little to get to LEFT button, then back to UP.

File: Game Jam_Oct18_v11

New player male on game controls

Starts in 4 finger position, right index over UP, right middle over RIGHT, left index over DOWN and left middle over LEFT. Tips of fingers are resting on each button but lifts hand slightly and fingers when about to press a button…..this is same game as knitting machine getting stuck and we all hear the noise, I say behind camera "oooh, whats that's noise". Players hands stay poised over buttons, calmly, red light of game over has not be indicated

File: Game Jam_Oct18_v12 and Game Jam_Oct18_v13

James (co-facilitator) on knitting machine

James on knitting machine, right hand o carriage handle, left elbow resting casually on back of chair, eyes always on the screen, adjusting pace to gamer. His body sways side to side a little. He takes carriage right to end of knit bed and almost lets the carriage glide to a halt. Sometimes using just the side of his hand to push the carriage to the left, no gripping handle the whole time, pulling back with fingers through handle.

File: Game Jam_Oct18_v14

New player on game controls

Right hand, index finger hovering over RIGHT button, middle finger resting to side of button steady hand. Left hand, index finger of DWN button, middle finger over LEFT button, small finger resting to side of left button. Hands stumble to both go for TOP button when that comes into play and doesn't make it – Game over. Players, claps his hands together and laughs then asks "what's the highest score, what's the highest score?"

File: Game Jam_Oct18_v15

Same player tires again (game controls)

Same finger positioning as first try to start. This time right middle finger moves up more intentionally to the UP button, with right index finger held against it but not pressing the button. Left hand stays in same position throughout. Gets game over but unsure why, “What?” sounds surprised. I explain what happens when it gets to 20 with two prompts each row of the machine instead of one. He thinks he pressed the correct button and nothing happened, trying to justify why he lost. Put his hands back on the controller and says “I can beat him, I can beat him”, referring to James on the knitting machine. James is distracted, talking to someone else. Player says “he’s not event knowing that’s he’s knitting”. Player presses button to start game and James begins to knit (not sure if he sees screen or if sound of start game is heard) whilst still talking to the other person, explaining how the game works. Uses same finger positioning moving to UP button. When he gets game over, he quickly moves his hands away from buttons and appears to make fists and move down in slight frustration. He laughs then says “it is good though”.

File: Game Jam_Oct18_v16

Previous player now on knitting machine

Holds handle with both hands, moves carriage quite slowly but steady pace. Upper body moving from side to side. James on buttons, gets game over, knitter sits back comfortable and takes hands off handle, laughs quietly.

Appendix B3 Example field notes from participant observations of Pocket Racer

Pocket Racer

Festival of Making, Blackburn

15th/16th June 2019

Day One 15th June 2019

First participant:

"I wanted to get the high score" (when I said she was first so automatically highest)

She was critical of her line, said she wasn't very good but happy with speed

Said she worked in a factory and hated it "it was like a prison"

People interested in accuracy

"I'm nervous" *countdown to start seems to create anxiety

"that was fun"

Group of 3 ladies (friends), "you have to do it too", "as long as I beat them" *sense of competition

I say let's check accuracy – one of the ladies respond "no, don't", as if worried her accuracy was not good

People who look confident (use a sewing machine regularly) seem shocked if they are inaccurate. One girl suggests it's because she would be looking at the seam edge not needle *habitual practice and us of tools

*Does the application of sound induce a sense of urgency/panic? Is that good or bad?

*Game seems to motivate people to improve both speed and accuracy

*Would people (kids) have been upset if 'failed' if sewing was real (on actual fabric), What if they had to unpick it? Paper is throwaway yet can clearly see accuracy. Do they unpick failures in the factory?

Day Two 16th June 2019

If they (participants) hold the paper back or press down it creates more stitches and noise of game finishes way before pocket and the time therefore stops. Should they be trying to get the correct number of stitches and thus finish on end of pocket? Should game over be stipulated if they get under or over correct number of stitches?

*Lots of conversations over the weekend with people that work, or worked, in textile manufacturing, many retired.

Several people with sewing experience say things like “I should be good at this”

The visual countdown on screen is mostly ignored, I do a verbal countdown. A lot of people start before countdown is finished.

People having a 2nd try, some returning later, may go for speed on first try but then want to improve their accuracy on following tries.

Appendix B4 Video transcripts from participant observations of factory machinists

Name: CandC Observations 30.7.19_P1_Full video

Description: Video observations of participant 1 in factory 30th July 2019

	Timespan	Content
1	0:00.0 - 3:16.9	1st pair shorts (just started - add 2 secs to time) - securing belt loop waistband Total time 3mins 19 secs
2	3:19.6 - 6:50.7	2nd pair shorts - securing belt loops to waistband Total time 3 mins 31 secs
3	6:56.8 - 10:55.8	3rd pair shorts - securing belt loops to waistband Total time 3 mins 59 secs
4	11:03.2 - 14:27.2	4th pair shorts - securing belt loops to waistband Total time 3 mins 24 secs
5	14:32.3 - 18:03.2	5th pair shorts - securing belt loops to waistband Total time 3 mins 31 secs
6	18:11.3 - 21:26.7	6th pair shorts - securing belt loops to waistband Total time 3 mins 16 secs
7	21:33.7 - 24:42.9	7th pair shorts - securing belt loops to waistband Total time 3 mins 9 secs
8	24:48.5 - 28:12.0	8th pair shorts - securing belt loops to waistband Total time 3mins 23 secs
9	28:19.2 - 31:37.5	9th pair short - securing belt loops to waistband Total time 3 mins 19 secs
10	31:44.4 - 34:56.2	10th pair shorts - securing belt loops to waistband Total time 3 mins 12 secs

11	34:59.8 - 35:16.7	End of pile to do - tidies cut ends (from belt loops) from around machine and puts in bin below
12	36:10.9 - 36:50.6	Gets a notebook, pen and piece of paper from side/under machine Writes something on the paper, appears to count something on fin
13	36:56.7 - 38:00.0	**Idle time** Removes glasses. Places shorts in pile to on side. Stands up and moves around space a bit. Sits down, take drink of water from bottle under desk/machine. Talks to someone behind END

Name: CandC Observations 20.8.19_P4_Full video

Description: Video observations of participant 4 in factory 20th August 2019

	Timespan	Content
1	0:00.1 - 3:45.1	1st shirt attaching and topstitching cuff *loads new bobbin (just after 3 mins) Total time 3 mins 45 secs
2	3:46.8 - 6:53.5	1st shirt - attaching and topstitching cuff 2 Total time 3 mins 7 secs
3	6:55.2 - 7:37.4	1st shirt - attaching care label (inner side seam) Total time 42 secs
4	7:48.8 - 10:21.1	Gets 2nd garment, Marks one cuff and sleeve with chalk, sews cuff to sleeve 1, one fin pushes seam allowance under cuff as other hand guides on top. Grabs snips to assist with tucking(?) bit of seam in at end of cuff. Uses back-tack button by needle. Does top stitch around cuff. Trims threads. Much faster sewing when doing straight edge of top stitch as oppo

5	7:49.5 - 10:41.7	2nd shirt - attaching and topstitching cuff 1 Total time 2 mins 52 secs
6	10:43.2 - 13:52.6	2nd shirt - attaching and topstitching cuff 2 Total time 3 mins 10 secs
7	13:54.5 - 14:32.6	2nd shirt - attaching care label (inner side seam) Total time 38 secs
8	14:39.0 - 15:12.2	3rd shirt - attaching care label (inner side seam) Total time 33 secs
9	15:17.2 - 15:48.7	4th shirt - attaching care label (inner side seam) Total time 32 secs
10	15:52.8 - 16:37.7	5th shirt - attaching care label (inner side seam) Gets interrupted briefly Total time 45 secs
11	16:44.1 - 17:14.6	6th shirt - attaching care label (inner side seam) Total time 31 secs
12	17:20.6 - 17:44.5	Pre-stitching/preparing labels on machine
13	17:50.9 - 18:15.8	7th shirt - attaching care label (inner side seam) Total time 25 secs
14	18:18.6 - 18:43.8	8th shirt - attaching care label (inner side seam) Total time 25 secs
15	18:46.9 - 19:50.9	Away from machine

16	19:55.9 - 27:02.3	8th shirt - attaching and topstitching cuff 1 *changes bobbin from pre wound selection at machine *interrupted whilst doing this *restarts task then has to change main thread *interrupted 2 more times and has to pause sewing [see field notes this is part of discussion where she corrects another machinist on method "no no this if first"]. Then pattern cutter/designer comes to a question about another style Total time 7 mins 6 secs
17	27:00.8 - 30:45.3	8th shirt - attaching and topstitching and cuff 2 * Trims cuff raw edge whilst marking with chalk *Gets interrupted while marking, carries on talking as begins sewin Total time 3 mins 44 secs
18	30:49.6 - 31:21.7	9th shirt - attaching care label (inner side seam) Total time 32 secs
19	31:28.6 - 34:58.5	9th shirt - attaching and topstitching cuff 1 *interrupted with a question, pauses sewing briefly Total time 3 mins 30 secs
20	35:00.3 - 38:04.6	9th shirt - attaching and topstitching cuff 2 Total time 3 mins 5 secs
21	38:17.2 - 38:58.0	10th shirt - attaching care label (inner side seam) Total time 42 secs
22	39:01.0 - 42:35.2	10th shirt - attaching and topstitching cuff 1 *interrupted briefly to talk to another machinist Total time 3 mins 3 secs

23	42:38.1 - 45:50.8	10th shirt - attaching and topstitching cuff 2 *appears to pause and watch something at one of other machines *changes main thread time 3 mins 13 secs
24	45:50.4 - 46:28.6	looks at a cuff being made by another machinist (who has bought it over to her), quality check or discussing method perhaps? Speaking another language
25	46:28.6 - 47:02.2	goes back to stitching on 10th shirt cuff 2 *interrupted again to check something else briefly *another interruption, before completing calls her away from the machine, leaving cuff under presser foot on machine time 33 secs
26	47:02.2 - 47:32.8	away from machine
27	47:32.8 - 48:17.9	completes 10th shirt cuff 2 Total time including previous interrupted actions time 45 secs Total time 4 mins 31 secs
28	48:20.1 - 49:53.1	preparing stitching of care labels *interrupted in discussion stitches 5? labels
29	49:55.1 - 50:21.0	11th shirt attaching care label inner side seam Total time 26 secs
30	50:32.4 - 54:13.6	11th shirt attaching and topstitching cuff 1 *discusses something with machinist in front Total time 3 mins 42 secs

31	54:16.0 - 59:13.7	11th shirt attaching and topstitching cuff 2 *pauses whilst marking with chalk to look at a cuff another machin shows her. Again maybe checking method or inspecting quality *changes bobbin and loads machine with new bobbin to be loaded (time saving) Total time 4 mins 58 secs
32	59:17.2 - 59:47.9	12th shirt attaching care label (inner side seam) Total time 31 secs
33	59:52.4 - 1:04:52.3	12th shirt attaching and topstitching cuff 1 *discussion with another machinist, looks for something under her desk Total time 5 mins 0 secs
34	1:04:53.3 - 1:07:09.0	12th shirt attaching and topstitching cuff 2 *interrupted briefly, then leaves machine at end of one of the processes (not end of cuff) time 2 mins 16 secs
35	1:07:09.0 - 1:15:24.2	away from machine
36	1:15:24.2 - 1:16:44.3	12th shirt cuff 2 - continued *returns to machine and carries on with cuff time 1 mins 20 secs Total time (cuff 2) 3 mins 36 secs
37	1:16:47.7 - 1:17:30.2	13th shirt attaching care label (inner side seam) Total time 42 secs
38	1:17:42.4 - 1:22:33.9	Leaves machine - possible taking completed pile away
39	1:22:33.9 - 1:22:34.9	Returns to machine with more garments
40	1:22:34.9 - 1:23:54.8	13th shirt - unpicking and neatening stitching on side seams/side sp

Name: CandC Observations 20.8.19_P7_Full video

Description: Video observation of participant 7 in factory 20th August 2019

	Timespan	Content
1	0:00.1 - 3:26.8	1st shirt attaching CF placket and sewing hem *talks to someone whilst sewing *stops to wind and change bobbin (mid seam) Total time 3 mins 26 secs
2	1:54.3 - 2:47.7	Removes bobbin and winds a new one up. Inserts back in machine
3	2:47.2 - 2:55.8	threading needle
4	3:16.3 - 3:23.0	Uses pole/stick to poke through corner. Grabs stick (on wooden base) from right hand side, brings to left of machine, uses then outs back on right.
5	3:25.4 - 5:31.4	2nd shirt attaching CF placket and sewing hem Total time 2 mins 6 secs
6	5:33.3 - 6:24.0	3rd front panel sewing hem Total time 51 secs
7	6:27.5 - 7:15.2	4th front panel sewing hem Total time 47 secs
8	7:16.6 - 8:09.6	5th front panel sewing hem Total time 53 secs
9	8:11.5 - 9:01.7	6th front panel sewing hem Total time 50
10	9:04.1 - 9:50.9	7th front panel sewing hem Total time 47 secs

11	9:53.0 - 10:37.3	8th front panel sewing hem Total time 44 secs
12	10:41.8 - 11:05.4	takes pile and moves away from machine
13	11:30.1 - 11:30.5	sits back at machine
14	11:34.9 - 13:25.0	Placket pieces x 5 takes from pile on left, marks up using chalk and ruler, moves to pil right of machine (one at a time) Measuring from folded edged along one long edge, across width towards cut edge opposite, same distance at various points along t length of the placket (seam allowance?)
15	13:25.1 - 14:21.1	9th front panel sewing hem Total time 56 secs
16	14:23.5 - 15:14.3	10th front panel sewing hem Total time 50 secs
17	15:16.3 - 16:06.9	11th front panel sewing hem Total time 51 secs
18	16:08.9 - 16:54.6	12th panel sewing hem Total time 46 secs
19	16:57.4 - 17:44.9	13th front panel sewing hem Total time 48 secs
20	17:47.7 - 17:51.3	folds completed pile so far (5 front panels?) and puts to right of machine (can't see if places on table or in a basket)
21	17:52.9 - 19:49.6	14th front panel attaching placket and sewing hem Total time 1 min 57 secs
22	19:49.6 - 22:05.5	15th front panel attaching placket and sewing hem Total time 2 mins 16 secs

23	22:07.0 - 24:16.2	16th front panel attaching placket and sewing hem Total time 2 mins 9 secs
24	24:17.7 - 26:26.4	17th front panel attaching placket and sewing hem Total time 2 mins 8 secs
25	26:28.3 - 28:38.8	18th front panel attaching placket and sewing hem Total time 2 mins 11 secs
26	28:40.3 - 28:46.3	Takes pile of completed front panels from left (last 5 with plackets? folds together and puts to right of machine
27	28:54.1 - 30:59.0	1st Back panel sewing hem *Takes panel from pile to left of machine (out of shot) *Folds panel when completed and places to right of machine Total time 2 mins 5 secs
28	31:05.2 - 33:07.9	2nd back panel sewing hem Total time 2 mins 3 secs
29	33:18.9 - 35:17.0	3rd back panel sewing hem Total time 1 min 58 secs
30	35:27.5 - 37:39.0	4th back panel sewing hem Total time 2 mins 11 secs
31	37:46.7 - 39:43.6	5th back panel sewing hem Total time 1 min 57 secs
32	39:48.1 - 39:59.8	Leaves machine (possibly taking pile of back panels with hems sewi
33	40:02.0 - 40:40.5	Places new piles of items to do on left of machine (she is out of sho then sits back at machine
34	40:42.8 - 40:53.7	sorts work brought into piles
35	40:54.9 - 41:25.3	Trimming bottom edge of placket pieces to remove frayed materia

36	41:29.7 - 43:27.4	Preps placket pieces x 5 Marking from folded edge as before with ruler and chalk
37	43:28.9 - 44:20.5	19th front panel sewing hem Total time 52 secs
38	44:22.0 - 45:19.3	20th front panel sewing hem Total time 57 secs
39	45:22.3 - 46:18.5	21st front panel sewing hem Total time 57 secs
40	46:20.7 - 48:19.0	22nd front panel sewing hem *speaks to another machinist whilst sewing *changes bobbin mid hem (already wound up) Total time 1 min 58 secs
41	48:21.0 - 49:19.3	23rd front panel sewing hem Total time 58 secs
42	49:20.8 - 49:27.4	Folds completed front panels together and places to right of machi
43	49:27.4 - 51:41.4	24th front panel attaching placket and sewing hem Total time 2 mins 14 secs
44	51:42.7 - 53:52.1	25th front panel attaching placket and sewing hem Total time 2 mins 9 secs
45	53:54.1 - 56:08.4	26th front panel attaching placket and sewing hem Total time 2 mins 14 secs
46	56:10.5 - 58:21.1	27th front panel attaching placket and sewing hem Total time 2 mins 10 secs
47	58:23.3 - 1:00:40.2	28th front panel attaching placket and sewing hem Total time 2 mins 17 secs

48	1:00:39.2 - 1:00:44.4	Folds completed pile and places to right of machine
49	1:00:53.8 - 1:03:25.0	6th back panel sewing hem Total time 2 mins 31 secs
50	1:03:36.9 - 1:05:40.1	7th back panel sewing hem Total time 2 mins 3 secs
51	1:05:44.2 - 1:07:49.1	Leaves machine (walks towards front (possibly to bathroom)
52	1:07:52.5 - 1:07:53.9	Returns to machine
53	1:07:55.7 - 1:10:44.9	8th back panel sewing hem Total time 2 mins 49 secs
54	1:10:50.9 - 1:13:07.7	9th back panel sewing hem Total time 2 mins 17 secs
55	1:13:14.6 - 1:15:23.8	10th back panel sewing hem Total time 2 mins 9 secs
56	1:15:42.0 - 1:16:45.6	Leaves machine
57	1:16:45.6 - 1:23:22.0	Appears at P4s machine next to hers with carte of items. They go through items together and P7 places things at her machine. Then leaning on P4s machine discussing something. Is P4 showing h how to do something? P4 s sewing something on her machine as P7 watches
58	1:23:29.2 - 1:23:31.0	Returns to machine
59	1:23:33.4 - 1:23:53.0	Arranges items on machine

60	1:23:53.0 - 1:30:29.2	1st Attaching and closing placket (first go after demo) Marking out placket with chalk Attaching stitched placket front panel (LHS) Bagging out placket at bottom, poking through with stick tool, trim corner Closing placket over CF placket - slow steady pulses of stitching Inspects and compares with sample piece Trims threads, then topstitches edge Total time 6 mins 36 secs
61	1:30:28.9 - 1:31:36.0	Leaves machine and takes piece just done to P4 to show her and th discuss
62	1:31:36.0 - 1:31:48.0	Returns to machine, folds completed pieces
63	1:31:58.6 - 1:38:07.4	2nd shirt attaching and enclosing CF placket Total time 6 mins 8 secs
64	1:38:13.1 - 1:43:44.1	3rd shirt attaching and enclosing CF placket *pauses briefly to speak to someone out of shot Total time 5 mins 31 secs
65	1:44:36.8 - 1:49:34.8	4th shirt attaching and enclosing CF placket Total time 4 mins 58 secs
66	1:49:41.8 - 1:50:42.0	Leaves machine, returns with a backet as I turn off video

Name: CandC Observations 30.7.19_P9_Full video

Description: Video observations of participant 9 in factory 30th July 2019

	Timespan	Content
1	0:00.0 - 2:51.0	1st shirt - side seam/underarm Total time 2 mins 51 secs
2	2:54.7 - 5:27.6	2nd shirt - side seams/underarm Total time 2 mins 33 secs
3	5:30.9 - 8:15.5	3rd shirt - side seams/underarm Total time 2 mins 45 secs
4	8:22.0 - 12:12.3	4th shirt - side seams/underarm calls someone over mid-way through 2nd side seam to pint out a mistake which he has to trim stitching from (hem side split top stit perhaps) Continues, re-threads machine just before end Total time 3 mins 50 secs
5	12:18.5 - 14:45.4	5th shirt - side seams/underarm Total time 2 mins 26 secs
6	14:50.2 - 17:21.1	6th shirt - side seams/underarm Total time 2 mins 31 secs
7	17:26.8 - 20:03.2	7th shirt - side seams/underarm takes sip of water at start Total time 2 mins 36 secs
8	20:04.7 - 22:47.6	8th shirt - side seams/underarm small discussion with another machinist mid-way through. Does no pause process

9	22:51.2 - 26:22.1	9th shirt - side seams/underarm stops mid-2nd seam, removes shirt from sleeve, examines it and tri undoes that seam then starts again Total time 3 mins 31 secs
10	26:22.1 - 26:51.6	takes item/shirt from the completed crate, examines it then tells m "I need to go that machine now for 2 minutes, or maybe 1 minute" leaves machine. Takes a crate with him (looks like one he was takin things to do from as oppose to completed pile)
11	27:43.3 - 27:49.8	Returns with crate
12	28:00.4 - 30:43.6	10th shirt - side seams/underarm Total time 2mins 44 secs
13	30:45.2 - 33:30.3	11th shirt - side seams/underarm Total time 2 mins 45 secs
14	33:39.0 - 33:47.7	gets another crate from his right and puts it on tops of crates of wc to do on his left
15	33:48.0 - 33:52.0	looks at note/paper from in this new crate
16	33:53.1 - 37:01.3	Proceed with next batch of side seams/underarms 12th shirt pauses to rethread machine mid-way through 2nd seam moves presser foot back slightly along seam so that sewing will ove (secure) Total time 3 mins 8 secs
17	37:09.4 - 39:42.1	13th shirt - side seams/underarm talks to someone just as lining up seams on machine, does not pau: process pauses part way through first seam to trim fabric at end Total time 2 mins 33 secs

18	39:45.5 - 43:12.9	14th shirt - side seams/underarm trims fabric at start edge a little before starting has to re thread needle again at start, shortly after starting seam Pauses near end of 2nd s/side to trim something. Has to pull threac bit then represses edge with fingers before continuing Total time 3 mins 27 secs
19	43:55.0 - 44:02.3	takes drink of water from bottle
20	44:05.0 - 44:31.6	Moves 2 completed crates/bundles to side. Talks to someone

Name: CandC Observations 30.7.19_P10_Full video

Description: Video observations of participant 10 in factory 30th July 2019

	Timespan	Content
1	0:00.7 - 1:30.4	1st pair jeans - enclosing ends of waistband Total time 1 min 29 secs
2	1:41.2 - 3:31.5	2nd pair jeans - enclosing ends of waistband Total time 1 min 51 secs
3	3:36.9 - 4:58.7	3rd pair jeans - enclosing ends of waistband Total time 1 min 22 secs
4	5:08.7 - 6:20.7	4th pair jeans - enclosing ends of waistband Total time 1 min 12 secs
5	6:31.7 - 7:56.4	5th pair jeans - enclosing ends of waistband Total time 1 min 24 secs

6	8:00.6 - 9:42.1	6th pair jeans - enclosing ends of waistband *talking to me whilst sewing *I move camera for better view of actions Total time 1 min 41 secs
7	9:50.5 - 11:03.0	7th pair jeans - enclosing ends of waistband *talking to me whilst sewing Total time 1 min 12 secs
8	11:08.0 - 12:31.5	8th pair jeans - enclosing ends of waistband *talking to me whilst sewing Total time 1 min 24 secs
9	12:41.8 - 14:06.6	9th pair jeans - enclosing ends of waistband *talking to me whilst sewing Total time 1 min 25 secs
10	14:13.5 - 15:20.1	10th pair jeans - enclosing ends of waistband Total time 1 min 6 secs
11	15:26.5 - 15:47.6	Pile is complete, appears to talk to someone behind from his seat
12	15:47.6 - 16:18.8	changes thread on machine, can’t see thread so not sur if changing is running out or is changing colour in preparation for next task
13	16:19.6 - 16:47.2	Gathers completed items from crate to back left side of machine, places in a pile on machine table, then takes pile away
14	16:47.2 - 17:10.8	Leaves machine
15	17:10.8 - 17:23.3	Returns to machine, places new pile on machine (left side of table)
16	17:23.2 - 17:47.2	Looks in drawer and on shelves to side of machine. Finds small tools/templates
17	17:50.0 - 20:11.6	11th pair jeans securing belt loops to waistband x 5 *uses cut template for first belt loop then checks with a ruler *checks length of 3rd belt loop with ruler also *uses template on each beltloop

18	20:17.3 - 20:39.9	I ask him about the template "it's 6cm, this is easy"
19	20:39.9 - 22:44.7	12th pair jeans securing belt loops to waistband x 5 *measures last belt loop, checking size sewn Total time 2 mins 5 secs
20	22:49.0 - 25:33.2	13th pair jeans securing belt loops to waistband x 5 *pauses to pull some thread off, then lifts garment and to show to someone behind and discusses with them Total time 2 mins 44 secs
21	25:44.9 - 27:41.8	14th pair jeans securing belt loops to waistband x 5 *talks to me whilst sewing *another person brings a new pile and places on end of machine ta P10 acknowledges this but does not stop sewing Total time 1 min 57 secs
22	27:46.2 - 29:45.2	15th pair jeans securing belt loops to waistband x 5 Total time 1 min 59 secs
23	29:50.3 - 31:45.1	16th pair jeans securing belt loops to waistband x 5 *talking to me while sewing Total time 1 min 55 secs
24	31:48.9 - 33:30.4	17th pair jeans securing belt loops to waistband x 5 Total time 1 min 41 secs
25	33:37.9 - 35:42.5	18th pair jeans securing belt loops to waistband x 5 Total time 2 mins 5 secs
26	35:50.5 - 37:34.9	19th pair jeans securing belt loops to waistband x 5 Total time 1 min 44 secs

27	37:52.0 - 39:40.9	20th pair jeans securing belt loops to waistband x 5 Total time 1 min 49 secs
28	39:44.0 - 39:58.9	Speaks to someone behind then leaves the machine, taking crate o competed items with him
29	40:20.1 - 40:35.2	Returns pushing a crate and places piles on the machine table
30	40:37.9 - 42:36.3	21st pair jeans securing belt loops to waistband x 5 Total time 1 min 58 secs
31	42:41.4 - 44:33.3	22nd pair jeans securing belt loops to waistband x 5 Total time 1 min 52 secs
32	44:39.4 - 46:31.4	23rd pair jeans securing belt loops to waistband x 5 *talks to me again whilst sewing Total time 1 min 52 secs
33	46:36.9 - 48:45.8	24th pair jeans securing belt loops to waistband x 5 Total time 2 mins 9 secs
34	48:52.9 - 49:09.0	Leaves machine (does not appear to take anything with him
35	49:09.2 - 49:16.0	Returns with pile of garments in hands and places on machine tabl
36	49:17.6 - 50:59.5	25th pair jeans securing belt loops to waistband x 5 *talks to me again while sewing Total time 1 min 42 secs
37	51:05.6 - 52:40.2	26th pair jeans securing belt loops to waistband x 5 *still talking to me whilst sewing Total time 1 min 34 secs

38	52:36.6 - 52:40.0	Measures last belt loop sewn (26th pair) with ruler then gives me a thumbs up *celebrating?
39	52:50.1 - 53:13.0	Start recording 27th pair I ask "Do you count how many you are making?", "how many have done today?" he says "No. I don't know maybe 10" Camera battery dies

Name: CandC Observations 21.1.20__P15Full video

Description: Video observations of participant 15 in factory 21st January 2020

	Timespan	Content
1	0:00.0 - 0:31.9	Talking to a colleague (not in English) possibly asking to pass somet
2	0:39.7 - 1:56.3	1st trouser/fly -attaching fly -trim threads -fold and topstitch -trim threads -attach next layer stitching across for button -trims fabric Total time 1 mins 16.6 secs
3	2:01.9 - 3:05.5	2nd trouser/fly uses ruler to measure fly Total time 1 mins 3.6 secs
4	3:10.3 - 4:07.2	3rd trouser/fly Total time 56.9 secs

5	4:10.0 - 5:08.0	4th trouser/fly Total time 58 secs
6	5:14.5 - 5:17.6	leaves machine
7	5:30.7 - 5:43.3	move camera to other machine to follow
8	5:41.0 - 6:44.0	moves to another machine to attach binding. Attaches as a continu line to all 4 trouser panels. Then trims to separate. Machine has a binding attachment tool *missed start so unable to time precisely Total time approx. 1 mins 3 secs for all 4 panels (15.75 per trouser)
9	6:45.0 - 7:43.8	Leaves second machine
10	8:10.8 - 8:25.4	move camera back to original machine
11	8:33.1 - 9:36.5	repeating same processes as before on fly 5th trouser/fly Total time 1 mins 3.4 secs
12	9:40.8 - 10:41.8	6th trouser/fly Total time 1 mins 1 secs
13	10:44.0 - 11:27.9	turns away from machine (on chair). Appears to be sorting items in crates and placing next items on table
14	11:30.1 - 11:42.3	changing bobbin thread (to contrast colour)
15	11:44.9 - 12:10.1	process 3, attaching contrast facing to fly piece. trimming fabric ed when stitched Total time 25.2 secs
16	12:13.4 - 12:32.2	process 3 - 2nd Total time 18.8 secs

17	12:39.2 - 13:24.7	turning through stitch fly x2 (using spike tool) uses a technique of running spike tip along sides as well as just turr through edge, this may aid seams lying flat for top stitching.
18	13:24.9 - 13:42.6	process 4 - top stitching turned through fly Total time 17.7 secs
19	13:44.4 - 13:58.3	process 4 - 2nd Total time 14.7 secs
20	14:01.3 - 14:24.1	Turns around to get additional fly pieces and front panels from crat behind and places them on machine table
21	14:28.3 - 14:41.6	Places front panel under machine foot but then appears to change mind and removes. Instead gets more fly pieces (with contrast piec
22	14:49.1 - 15:03.8	process 3 - 3rd Total time 13.9 secs
23	15:29.0 - 16:22.3	turning through stitched fly pieces x 2 (using spike tool)
24	16:28.0 - 16:38.3	process 4 - 3rd Total time 10.3 secs
25	16:43.6 - 16:54.0	process 4 - 4th Total time 10.4 secs
26	17:17.2 - 18:03.7	process 1 - attaching fly to front again 7th Trouser/fly Total time 46.5 secs
27	18:09.0 - 19:02.5	8th trouser/fly Total time 53.5 secs
28	19:03.7 - 19:52.9	Turns to place things in crates and get out more pieces, placing the on machine table
29	19:55.9 - 20:56.2	9th trouser/fly Total time 1 min 0.3 secs

30	21:01.7 - 21:58.2	10th trouser/fly Total time 56.5 secs
31	21:59.2 - 22:36.9	Turns behind to place/get new pieces from crates
32	22:56.6 - 23:52.3	11th trouser/fly Total time 55.7 secs
33	23:56.5 - 24:53.4	12th trouser/fly method seems to be to place trouser piece under sewing foot first, hold it with foot, then grab fly from side before lining up to start sewing Total time 56.9 secs
34	24:54.4 - 25:10.7	changing bobbin thread
35	25:11.1 - 25:20.7	pairing fly pieces with contrast
36	25:24.3 - 25:42.7	process 3 Total time 18.4 secs
37	25:54.3 - 26:11.2	process 3 - 5th Total time 16.9 secs
38	26:13.9 - 26:20.3	re stitches a fly after checking it
39	26:22.2 - 27:05.1	turning through stitched fly x 2
40	27:08.9 - 27:20.7	process 4 - 5th Total time 11.8 secs
41	27:23.6 - 27:36.6	process 4 - 6th Total time 13 secs
42	27:40.2 - 27:55.6	Pairing fly pieces
43	27:57.3 - 28:15.7	process 3 - 6th Total time 18.4 secs

44	28:24.0 - 28:35.1	process 3 - 7th Total time 11.1 secs
45	28:46.0 - 29:34.0	turning through x 2
46	29:44.0 - 30:06.1	process 4 - 7th (including re-threading needle) Total time 22.1 secs
47	30:11.8 - 30:23.8	process 4 - 8th Total time 12 secs
48	30:30.1 - 30:36.3	checks bobbin thread
49	30:38.5 - 31:35.3	Turns behind, stands, leaves machine (taking crates?)
50	31:34.8 - 31:49.5	I move camera to other machine to follow P15
51	31:44.9 - 31:56.0	attaching binding at other machine (completes 2, miss start to time
52	32:21.8 - 32:46.3	attaches binding to 2 trousers Total time 24.5 secs (12.5 secs per pair)
53	33:09.2 - 33:33.6	attaches binding to another 2 Total time 24.4 secs (12.25 secs per pair)
54	33:57.4 - 34:23.0	attaches binding to another 2 Total time 25.6 secs (12.8 secs per pair)
55	34:36.4 - 34:50.1	leaves machine
56	34:59.9 - 35:16.4	move camera to follow P15 to pressing
57	35:22.2 - 37:53.2	pressing panels from 4 crates - appears to press front panels with f now attached, and an additional small piece with contrast (pocket bags?)
58	37:51.9 - 37:56.4	pushes crates to end of line and walks away
59	38:38.0 - 39:11.7	move camera back to first machine
60	39:11.1 - 39:43.9	P15 sorting items from crates and placing on machine table

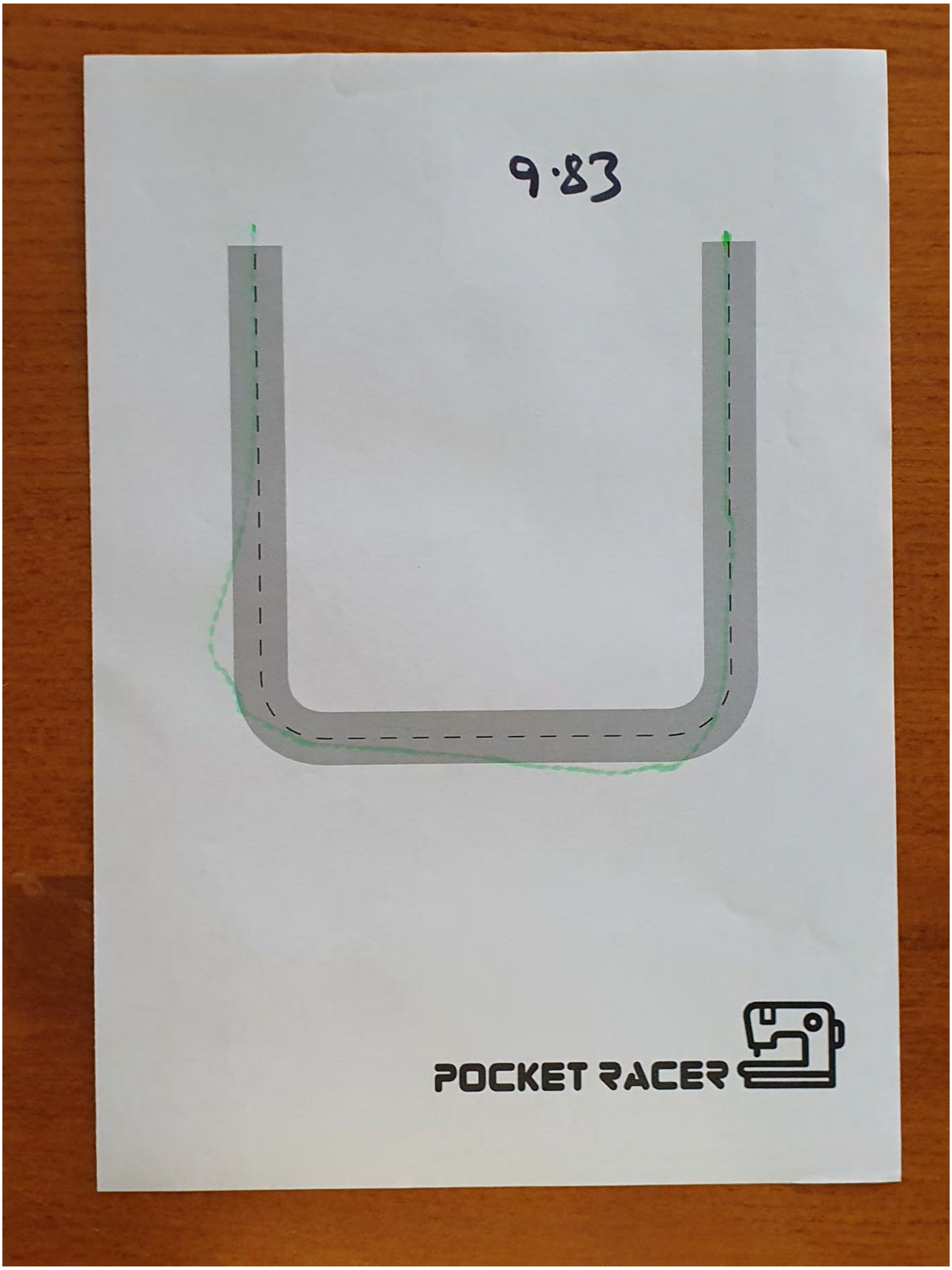
61	39:49.8 - 40:29.5	Process 5 - attaching pocket bag to back panel, then turn and topst Total time 39.7 secs
62	40:35.6 - 41:05.8	Process 5 - 2nd Total time 30.2 secs
63	41:12.6 - 41:42.0	Process 5 - 3rd Total time 29.4 secs
64	41:47.8 - 42:16.0	Process 5 - 4th Total time 28.2 secs
65	42:23.2 - 42:54.3	Process 5 - 5th Total time 31.1 secs
66	42:59.2 - 43:31.4	Process 5 - 6th Total time 32.2 secs
67	43:51.4 - 44:15.4	Process 5 - 7th (to front panel) Total time 24 secs
68	44:29.1 - 44:52.7	Process 5 - 8th Total time 23.6 secs
69	45:04.5 - 45:16.0	Process 5 - 9th - CUT SHORT battery died

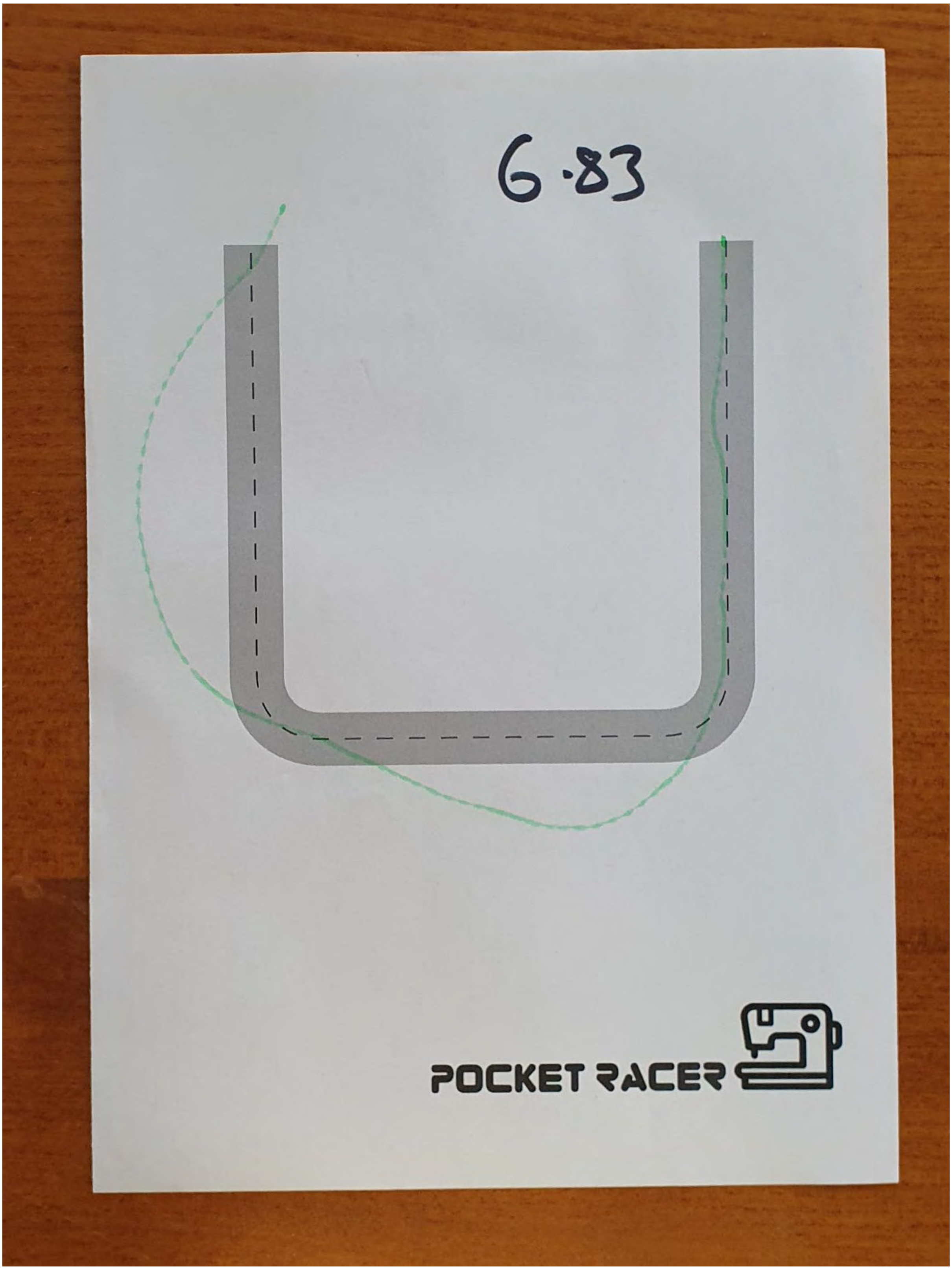
Appendix B5 **Supporting videos**

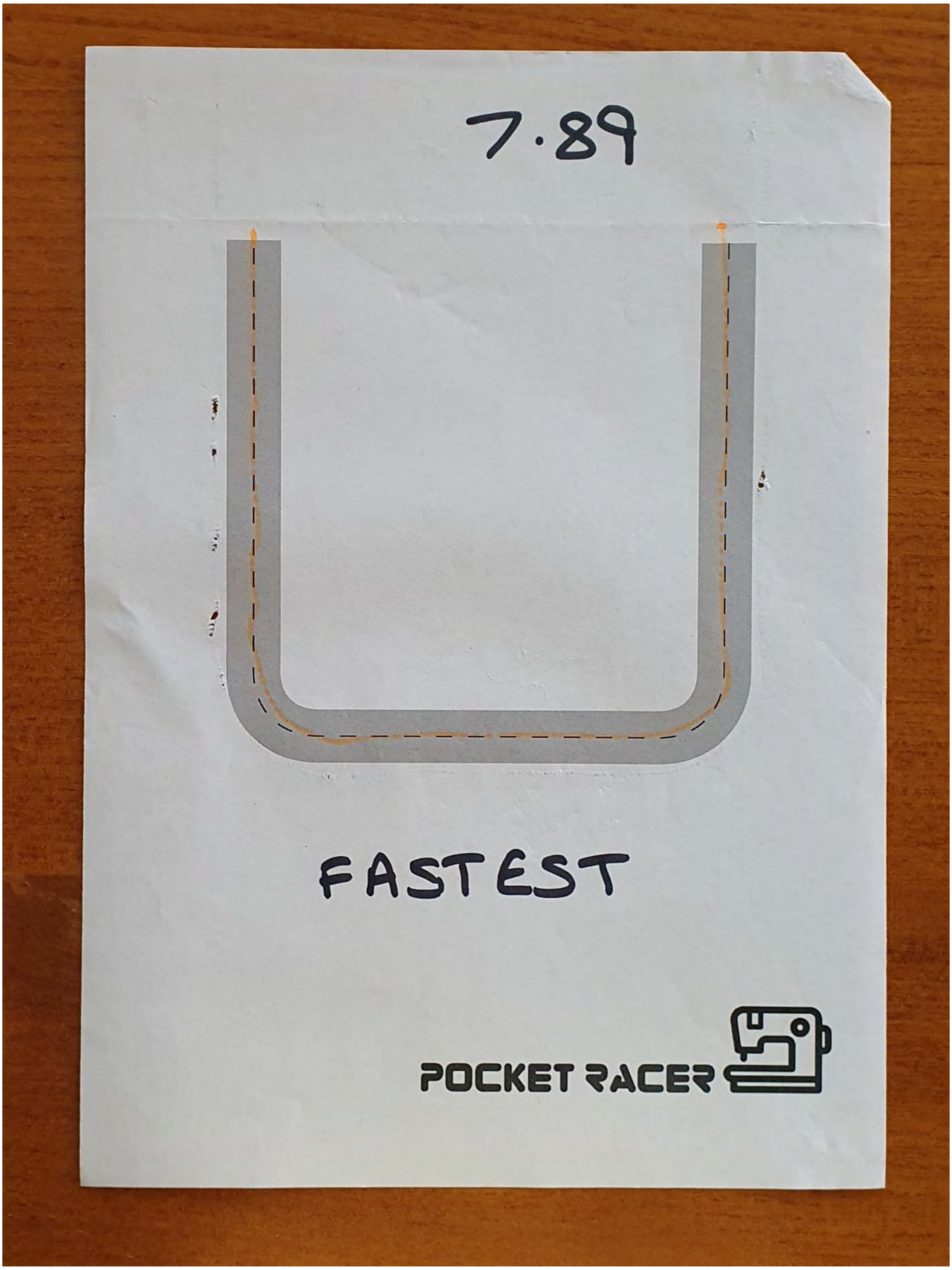
B5.1	Music picking up pace_Unravel
B5.2	Music changing pace on last lap of Mario Kart race
B5.3	Yarny running out of yarn
B5.4	Repeated death in water section_Unravel
B5.5	Repeated death in water section_Unravel_with hands
B5.6	Knitting Rib ripping out
B5.7	Clips of gameplay between Participants 3 and 4 of Hazuki Knit
B5.8	Knitting machine crunching sound
B5.9	DigiLab_Nov18_v14
B5.10	DigiLab_Nov18_v145
B5.11	Comparative video of belt loop attachment techniques_P1 and P10
B5.12	Comparative clips showing progression of sewing technique

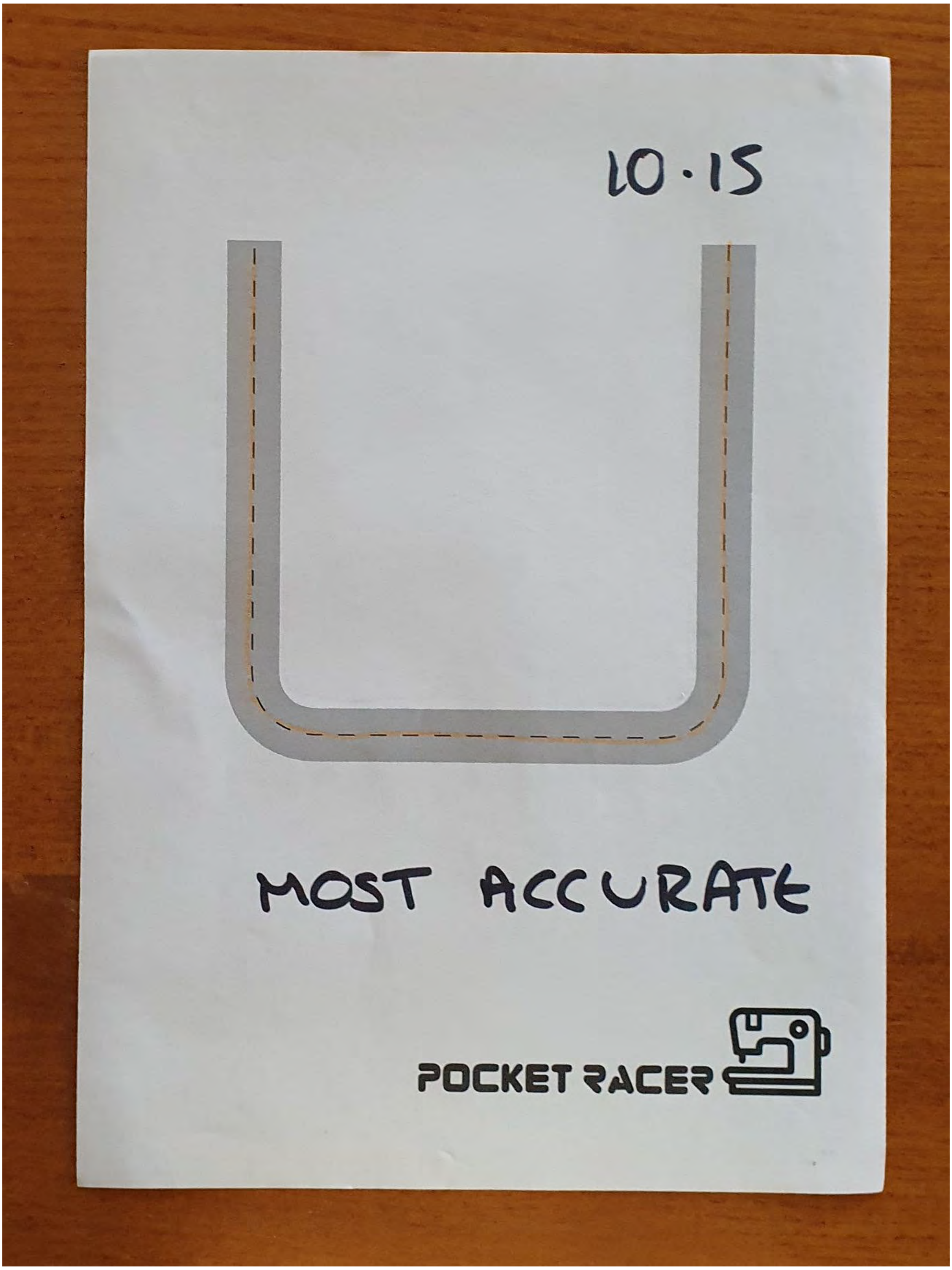
Supporting videos can be viewed via the One Drive folder Appendix B5 Supporting videos

Appendix C1 **Example completed pocket templates**




6.83
POCKET RACER


7.89
FASTEST
POCKET RACER


10·15
MOST ACCURATE
POCKET RACER

Appendix D1 Cookson and Clegg (project partner) Digital Strategy document

Cookson & Clegg Digital Strategy

Aim

Through the adoption of digital technologies, we aim to improve our production processes and gain significant efficiencies in our operations.

Current DRL: 3 → Predicted DRL: 5

Challenges

Workflow

- Production timings are out-of-date, so product costings are inaccurate
- Production flow is inefficient
- Production lines not consistently achieving production targets
- Too much idle time on production lines

Management

- Disjointed systems, no centralised computer system
- Information is held in people's heads and not recorded
- Too many decisions based on individual assumptions and not on real data

Control

- Lack of control of delivery of raw materials
- Lack of visibility of critical path
- Uneven and unpredictable workloads

Customers

- Lots of start-ups with little knowledge of manufacturing
- All big customers want delivery in 2 x seasons causing big peaks and troughs
- Too many small orders

Employees

- Disengaged workforce
- Motivated by money
- Not consistently hitting targets so bonuses are infrequent

Plan

'Adoption of a digital workflow system.'

Implement and adoption of a centralised system that will facilitate: a better understanding of the production workflow; improved knowledge retention; a more collaborative approach with customers; and introduction of performance related pay and bonuses.

Once adopted the 2nd stage of our strategy will combine the digital workflow with automated machinery that will further improve efficiencies and set the foundations for a smart factory layout.

System Requirements

- Customer information
  - Orders
  - BOMs
  - Tech packs & comments
  - communication
- Critical path & visibility of status for customers
- Real time date on production workflow
  - To cover from development and sampling to cutting and bulk production
- Provide work order information for machinists
- Performance information on machinists and balance of production line
- Efficient reporting systems
- Performance related pay & bonuses
- Customisation

Adoption/Implementation

- Data cleanse
- Collation of all existing customer/order/product data in to an uploadable format.
- 1st testing phase
- Key personnel to analyse trial and suggest amendments/improvements
- 2nd testing phase
- Analysis/amendments/improvements
- Implementation team trained on system
- Draft instructions for all types of users
- Employee training
- System run concurrently with exiting spreadsheets for 2 months and review
- Further data analysis and employee input in to what data is being captures, how it is being used and any suggestions for amendments/improvements
- After 6mths we would look to introduce the performance related pay module
- Ongoing review/feedback/discussions in the first 12 months of implementation.
- Open communication for the project is key, as we want the software to benefit everyone in their individual job roles.

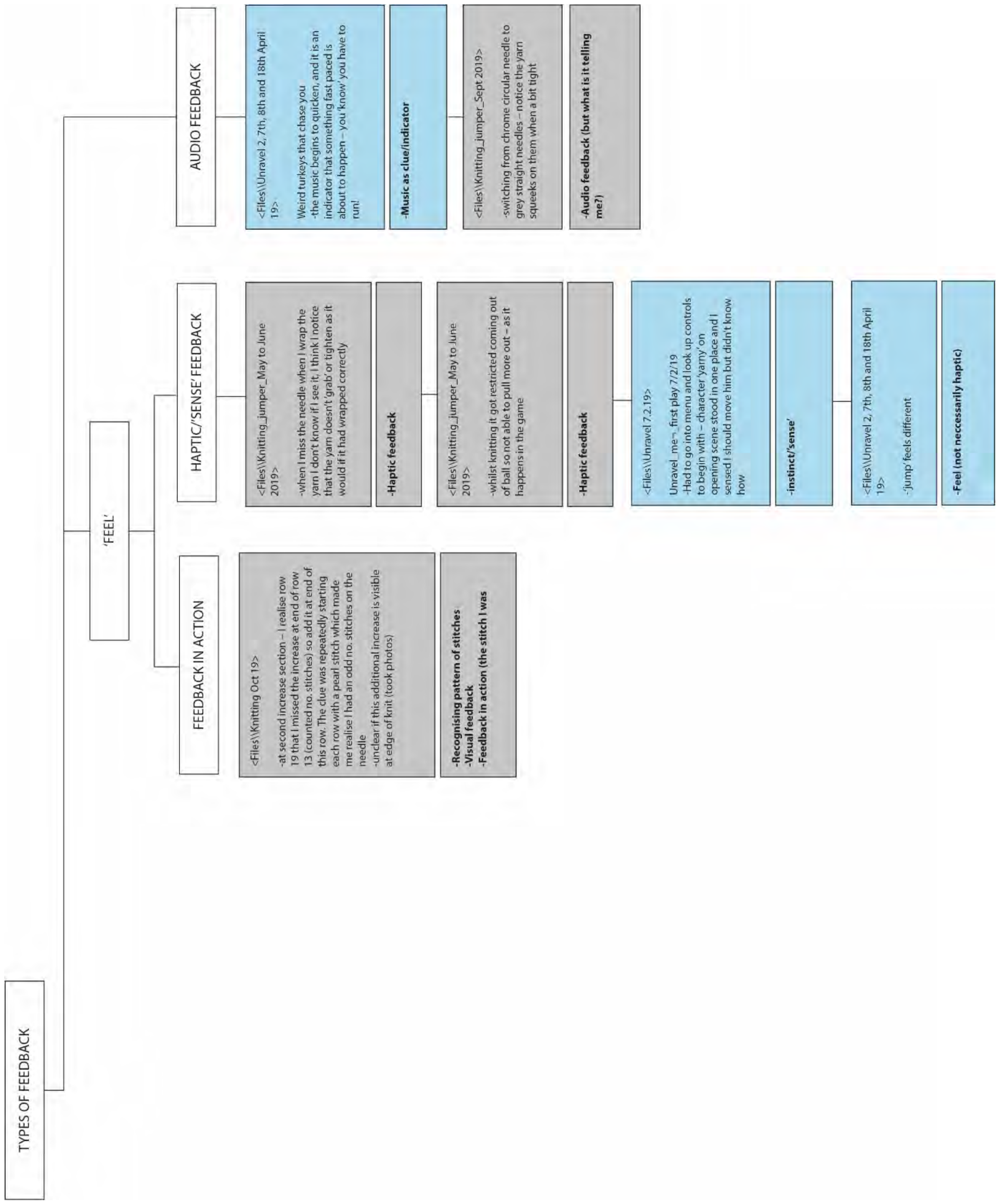
Future Goals

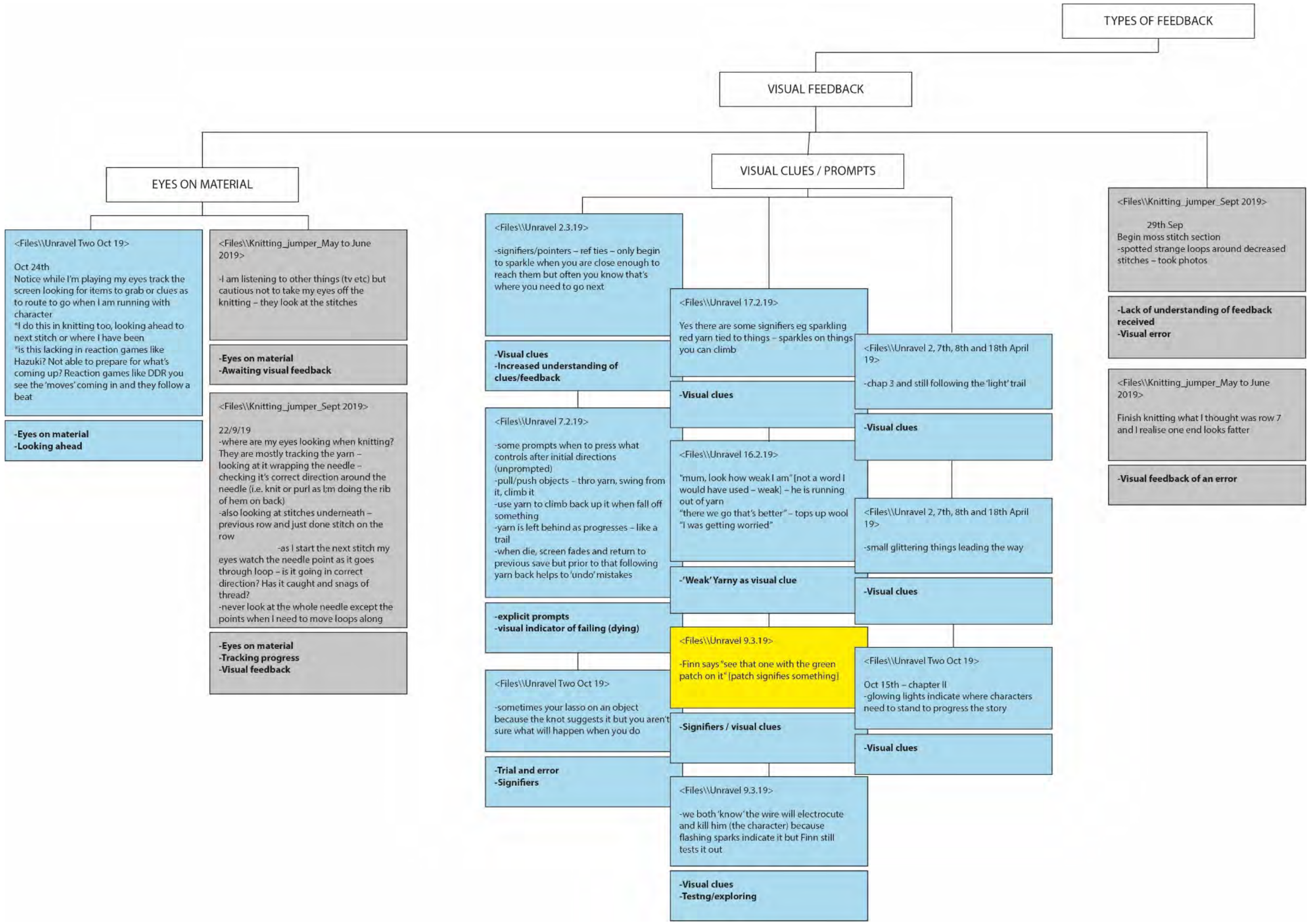
- Develop simple interface to display real time production information on individuals devices and large screens in an easily understood format.
- Visualisation of daily targets and real time data on achievement against them will help employees achieve their weekly individual and team targets and achieve their bonuses. This will improve employee motivation and engagement.
- Better customer collaboration
- Traceability capability
- We hope to roll out the design and development module to Community Clothing (group clothing brand) so that they can design & produced all their tech packs on the same system thus creating a seamless transition from to development to production.
- Achievement of DRL: 6 – Digital Innovator

Appendix D2 **Example style Standard Minute Breakdown sheet from production**

	[redacted] Unisex Sweatshirt			Production Quantity		793
	STANDA[redacted] MINUTE BREAKDOWN			Efficiency - %		60
				Weekly Mins		6840
OPERATION	DESCRIPTION	SMV	Quantity	Mins Req	Op Mins	Per Week
1	Overlock Back Buggy. (Surfilat Aplac)	0.50	793	396.5	0	0.00
2	Attach Back Buggy & Wash/Size label. (Aplicutat Aplact Marime)	1.00	793	793	0	0.00
3	Apply V - Stitch in Front. (Executat V La Fata)	1.00	793	793	0	0.00
4	Bartack V-Stitch. (Cheita La V)	0.50	793	396.5	0	0.00
5	Close Neck,Cuff & Hem Rib. (Ancheiat Mansete Guler Talie)	1.25	793	991.25	0	0.00
6	Join Shoulders overlock. (Ancheita Umar)	0.50	793	396.5	0	0.00
7	Cover-Stitch Shoulders. (Tighelit Umar)	1.00	793	793	0	0.00
8	Insert Sleeves - Overlock. (Aplicat Maheca Surfilat)	1.75	793	1387.75	0	0.00
9	Cover-Stitch Sleeves. (Tighelit Maheca)	2.00	793	1586	0	0.00
10	Join Underarms & Side Seams - Overlock (Ancheiat Lateral)	1.50	793	1189.5	0	0.00
11	Attach Neck & Hem Rib - Overlock (Aplicat Guler & Talie)	2.00	793	1586	0	0.00
12	Cover-Stitch Neck & Hem (Tighelit Guler & Talie)	2.50	793	1982.5	0	0.00
13	Attach Rib Cuffs - Overlock (Aplicat Mansete Surfilat)	1.00	793	793	0	0.00
14	Attach CC Logo - Heat Transfer (Imprimat Enblema)	0.50	793	396.5	0	0.00
15	Trim - Press - Pack (Curatat - Calat - Ampachetat)	3.00	793	2379	0	0.00
TOTAL	Standard Minute Value	20.00		15860	4104	205.2
Ammd't	Description	Date	Signed			
[redacted]	[redacted]	[redacted]	[redacted]			

Appendix E1 Example thematic map using coded data extracts from NVivo




TYPES OF FEEDBACK
VISUAL FEEDBACK
EYES ON MATERIAL
VISUAL CLUES / PROMPTS
<Files\\Unravel Two Oct 19>
Oct 24th
Notice while I'm playing my eyes track the screen looking for items to grab or clues as to route to go when I am running with character
*I do this in knitting too, looking ahead to next stitch or where I have been
*is this lacking in reaction games like Hazuki? Not able to prepare for what's coming up? Reaction games like DDR you see the 'moves' coming in and they follow a beat
-Eyes on material
-Looking ahead
<Files\\Knitting_jumper_May to June 2019>
-I am listening to other things (tv etc) but cautious not to take my eyes off the knitting – they look at the stitches
-Eyes on material
-Awaiting visual feedback
<Files\\Knitting_jumper_Sept 2019>
22/9/19
-where are my eyes looking when knitting? They are mostly tracking the yarn – looking at it wrapping the needle – checking it's correct direction around the needle (i.e. knit or purl as I;m doing the rib of hem on back)
-also looking at stitches underneath – previous row and just done stitch on the row
-as I start the next stitch my eyes watch the needle point as it goes through loop – is it going in correct direction? Has it caught and snags of thread?
-never look at the whole needle except the points when I need to move loops along
-Eyes on material
-Tracking progress
-Visual feedback
<Files\\Unravel 2.3.19>
-signifiers/pointers – ref ties – only begin to sparkle when you are close enough to reach them but often you know that's where you need to go next
-Visual clues
-Increased understanding of clues/feedback
<Files\\Unravel 7.2.19>
-some prompts when to press what controls after initial directions (unprompted)
-pull/push objects – thro yarn, swing from it, climb it
-use yarn to climb back up it when fall off something
-yarn is left behind as progresses – like a trail
-when die, screen fades and return to previous save but prior to that following yarn back helps to 'undo' mistakes
-explicit prompts
-visual indicator of failing (dying)
<Files\\Unravel Two Oct 19>
-sometimes your lasso on an object because the knot suggests it but you aren't sure what will happen when you do
-Trial and error
-Signifiers
<Files\\Unravel 17.2.19>
Yes there are some signifiers eg sparkling red yarn tied to things – sparkles on things you can climb
-Visual clues
<Files\\Unravel 16.2.19>
"mum, look how weak I am" [not a word I would have used – weak] – he is running out of yarn
"there we go that's better" – tops up wool
"I was getting worried"
-'Weak' Yarny as visual clue
<Files\\Unravel 9.3.19>
-Finn says "see that one with the green patch on it" [patch signifies something]
-Signifiers / visual clues
<Files\\Unravel 9.3.19>
-we both 'know' the wire will electrocute and kill him (the character) because flashing sparks indicate it but Finn still tests it out
-Visual clues
-Testng/exploring
<Files\\Unravel 2, 7th, 8th and 18th April 19>
-chap 3 and still following the 'light' trail
-Visual clues
<Files\\Unravel 2, 7th, 8th and 18th April 19>
-small glittering things leading the way
-Visual clues
<Files\\Unravel Two Oct 19>
Oct 15th – chapter II
-glowing lights indicate where characters need to stand to progress the story
-Visual clues
<Files\\Knitting_jumper_Sept 2019>
29th Sep
Begin moss stitch section
-spotted strange loops around decreased stitches – took photos
-Lack of understanding of feedback received
-Visual error
<Files\\Knitting_jumper_May to June 2019>
Finish knitting what I thought was row 7 and I realise one end looks fatter
-Visual feedback of an error

UNDERSTANDING

RECOGNISING AFFORDANCES

<Files\\Unravel 9.3.19>

-recognising when I might need to drag objects for use further along

-Recognising affordances

<Files\\Unravel 16.2.19>

-Barney is more familiar with potential 'affordances' – doesn't take him long to work out to tie yarn on to things and pull them – leaves – bushes – struggles with tricycle

-Discovering affordances
-Familiarity with affordances

<Files\\Unravel 16.2.19>

-moving apples "move them all at once it will be quicker"
Didn't take any of us long to work that out

-Discovering affordances
-Making process quicker

<Files\\Unravel 2, 7th, 8th and 18th April 19>

-now when an object falls, I instantly know that I probably should push it – especially if a bridge is available to build

-Recognising affordances

<Files\\Unravel 2.3.19>

Unravel 2/3/19
Off the Rails – level 5
Every puzzle is like learning a new knot without instructions on how to do it
-trying to work out how to achieve a particular pattern in knit based on a combo of already understood knots
-once I've worked out what I need to do it's easier to execute the moves although I still miss-time some

-Problem solving
-Knowing affordances

UNDERSTANDING CLUES

<Files\\Unravel 2.3.19>

-signifiers/pointers – ref ties – only begin to sparkle when you are close enough to reach them but often you know that's where you need to go next

-Visual clues
-Increased understanding of clues/feedback

<Files\\Unravel 17.2.19>

-Finn finishes 3 and goes on to 4, I am observing and he is asking for help. Together we are beginning to understand the affordances – through perception and action e.g. where a bridge might be appropriate or where a rock or log could be pulled/moved

-Affordances
-Trial and error

UNDERSTANDING FEEDBACK

<Files\\Knitting Oct 19>

-at second increase section – I realise row 19 that I missed the increase at end of row 13 (counted no. stitches) so add it at end of this row. The clue was repeatedly starting each row with a pearl stitch which made me realise I had an odd no. stitches on the needle
-unclear if this additional increase is visible at edge of knit (took photos)

-Recognising pattern of stitches
-Visual feedback
-Feedback in action (the stitch I was

<Files\\Unravel 2.3.19>

-signifiers/pointers – ref ties – only begin to sparkle when you are close enough to reach them but often you know that's where you need to go next

-Visual clues
-Increased understanding of clues/feedback

<Files\\Knitting_jumper_May to June 2019>

-I put needle in a stitch instead of loop on needle on a purl stitch but realise it doesn't look right and am able to pull out needle and correct it

-Recognising visual feedback

<Files\\Knitting_jumper_May to June 2019>

-1st time I did/started the rib hem was keeping a tally chart to keep track of the # of rows, I'm not doing that now, feel confident at counting rows by looking at stitches

-Method of tracking progress adapts as get more confident
-Learning to understanding feedback

<Files\\Knitting_jumper_Sept 2019>

29th Sep
Begin moss stitch section
-spotted strange loops around decreased stitches – took photos

-Lack of understanding of feedback received
-Visual error

Participant: Bue

data__x		data__y	id		
2021-01-31 14:30:03	1	78.470	E0D61ABD	78.894	
2021-01-31 14:39:17	2	67.754			
2021-01-31 14:46:34	3	91.289			
2021-01-31 14:50:18	4	72.613			
2021-01-31 14:53:18	5	95.926			
2021-01-31 14:55:47	6	70.453			
2021-01-31 14:58:58	7	75.753			
2021-02-02 18:48:39	8	63.533		59.135	at this point I am aware of others scores
2021-02-02 18:51:48	9	65.402			
2021-02-02 19:02:29	10	34.160			
2021-02-02 19:04:32	11	69.703			
2021-02-02 19:13:49	12	71.407	video 20210202_191212 and 195244		
2021-02-02 19:16:51	13	68.332			
2021-02-02 19:20:05	14	66.555			
2021-02-02 19:23:26	15	75.863			
2021-02-02 19:26:31	16	65.222			
2021-02-02 19:30:04	17	57.768			
2021-02-02 19:34:49	18	60.048			
2021-02-02 19:37:12	19	49.301			
2021-02-02 19:40:53	20	54.924			
2021-02-02 19:43:08	21	50.755			
2021-02-02 19:45:29	22	60.555			
2021-02-02 19:47:40	23	56.616			
2021-02-02 19:51:04	24	51.109			
2021-02-02 19:53:32	25	43.178			
2021-02-04 18:50:32	26	40.818	void	43.022	
2021-02-04 18:54:30	27	42.288	video 20210202_184856 and 192927		
2021-02-04 18:56:28	28	39.526			
2021-02-04 18:58:40	29	41.079			
2021-02-04 19:00:38	30	37.855			
2021-02-04 19:03:06	31	39.121			
2021-02-04 19:05:03	32	41.351			le turn corn
2021-02-04 19:07:03	33	43.887			double turn on 1st corner
2021-02-04 19:09:41	34	57.672			error in starting and ending
2021-02-04 19:11:42	35	46.539			
2021-02-04 19:14:55	36	42.139			
2021-02-04 19:17:02	37	45.102			
2021-02-04 19:19:20	38	47.675			
2021-02-04 19:21:29	39	42.923			
2021-02-04 19:23:35	40	45.124			
2021-02-04 19:25:39	41	39.572			
2021-02-04 19:27:50	42	45.402			
2021-02-04 19:29:39	43	36.779			
2021-02-04 19:31:22	44	40.360			

Participant: Pink

data__x		data__y	id	
2021-01-31 15:19:12	1	6.238	BDF951C75054414B352E3120FF16041B	
2021-01-31 15:23:12	2	6.122		
2021-01-31 15:24:47	3	12.117		
2021-01-31 15:26:22	4	7.797		
2021-01-31 15:27:42	5	5.46		
2021-01-31 15:28:24	6	3.764		
2021-01-31 15:29:53	7	12.758		
2021-02-01 18:58:07	8	80.095		
2021-02-01 19:11:44	9	32.336		
2021-02-01 19:26:47	10	51.648		
2021-02-01 19:32:10	11	42.661		
2021-02-01 19:36:23	12	44.135		
2021-02-01 19:42:40	13	57.44		
2021-02-01 19:59:45	14	56.626		
2021-02-01 20:01:17	15	46.689		
2021-02-01 20:02:52	16	48.369		
2021-02-01 20:12:04	17	43.026		
2021-02-01 20:31:50	18	49.058		
2021-02-01 20:33:28	19	42.223		
2021-02-01 20:34:49	20	44.298		
2021-02-01 20:40:01	21	43.434		46.47161
2021-02-01 20:47:12	22	45.28		
2021-02-01 20:49:18	23	41.167		
2021-02-01 20:49:18	24	41.167		
2021-02-01 20:56:00	25	44.646		
2021-02-01 20:58:33	26	46.659		
2021-02-01 21:00:09	27	49.923		
2021-02-01 21:06:04	28	45.975		
2021-02-01 21:08:37	29	51.793		
2021-02-01 21:21:21	30	46.133		
2021-02-01 21:23:38	31	37.642		
2021-02-01 21:32:13	32	48.855		
2021-02-03 09:41:31	33	48.341		
2021-02-03 09:44:43	34	45.459		
2021-02-03 09:49:00	35	37.823		
2021-02-03 09:57:54	36	51.235		
2021-02-03 10:00:34	37	36.82		
2021-02-03 10:04:25	38	39.411		
2021-02-03 10:06:07	39	38.859		
2021-02-03 10:08:48	40	37.813		
2021-02-03 10:59:34	41	43.332		
2021-02-03 11:01:16	42	42.654		
2021-02-03 11:46:29	43	43.4		
2021-02-03 11:52:22	44	46.797		
2021-02-03 11:54:15	45	37.835		
2021-02-03 12:01:18	46	54.752		
2021-02-03 12:03:49	47	50.064		
2021-02-03 12:05:45	48	45.188		
2021-02-03 12:07:53	49	35.065		
2021-02-03 12:11:08	50	50.247		
2021-02-03 12:13:29	51	37.362		
2021-02-03 12:15:38	52	40.154		
2021-02-03 12:24:29	53	45.021		
2021-02-03 13:51:53	54	38.756		
2021-02-03 13:54:27	55	44.56		41.02076
2021-02-03 13:57:24	56	51.483		
2021-02-03 14:00:02	57	37.584		

Participant: Pink (continued)

2021-02-03 14:14:16	58	38.945
2021-02-03 14:17:11	59	37.953
2021-02-03 14:19:10	60	40.709
2021-02-03 14:26:03	61	40.968
2021-02-03 14:27:32	62	37.693
2021-02-03 14:31:56	63	35.111
2021-02-03 14:33:36	64	37.333
2021-02-03 14:38:08	65	37.813
2021-02-03 15:06:08	66	40.297
2021-02-03 15:10:08	67	40.667
2021-02-03 15:11:52	68	40.266
2021-02-03 15:14:39	69	34.13
2021-02-03 16:15:26	70	43.58
2021-02-03 16:16:59	71	38.31
2021-02-03 16:22:11	72	35.452
2021-02-03 16:24:20	73	44.95
2021-02-03 16:26:52	74	38.142
2021-02-03 16:28:26	75	32.531
2021-02-03 16:30:40	76	38.138
2021-02-03 16:34:45	77	42.406
2021-02-03 16:37:52	78	31.546

Participant: Green

data__x		data__y	id					
2021-01-31 20:30:25	1	43.459	126E6BEB5054414B352E3120FF150E09					
2021-02-01 15:47:45	2	92.368						
2021-02-01 15:56:36	3	93.335						
2021-02-01 16:04:26	4	82.157						
2021-02-01 16:06:50	5	66.758						
2021-02-01 16:09:46	6	64.69						
2021-02-01 17:20:10	7	61.788						
2021-02-01 17:26:03	8	63.393						
2021-02-01 17:28:17	9	59.609						
2021-02-01 17:30:42	10	61.996						
2021-02-01 17:36:02	11	50.941						
2021-02-01 17:38:07	12	55.229						
2021-02-01 17:40:27	13	60.115						
2021-02-01 17:42:43	14	60.554						
2021-02-01 17:44:56	15	53.695		62.84729				
2021-02-01 17:47:05	16	51.936						
2021-02-01 17:49:21	17	57.606						
2021-02-01 21:16:26	18	56.037						
2021-02-01 21:19:15	19	72.27						
2021-02-01 21:22:15	20	77.791						
2021-02-01 21:25:51	21	58.729						
2021-02-01 21:29:17	22	61.01						
2021-02-01 21:34:57	23	60.708						
2021-02-01 21:37:59	24	57.459						
2021-02-01 21:40:36	25	54.897						
2021-02-01 21:49:08	26	53.359						
2021-02-01 21:51:35	27	54.657						
2021-02-01 21:56:33	28	58.944						
2021-02-01 21:59:03	29	57.693						
2021-02-04 15:22:38	30	0.859	messaged to say sensor wasn't picking up/wasn't feeding back					
2021-02-04 16:09:10	31	null	bing sound. Swapped to new sensor					
2021-02-04 16:14:22	32	0.022						
2021-02-04 16:33:27	33	49.772						
2021-02-04 16:36:56	34	136.414						
2021-02-04 16:42:41	35	51.01						
2021-02-04 16:44:43	36	40.605						
2021-02-04 17:52:34	37	121.374	error setting up new sensor					
2021-02-04 17:56:07	38	52.607						
2021-02-04 18:04:24	39	56.271						
2021-02-04 18:06:51	40	62.76						
2021-02-04 18:09:25	41	47.791						
2021-02-04 18:11:48	42	53.934						
2021-02-04 18:13:55	43	43.059						
2021-02-04 18:16:04	44	50.369		52.0585				
2021-02-04 18:18:35	45	58.53						
2021-02-04 18:23:43	46	52.388						
2021-02-04 18:26:38	47	46.722						
2021-02-04 18:29:04	48	47.768						
2021-02-04 18:33:10	49	45.984						
2021-02-04 18:35:39	50	52.932						
2021-02-04 18:40:50	51	57.704						