Universiteit
Leiden
The Netherlands

Knitted Binaries: The Embodiment of Craft and Code

Zijderveld, Holly

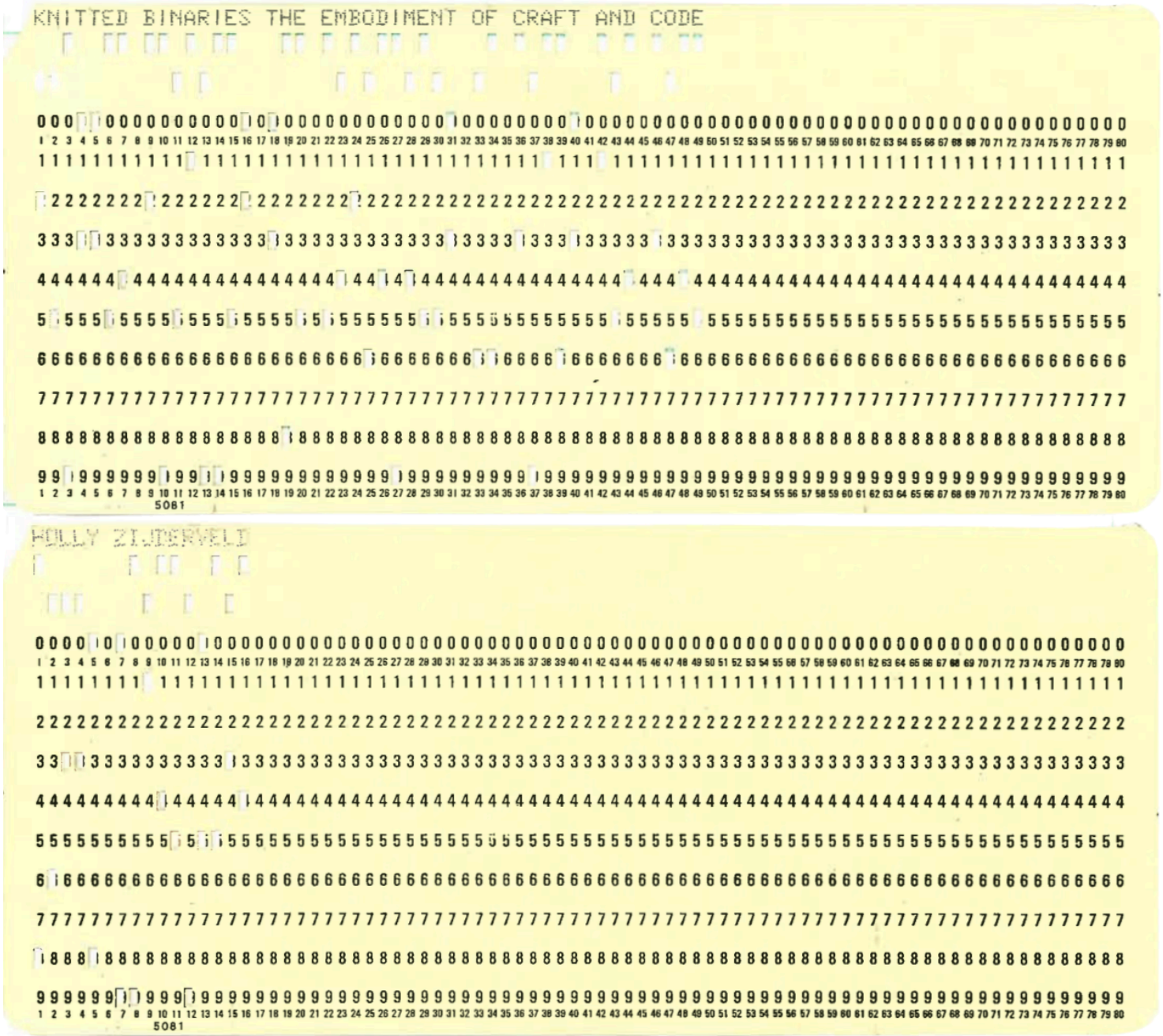
Citation
Zijderveld, H. (2025). *Knitted Binaries: The Embodiment of Craft and Code*.

Version:	Not Applicable (or Unknown)
License:	License to inclusion and publication of a Bachelor or Master Thesis, 2023
Downloaded from:	https://hdl.handle.net/1887/4257969

Note: To cite this publication please use the final published version (if applicable).

Knitted Binaries

THE EMBODIMENT OF CRAFT AND CODE



Holly Zijderveld

Universiteit Leiden
Institute of Cultural Anthropology and Development Sociology

KNITTED BINARIES

The Embodiment of Craft and Code

Holly Zijderveld
s3059510

Word count: 25,236

Supervisor
Elsa Charlety

MSc Global Ethnography
Cultural Anthropology and Development Sociology
Faculty of Social Sciences
Leiden University

Spring 2025

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

There are many people without which conducting this research wouldn't have been possible. Firstly, my supervisor Elsa Charlety, who is endlessly helpful, inspiring, and kind. In a similar vein, this research wouldn't have happened without conversations with and support from Rodrigo Ochigame.

I want to thank my parents, whose kindness allowed me to be ambitious with my fieldwork; my partner, Shiva Shah, for their constant support; my friends – Karen Jacobs, Des van Binnebeke, Kim Meijer, and Liselotte Mahieu especially – for our writing sessions; and the members of the self-model-making research group, for the inspiring line of thought which came at just the right time.

Lastly, and most importantly, thank you to all of my interlocutors for your kindness and knowledge. Thank you especially to Adrienne, Carson, Danny, Jonathan, Quinn, Victoria, and everybody else who went out of their way to answer my questions and help me. None of this would've been possible without your insights.

“The yarn is neither metaphorical nor literal, but quite simply material, a gathering of threads which twist and turn through the history of computing, technology, the sciences and arts. In and out of the punched holes of automated looms, up and down through the ages of spinning and weaving, back and forth through the fabrication of fabrics, shuttles and looms, cotton and silk, canvas and paper, brushes and pens, typewriters, carriages, telephone wires, synthetic fibers, electrical filaments, silicon strands, fiber-optic cables, pixeled screens, telecom lines, the World Wide Web, the net, and matrices to come.”

- Sadie Plant (1998), Zeros + Ones: Digital Women and New Technoculture

“The computer was always a simulation of weaving; threads of ones and zeros riding the carpets and simulating silk screens in the perceptual minions of cyberspace. It joins women on and as the interface between man and matter, identity and difference, one and zero, the actual and the virtual. An interface which is taking off on its own: no longer the void, the gap, or the absence, the veils are already cybernetic.”

- Sadie Plant (1995), The Future Looms: Weaving Women and Cybernetics

1. INTRODUCTION

My knitting machine arrived in late October or early November in 2024. I had bought it on a Belgian resale website, for 200 euros. One day, it arrived at my house: a Brother KH-910 in supposedly working order, a Brother KR-830 ribber attachment, a knitleader, and a box of tools. I brought them into my house where they continued to sit untouched for a month. Although I had been reading about knitting machines for a while, I had very little idea what to actually *do* with it.

Even when I did decide to start working on it, it didn't get much easier. Following a walkthrough I found on YouTube, I took off the lid to finally understand what I was confronting. I cleaned, with hindsight much too delicately, removing long-accumulated dirt with a not-too-wet cloth. I held everything with care and fear, feeling that the machine would somehow crumble in my hands and that this all would be for nothing.

My most important task here, I was told, was to check the sponge bar: a strip of sponge attached to a metal back, which sits along the needles to hold it down. As time goes on, the sponge bar disintegrates - most vintage machines that you buy need a replacement. I gripped the end and attempted to pull it out. It was stubborn. Grabbing some pliers, I finally managed to take it out. I googled 'knitting machine sponge bar' and saw many photos that looked like mine - it was brown, sat flush to the bar, and had little divots in. "Perfect," I thought, "my sponge bar is fine!" I shoved it back into the machine, pushing the needles down as I had read to do online. After some surface cleaning, I swiftly put the lid back on and left the further confrontation to another day.

It was then another month later, and my fieldwork period had officially begun. I couldn't put it off anymore: I really had to start knitting. One evening, late into the night, I threw some caution to the wind and positioned it on my table for the first time, setting up the side rails and attaching the carriage to the bed. When I awoke, I had one mission: to knit.

Having been a hand knitter for some years, the steps of knitting were at least familiar to me if nothing else was. Following the same tutorial as before, I attempted to cast on. However, it just wasn't working: every attempt (and every method of cast on) would just end up with a tangled mess. Frustrated, I turned to the Machine Knitting discord server, where I posted my plea for help. Around four people gathered in the help channel, asking me for photos and videos of my technique and the outcome. Frustration only grew as nothing worked: I found myself so badly wanting to blame the machine, feeling that I couldn't be doing anything wrong. Then, someone new entered the chat: "Do you even have a spongebar in there? The needles are sitting *much* too high." I responded that I checked it, and I thought it was fine. Suddenly, photos of people's needles came flooding into the chat, and they were right. My needles were far too high. I described the condition of my spongebar to them. If we were in the room together, the silence would've been palpable. They sent me a picture of what spongebars were *meant* to look like – white, and very puffy. Honestly, I felt very foolish, as I admitted that the mistake was mine after all.

It is slowly becoming more common knowledge that technology and textile creation have a shared history in a myriad of ways. This can be seen in the story of Charles Babbage's inspiration by the (punch-card operated) Jacquard Loom for the Analytical Engine (Harlizus-Klück 2017); or the use of textile makers for the creation of core rope memory for the Apollo 11 mission (Rosner 2018, 3). The woven history of textile creation, computing history, and gendered labour tells an interesting tale, increasingly being spoken about in museum exhibitions, blog posts, and other accessible forums[1]. Despite this, it is still a widespread belief that textile creation and computing occupy completely separate spheres: that of the 'traditional' and the 'technological'.

The resemblances between the two are not coincidental, as many point out. Instead, they are concerned with the shared attributes of each pursuit. Both computing and textile transfer data and information, and are created with a series of operations which create different outcomes when executed differently. As such, these connections do not only concern the past of computing and crafting, but are also relevant today.

This research explores how such connections manifest in the lives of those actively and simultaneously interacting with both textile and technology everyday. To understand this, I underwent three months of fieldwork with All Yarns Are Beautiful: a machine knitting community who develop an open source modification for Brother electronic knitting machines. In creating the modification, and making knitted fabric with it, crafters in the community interface consistently with the intersections of textile and technology previously identified (including the transfer of information and the similarity of certain skills). Thus, this research sought to find out how these connections impact the process of crafting a textile which is so often considered to be 'traditional,' not modern or technological.

Such a project aims to contribute to scholarship on craft in our current times, discourse about our gendered interactions with technology, and research on free and open source communities. To do so, this thesis aims to come together to answer the question: "How do modified knitting machine users form relationships with the crafts and technologies that they interact with, and how does this reflect on self-ascribed binaries found in the community?" To culminate at this point, the research tells a story through three different aspects: processes of relationship forming, technological craft, and binary identities.

Assisting me in this research was the concept of the 'binary', which ran as a constant throughout and proved applicable as a metaphor in many situations. The idea to use the binary in such a way started for me with Sadie Plant's *Zeros + Ones* (1997), a seminal text in cyberfeminist thought which compared gender and data binaries, insinuating that women are treated as equivalent to 0 and men to 1. Although the book has garnered criticism over its naturalisation of gender, the concept of the binary as applicable to more than just the processing of information (by computers and knitting machines both) seemed useful. Thus, this research takes the binary, and

[1] During my fieldwork, I saw a number of museum exhibitions explicitly discussing this history: at the Tate Modern's 'Electric Dreams' exhibition (London, UK), The National Museum of Computing (Bletchley, UK), the Computer History Museum (Mountain View, USA), and the Palo Alto Art Center's 'Cut From The Same Cloth' exhibition (Palo Alto, USA).

its many interpretations, as a starting point for analysis that materially relates technology and information to social reality.

1.1 ALL YARNS ARE BEAUTIFUL

All Yarns Are Beautiful (AYAB) is a project which develops a 'hack' or modification to flatbed electronic knitting machines. This section will explain what these knitting machines are and how they work, how the AYAB hack works, and some details about the AYAB community.

A flatbed knitting machine (hereafter referred to only as a knitting machine) is a crafting machine which is used for the creation of knitted textile. The machine consists of a bed of approximately 200 *needles*, which have latch-hooks on the end. Yarn is fed from behind the machine through a *tension mast*, and through the *carriage*, which slides on top of the needles. When the carriage is passed over the needles, a stitch is created in the latch hook. Beneath the carriage (when it is moved), the needle is brought out and the stitch moves from the hook to the body of the needle. The hook catches the new yarn from the carriage and pulls it through the previous stitch, creating interlocking loops. When a piece is started, you need to *cast on*, and when you finish, you need to *cast off* to secure the stitches. Stitches can be moved from needle to needle for a variety of reasons (for example, creating decorative holes or casting off) using a *transfer tool*, and doing this is called *hand manipulation*.

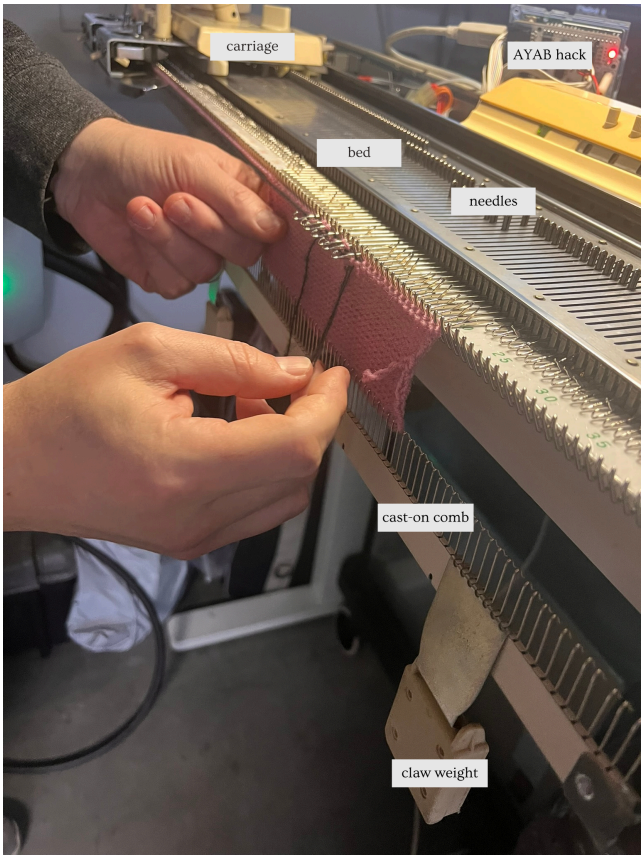


Figure 1: Annotated diagram of an AYAB-hacked knitting machine in use. Photo taken and annotated by author.

Since the initial invention of entirely manual knitting machines, where all 'patterning' (meaning designs with different colours or textures) had to be done by hand, a number of different *patterning mechanisms* have been introduced to knitting machines. In the mid-1950s, push button mechanisms became popular, where the user would press buttons on the machine to create a binary 8-stitch pattern repeat. Punch cards then became the popular way to program patterning in knitting machines. Punch cards are a technology that were popularised by the Jacquard loom (a punched card-based weaving loom), enabling the intricate patterning of loom-woven fabrics. Finally, some knitting machines have electronic patterning mechanisms. These machines are computerised and have pre-loaded patterns, as well as the ability to read in new patterns through a mylar sheet reader or floppy disk. *Brother*, a Japanese electronics company, widely produced knitting machines from 1954-1996 with all four types of patterning mechanism described here.

The AYAB project specifically makes their hack for electronic Brother knitting machines, which were produced from around 1976 to 1999. Their hack replaces the existing electronic board from inside of the machine with either a 'shield' (a small PCB attached to an Arduino microcontroller) or an 'interface' (which doesn't require a separate microcontroller), which can then be plugged into your laptop. The corresponding AYAB software allows the user to upload pixelated designs for patterning, where each pixel corresponds to a stitch. The patterning information is sent from the computer to the machine row by row, and solenoids inside of the machine help to track where the carriage is and moves the needles for the patterning accordingly. With other patterning mechanisms, there is often a limit (or 'stitch repeat'), where the same section of design must be repeated. AYAB allows the user to disregard such limits, creating more detailed designs with no repeats.

The AYAB project began in 2012, created by a pair of German engineers who met through the Chaos Computer Club (self-described as "Europe's largest association of hackers"[2]). AYAB is open source, meaning that the hardware specifications and source code for the software are openly available for anyone to see and use. Although it is not necessarily the case that open source software is free to use, AYAB is - the only costs associated are hardware related. Additionally, AYAB relies solely on volunteer developers and testers, who work on all aspects of development (including bug fixing, developing new features, and organisational matters). The active development team consists of roughly 10 people, although other members of the community are always welcome to make occasional contributions. The group is spread globally, and congregates in a number of online spaces. Github is used to share code and report bugs, Discord is primarily used for discussion of development, and Discord and Facebook are both used to share projects and ask for troubleshooting help from the community. Additionally, but less predominantly, spaces for AYAB exist in a number of online knitting forums.

The project exists alongside a number of other open source and proprietary projects expanding the capabilities of knitting machines. These include img2track, DesignaKnit, and eknitter. Each project offers their own capabilities and functions. Although AYAB is designed primarily for

[2] https://www.ccc.de/en/

Brother knitting machines, work is being done to adapt the hack for other knitting machine brands, such as Silver Reed.

To look at the relationship between technology, craft, and crafter in experiences of those in the AYAB community, I conducted three months of fieldwork from January to March 2025. This proved an exciting time in the history of AYAB, as after 12 years they would be finally releasing AYAB version 1.0. My fieldwork consisted of participation in the community on Discord[3] and Facebook, interviews with members of the community, travel to two cities (San Francisco and Berlin) to visit AYAB users and developers, and learning to use my own knitting machine.

1.2 TECHNOLOGY AND THE INNER WORKINGS OF TEXTILE

It seems to be a modern, popular understanding that technology and textiles occupy very distinct and distant domains. Whereas textile craft is handmade, material and traditional, technological work is disembodied, immaterial and frightfully modern. Whereas one draws us to our roots, the other propels us into the future. Such a characterisation runs through current-day representations and understandings. Recently, a movement of work has come to disrupt this understanding, both in academic work and popular culture. Textile craft is far more mathematical and technological than many imagined, and the history of technology is too woven into textile's complex threads. This section aims to demonstrate this tangle of technology and textile through two lenses: the history of textile workers in technological work; and the commonalities in punched cards, binary information, and coding which link textiles and computing. This exploration provides a vital basis for the further ethnographic discussion of textile craft and technology in this thesis.

1.2.1 TEXTILE AND TECHNOLOGICAL LABOUR

One of the first interactions between textile labour and technological labour was that of the so-called 'Little Old Ladies', or the women line workers at NASA (Rosner et al. 2018). Preparing for the Apollo missions, their role was to create physical, woven manifestations of the code for the Apollo Guidance Computer - called core rope memory. The memory relied on wire and small metal rings (the 'cores'), which could materially represent binary code depending on whether the wire passed through the core (representing a 'one') or passed by it (representing a 'zero'). The tightly woven nature of the core rope memory made it incredibly robust and compact, making it ideal for usage on a spacecraft (Rosner et al. 2018).

The employment of women in technological labour did not end with core rope memory. Many women of colour have been recruited by electronics companies throughout history to manufacture computer components, due to essentialised notions such as their 'nimble fingers' (Nakamura 2014, 920). As Nakamura (2014) discovered through her analysis of a brochure for Fairchild semiconductors, Navajo women were depicted as being naturally suitable for electronics manufacturing. Going further, however, Fairchild depicted that the circuit-building was a central

[3] Discord is a community messaging platform that builds a lot from the structure and functioning of IRC messaging. A 'server' is a collection of 'channels' (which are marked using a # at the beginning, for example #help). AYAB has their own discord server, which anyone can join. You have a username, profile picture, and bio statement which are consistent across your servers (which also shows when you created your account). You can also set an individual nickname for each server.

part to their culture, arguing that in allowing Navajo women to reproduce their traditional skills they were keeping their culture alive (2014). Such depictions of women of colour as naturally suitable in brochures and advertising was not uncommon: Elson and Pearson (1984) show very similar language in a Malaysian manufacturing investment brochure.

1.2.2 PUNCHED CARDS, BINARY, AND CODE

As I previously mentioned, punched cards are still a common method of information processing for knitting machines. However, before their introduction in such machines, they had a more complex history. Punch cards are a technology that was popularised by the Jacquard loom, enabling the intricate patterning of loom-woven fabrics. Roughly 20 years after their widespread introduction in the Jacquard loom, Charles Babbage took inspiration from them in his design of the Analytical Engine, considered to be the first programmable computer (Wahl 2018, 29). Ada Lovelace, who wrote the first programs for the Analytical Engine, further drew the comparison between Jacquard loom and computer (Harlizius-Klück 2017). Punched cards then became widely used in computing in the 1960s and 1970s, especially being used to program mainframe computers (Wahl 2018). Punch cards were used in knitting machines from around 1970, with a mechanism very similar to that used in the Jacquard loom.

The use of punched cards in both textile creation and computing is no coincidence: it comes from a deep similarity in the demands of communicating and storing information that needs to be processed. In the case of punched cards in looms, the pattern (represented by the position of the punched holes) determined whether the warp threads should be lifted or lowered, depending on whether there was a hole or not. In machine knitting, it works very similarly: needles corresponding to a hole will be placed in *D position* (to be coloured with the accent colour, for example), whereas those corresponding to a blank will remain in *working position* (also called *B position*). An important aspect of punched cards in machine knitting is the idea of a 'stitch repeat'. Usually, punch cards could hold 24 rows of information, which is repeated next to each other along the bed. Such a mechanism can place a limitation upon design.

Punched cards were used in computing for the long-term storage of information (such as census data), and for the writing of programs through which to process this data (Wahl 2018). As part of my stay in the San Francisco Bay Area, I visited the Computer History Museum in Mountain View. Among viewing many different textile data storage devices, such as Jacquard Loom punched cards and Quipus,[4] I also had the opportunity to participate in the demonstration of an IBM 1401 Data Processing Unit, from 1959. Alongside it was a IBM 1402 Card Reader and an IBM 1403 Line Printer. After the experience, I wrote:

> Pretty early into the demo, they looked for a volunteer: a woman, who they'd train to be a punch card typist. Obviously I volunteered. I sat down at the desk – there was a keyboard resembling a typewriter, and a mechanism. The demonstrator first showed me how to load a card into the printing area (one of the buttons on the keyboard). I then typed my name – the keys didn't require much more pressure than an ordinary modern keyboard. I then pressed two

[4] A Quipu is an Incan method of transferring data, through knotted strings which were created, transported by a chain of runners, and then read by someone on the other side (Niles 2007).

> other keys, one after the other, twice, moving the card left and eventually out of the top. I checked my name – printed small over the top – it was correct. The card was the loaded into the reader, along with approximately 100 other cards, which were the program. The data care was on top, to go through last. He pressed a button and the cards wooshed through. The computer whirred, and out of the printer came the output: Holly Zijderveld visited the Computer History Museum on February 15, 2025.[5]

As can be seen in this demonstration, the punching of cards was often a computing task that women were recruited to do. As Hicks (2017) shows in their historical account of the post-war computing industry in the UK, computing work such as punching and operating were often seen as women's roles, as they had performed them in wartime and were not seen as cognitively difficult tasks. This stands in contrast to writing computer programs, which was a role still given to men. As time progressed from the war, many processes led to the brute-force recharacterisation of computing work as 'men's work,' and many women found themselves training men who would eventually take their positions (Hicks 2017).

Attention has further been called to the structures of weaving and modern-day code (Griffiths and McLean 2017). Aiming to understand how to structure woven patterns in computer code, live-coding researchers Griffiths and McLean (2017) found "weaving to support a great depth of physical engagement with the fundamental nature of computation" (2017, 2). Such research explicitly shows the interconnected nature of these two endeavours. Underpinning the similarities of information transfer and storage in textile craft and computing is the mathematical nature of textile production. As Harlizus-Klück (2017) writes, in her exploration of the binary nature of weaving:

> (...) the binary pattern algebra was already present in the operation of the drawloom. The algorithms and patterns were always there, just not in a manner visible to outsiders and non-weavers. The punched card simply made the pattern algebra of weaving perceivable to someone interested in the construction of calculating engines on the basis of binary logic, someone like Charles Babbage. (2017, 179).

In this exploration, Harlizus-Klück looks beyond the association between Babbage and Jacquard to examine the algebraic and binary nature of weaving, which resulted in similar loom patterning mechanisms which predated Jacquard's (Harlizus-Klück 2017). The mathematical nature of textiles does not only apply to the patterning of woven fabric, but also the shape and construction of knitted garments (Arentes, 2020a). It is worth noting, however, that despite knitted stitches' ability to be *meaningfully encoded* (as in, they can store information that can be read later), this information can be more-than-binary, as many different aspects of the stitch can be changed in a myriad of ways. These similar aspects between craft and technology provide a basis for further discussion throughout the analysis provided in this thesis.

[5] The card I printed here can be seen on the front cover of this thesis.

1.3 CONCEPTUAL UNDERPINNINGS[6]

As will be explored and developed through this thesis, modified machine knitting is a craft that is multifaceted and hybrid, pulling from many unique disciplines and modes of making. In order to capture this complexity and the ways in which it interacts with the world, the study of such phenomena must follow in its wake, using exploration and hybridity as a method in analysis. Therefore, this research pulls from multiple expanding lines of thought, implicating wide discussion about our interactions with craft, technology, and materiality. Outside of debates in the anthropologies of craft and technology, this thesis also discourses with phenomenology, gender studies, design studies, history of technology, (feminist) science and technology studies, and human computer interaction studies.

Furthermore, this thesis aims to recognise the ways in which knowledge arises through interaction and relation (with each other and with, in this case, the craft and technology of machine knitting). Autoethnography thus becomes a backbone of analysis, as the creation of knowledge happens in correspondence with my crafting experience and those of my interlocutors. Such an autoethnographic record was then used in relation to this wide scope of literature to write this thesis.

This section introduces five key concepts which form the analytical basis of the research: materiality, technology, craft, embodiment, and correspondence. Each concept is defined and explored through its relationship with anthropology and other fields of study. Reaching understanding on each topic is essential in grounding the research in this inherently interdisciplinary space.

1.3.1 Materiality

The concept and study of materiality forms a basis for analysis in this research. Materiality was first imagined by phenomenologists, who acknowledged that things were not objective but instead had a "flexible character" which relies on "the relative position and the evaluation of the observer"(Hahn 2018, 8). Material things have been important to anthropology for a long time, despite their perceived relevance moving in and out of fashion in the discipline. Before the widespread adoption of the ethnographic method, museums of objects from 'other' places were the basis of thinking about dominant anthropological theories at the time (Hahn 2018, 3). Once participant observation became more widespread in anthropology, the supposed importance of material objects dwindled, as they were interpreted as byproducts of society within the dominant theories of structuralism and functionalism (Hahn 2018, 5). At this time, the arguments of phenomenologists proved useful to anthropology, as materials could be viewed as a useful mode of analysis.

Although materiality and material culture have long been written about in anthropology, Ingold (2007) writes that they seem "to have hardly anything to say about *materials*" (Ingold 2007, 1, emphasis in the original). Ingold argues that this typical way of understanding materiality in

[6] This research follows a call by Katie Collins (2016) for the reimagining of metaphors for academic thinking as material/textile, instead of architectural. Such thinking helps, I believe, in imagining ethnographic knowledge as a quilt of perspectives and experiences from interlocutors, assembled by the ethnographer: it is this approach that this thesis aims to take.

anthropology acts as a barrier to our understanding of the material world (2007, 3). He postures that materials are in flux, with surfaces that are in transformation. By viewing objects as "solid" instead of as materials, "the flux of materials is stifled and stilled" (2007, 11).

1.3.2 Technology

The word 'technology' can be defined in a wide number of ways. These span from consideration of only highly-engineered digital technologies, to a wide scope that considers most human tools to be technological (Batteau and Jazayeri 2018). Batteau and Jazayeri (2018) note that the definitions and understandings that people have of technology are often deeply embedded in other factors of the social environment. As such, previous anthropological investigations into technology have been wide reaching and address any number of different topics. Batteau and Jazayeri argue for this to continue: as they write how "an anthropology of technology ought to be the anthropological project of the twenty-first century" (2018, 10).

Digital infrastructures and technologies, such as computers or the internet, at first may appear immaterial to their user. We do not often see the servers our files are hosted on, or the components inside our laptops. However, it is a mistake to claim that these things are not there, that the processes of computing infrastructure do not happen in the material world (Blanchette 2011, 1042). This materiality of the digital is essential to consider, as Blanchette (2011) writes:

> [w]ithout a basic understanding of the material constraints under which computing systems operate, essential dynamics that animate the built environment of the virtual will remain invisible and unaccounted for (2011, 1055).

Noticing the ways in which the digital 'animates' our environment further allows us to observe how the digital, including its material infrastructures and parts with which hackers regularly tinker, interacts with other materials as well as our own bodies. However, as Batteau and Jazayeri (2018) purport, it is also important to realise that the materiality of technology does not disengage it from social context: just because technology is material, it does not become objective and removed from subjective meaning-making. Such relational and subjective views on making meaning in a material environment have been widely discussed by phenomenologists, such as Barad (2003) and Keane (2003). The term 'technology' also carries great conceptual weight in describing social values and phenomena. As Dunbar-Hester (2020) writes: "technology is a special case for social analysis: it is no less a product of social relations than other domains of culture, but its stature is so great and its shadow so long that it is worth concerted attention" (2020, 12).

1.3.3 Craft

Craft is a concept that is relatively understudied in modern anthropology (Denicola 2024). As anthropologists have aimed towards reflexivity and studying modern life, craftspeople have often fallen behind as an object of study due to their popular connotation with older ways of being. However, it has been argued that the concept should once again be taken up as a way for studying social life. As Denicola (2024) writes, "studying craft as a verb captures the everyday, mundane, ethnographic lives of makers at the same time as craft as a noun is a powerful space of

meaning making" (2024, 7). However, as Torell and Palmsköld (2020) show, work is currently being done across humanities fields (such as folklore studies) to highlight how people are living with craft today. Although this work is often not explicitly anthropological, much of it relies on autoethnographic methods and participant observation (Torell and Palmsköld 2020).

Despite this push towards studying craft, it is recognised as a specifically difficult concept to define. This is especially as the word has a place both in everyday vernacular and academic work. In this wake, Marchand (2016) proposes that craft be defined as a 'polythetic' category, where something should be deemed as a craft if it aligns with one or some of many categories. The categories that he provides are also non-exhaustive, and aim to capture characteristics commonly associated with crafting and craftspeople (2016, 9). Among other aspects, he names apprenticeship, expertise, materials, problem solving, skill, and tradition (2016, 9-10). The need for such a category shows how the boundaries for what should and should not be considered a craft are blurry, leaving space for discussion amongst academics and craft people alike.

Another way in which one could understand craft is in the transformation of material to surfaces, with an intentional form. Such surfaces, as Arentes (2020b) explores, are not covering and superficial: instead, they can be "rich and deep" (Arentes 2020b). As she shows, in knitting especially the creation of a surface is complicated by the necessary holes in the fabric. The idea of a simple process from material to surface is also disrupted due to the nature of emergence in knit fabric, where the yarn becomes a surface slowly over time and place (2020b, 154). Knitting, and other crafts, can thus be considered both a correspondence and a moving forward; as Arentes (2020b) writes, knitting is "somehow like walking" in this way (2020b, 155).

1.3.4 Embodiment

Similarly to materiality, embodiment as a concept in anthropology flourished in the poststructuralist era (Marchand 2018, 3). Initially studied was the embodiment of social and cultural forces, which Bourdieu termed 'habitus' (Marchand 2018, 4). This concept is used to discuss the ways in which the cultural world around us regulates our entire body and mind. Such ideas of the internalisation of outside social forces is also key to gender scholarship, such as Butler's key theory of gender performativity (Marchand 2018, 4). As Marchand describes: "The poststructural turn had broadened the understanding of discourse to include what people do in addition to what is communicated and exchanged in language" (Marchand 2018, 4, emphasis in the original). This opened the gates to a further anthropological exploration of embodiment in relation to our material world, often explored through the study and method of apprenticeship (Marchand 2018, 5).

Not only is embodiment a key frame of analysis in this research, but it also informs the methodology: as an ethnographer, gaining an understanding of the way that your interlocutors embody requires an acknowledgement of your own processes of embodiment. One way in which anthropological studies have adapted to a focus of embodiment is through the paradigm of multisensory anthropology. Here, anthropologists are encouraged to take seriously the different ways in which people interact with the environment around them and the ways in which they can be culturally constructed and influenced (Howes 2019). Special emphasis is placed on each sense, and the anthropologist is tasked with collecting a more diverse set of data than purely

visual (through observation or 'reading cultural texts', for example). In multisensory anthropology, "sensory values are social values and social interaction is sensory interaction" (Howes 2019, 22). Straying away from the cartesian mind-body duality of the past, such anthropological methodologies aim to view the person as whole and take seriously the feelings of the body as social, instead of only the 'mind' or the 'self'. Furthermore, Grasseni (2004) places emphasis back onto sight with her concept of 'skilled vision', where the sense of sight plays a key part in embodied skill acquisition.

1.3.5 Correspondence

'Correspondence' is a term widely used in understanding the intra-action of relational beings in the shaping of materials and meanings. Such thinking is widely attributed to Ingold (2014, for example) who popularised the term correspondence in the anthropology of craft. As he writes:

> This correspondence – this answering to a world that, in its relations and processes, also answers to us – is the generative dynamic that moves life Forward, and which leads by aspiration (Ingold 2014, 134).

In Ingold's view, creating taps into a flowing creativity, where crafter and crafted act in dialogue, animated by the current's movement (Ingold 2010). This idea of correspondence has been developed upon by multiple scholars working within the study of knitting itself. Jones (2022) draws on his idea to understand the role that correspondence and dialogue plays in the making and sharing of meaning through the creation of knit textiles. Furthermore, Arentes (2020b) critiques Ingold's suggestion that such a correspondence is untroubled, developing such creative flows to include issues of frustration which often occur during knitting.

Such discussion of correspondence has not only had its place in craft studies, but also in understanding relations between actors in our world. Barad (2003) criticises this idea of correspondence as implying a representational relation, where the material world *represents* "discursive practice" (2003, 802). Barad, following from Butler, instead argues for a view of performativity in understanding the nature of ontology. As Barla (2019) elaborates:

> Performative approaches circumvent the need for such a correspondence between world and words, matter and discourse by focusing on the question of how not only meanings but particularly (re)configured bodies, identities, and hence realities, are enacted through particular generative processes (Barla 2019, 128).

Despite this critique of the representational, back-and-forth nature of the term 'correspondence', I am motivated to use it to understand the relational nature of identity formation in this thesis due to its concurrent popularity in understanding the nature of craft-creation. This process of correspondence, as it relates to craft and technology, rests upon our viewing the world around us as material, and taking seriously the impacts that interaction between ourselves and the material world have. We do not only change our environment, but our environment changes us through the process of embodiment. The relationship between these concepts provides a framework through which to study the relationship between craft and technology in anthropology, and the

study of this new relationship promises to add interesting new dimensions to the concepts of materiality and embodiment alike.

1.4 METHODOLOGY

1.4.1 'The field' in digital ethnography

I met my interlocutors for this project mainly through online groups associated with the All Yarns Are Beautiful project, namely on Discord and Facebook. As I mentioned above, the AYAB community consists of developers and users of the project, as well as some people who hack electronic knitting machines in other ways (or intend to do so in the future). The project decentrally organises across these online platforms (with Discord and Github being more used by the development team than Facebook), bringing together members from all over the globe.

Despite AYAB being mainly discussed online, AYAB primarily refers to something happening in physical-material space, as people tinker with hardware and bring textile surfaces into being. As such, the 'field' for this research does not happen primarily in a virtual world as in other digital ethnographies (see Boellstorff 2015). Instead, Discord provides a platform for people to bring their 'real lives' to one another, as can be seen in other recent ethnographies conducted with Discord servers (Mouraviev 2024). My interlocutors, who I met both in person and online, continue to meet with each other in virtual and physical space: for example at guilds or conventions, or to exchange and lend knitting machine parts. Although a large part of this research may be considered 'digital ethnography', the frame of analysis that I utilise throughout does not consider the digital to constitute a virtual plane - instead, in this context it allows communication across our one, shared physical reality.

In the fieldwork for this research, I also visited the San Francisco Bay Area in California, USA and Berlin, Germany. I chose these locations purely as they allowed me to meet with the largest number of interlocutors. However, both locations set an interesting backdrop to research about craft and technology today. Firstly, the Bay Area is home to Silicon Valley, and is the home to many corporations working in new technological developments: many of my interlocutors in the Bay Area had experience working for Silicon Valley companies.

Furthermore, the rapidly changing political climate in the US hung constantly over my fieldwork. I arrived in San Francisco on the 26th January, 2025 – 5 days after Donald Trump's second inauguration as President. During the month of my fieldwork in the US, political tensions continued to grow, resulting in mass detentions and deportations in the following months. Talk of tariffs especially hung over the research, as machine knitters (who often order spare parts for their machines from websites like AliExpress) were concerned over the longevity of such a practice.

Such political tension was not only present in my fieldwork in the US, but also in Berlin. Arriving for an interview at Berlin Ostkreuz, I was met with a neo-Nazi demonstration of approximately 800 people, 1,500 police officers, and 2,000-5,000 anti-protestors.[7] Shouts from the

[7] https://www.dw.com/en/berlin-police-arrest-scores-as-neo-nazi-march-blocked/a-72008289

demonstration could be heard from my interlocutor's studio. Such political events cannot be excluded from ethnographic accounts, as they formed an explicit background for everybody. The question does not stay as "why do people care about machine knitting?" but it becomes "why do people care about machine knitting *right now*?"

1.4.2 Methods

My time doing research was primarily split between three wider methods, each with smaller considerations: autoethnography, participant observation, and interviewing. In this section I will describe each of these in turn, as well as how they worked in both digital and physical ethnographic contexts.

1.4.2.1 Autoethnography

Autoethnography blends ethnography and autobiographical writing to reflect the inner life of the ethnographer to understand wider cultural phenomena (Ellis et al. 2000). It is a method often used to highlight embodiment and "connecting the personal to the cultural" (Ellis et al. 2000, 740). As mentioned at the beginning of the conceptual underpinnings, autoethnography is key for the construction of an analysis which aims to capture the complex, relational co-creation of knowledge between craft, technology, and interlocutors. In this light, taking my own autoethnographic knowledge seriously, alongside valuing the knowledge created and held by my interlocutors, provides a base for the wide discussion of literature and theory across many disciplines.

My decision to pursue autoethnography as a method was further inspired by a tradition in the anthropology of craft which builds upon the idea of 'apprenticeship'. Such studies, for example O'Connor's (2007) study of glassblowing, allows the ethnographer to gain similar embodied knowledge as their interlocutors. Non-apprenticeship studies of crafting knowledge have also been undertaken by ethnographers, for instance Aktas's (2019) autoethnographic reflections on felting and the agency of wool, or Ehn's (2011) argument for autoethnography with the example of carpentry and DIY. Inspired by such studies, I developed my own thread for autoethnographic exploration of machine knitting.

As I recounted at the beginning of the introduction, I purchased a second-hand knitting machine for this project. To incorporate apprenticeship-style elements to the method, I learnt in the same ways that my interlocutors reported. Furthermore, I asked for help in the Discord servers where I was conducting participant observation. When I met with interlocutors physically, I asked them to show me how they knit on their machine, and in some cases tried myself with their methods. To keep track of my autoethnographic reflections, I wrote about my experiences with machine knitting every day of my fieldwork period - forming a primary source for analysis, alongside other observation and interview notes.

1.4.2.2 Participant observation

As mentioned above, I conducted participant observation within the AYAB community. As the AYAB community is not a distinct body, and instead is distributed and with fuzzy borders, the participant observation took place over a number of different forums. Firstly, I conducted digital participant observation across a number of online platforms: two Discord servers (All Yarns Are

Beautiful and Machine Knitting), a Facebook group (AYAB All Yarns are beautiful Strickmaschinen knitting machine), and the AYAB Github page. Much of my participation in these servers related to my autoethnography, where I would ask for help from my interlocutors. It is also common in the servers to share photos of things you were working on: this was also something I participated in. I conducted digital participant observation in the AYAB bi-weekly development meetings, which are open to attend. The meetings were coordinated on the Discord server and took place on Zoom.

In the San Francisco Bay Area, I participated in-person in a number of knitting circles and knitting machine related meet-ups. At these events, I met many of the people who I had initially met on Discord. Furthermore, when physically meeting interlocutors, I would often observe them working on their knitting machine. Such interactions between them and the machine were not as spontaneous as a participant observer would typically hope, but still provided insight into how knitters interacted with their machines.

1.4.2.3 Interviewing

In conducting this research, the equal co-production of knowledge is very important to me. Alongside valuing the creation of crafted things as knowledge production, interviewing formed a vital part of this. The interviews were either semi-structured or unstructured, which was a judgement I made depending on the flow of conversation between me and my interlocutor. Along with asking about my interlocutor's histories with using their machine/AYAB and opinions on technology, I also presented the key theories that I'm using in my research. I then asked explicitly what they thought of the theories, and whether they felt it aligned to their making practices. Such an approach explicitly centres the co-production of knowledge, and allows for invaluable insights through the research process.

1.4.3 Positionality

In conducting any ethnography, but especially one where the ethnographer's own experiences are analysed, being reflexive on one's positionality is essential (Ellis et al. 2020). In this section I will outline my previous experiences with knitting and technology, and I will also detail the roles that I took as a participant observer within the community.

I initially learnt to knit in my mid-teens, in school. Although I signed up to the class as a joke, I began to really enjoy knitting; I then borrowed some knitting supplies from a relative who had to stop knitting so frequently due to arthritis. The hobby faded for me until 2021, when I had moved to university. Looking for something to do with my hands alongside studying, I began knitting again. I looked online for inspiration, and started making accessories and pullovers from patterns I would buy. At this time, the slow making and traditional aspects were quite important to me: I found it beautiful that wool could be taken from a sheep, processed, spun, and knit into something to wear. A large part of my interaction with knitting happened through social media (Instagram and YouTube), where others would talk about and photograph the things they were making. I remember, at the time, being very weary of machine knitting – worrying that if I would start, the meaning that I attach to the process of knitting may be lost.

As with many people who grew up in Western Europe in the 2000s, I have had significant interaction with digital technologies from a very early age. However, looking back at it now, I would never describe my interactions as very 'critical': I put my whole life online and didn't worry about privacy, and I would rather adapt my behaviour than adapt a technology to fit my needs. When beginning to conceptualise this research, however, my attitude towards technology changed: I became a lot more conscious of what I shared online and started spending much less time with the social media I used to interact with daily. Furthermore, I became more concerned with using open source software when possible, and with the longevity and reparability of my technological devices.

To the benefit of my digital ethnography, I have been a long-time user of Discord (setting up my account in October 2017). For my fieldwork, I decided to keep the same account that I have always used, adapting only my account bio and nickname in certain servers to make clear my identity and role as a researcher. In these Discord servers, I was an overt participant observer, as I interacted in the server in the ways that others did (and that felt natural to me, as someone who has frequently used Discord before). Although I kept my research status overt, I became more of an observer in other situations, such as development meetings – in these situations, I had less to contribute as a participant due to my lack of software/hardware engineering knowledge. In physically attended meet-ups and knitting circles, I once again resumed an overt participant observer status.

1.4.4 Ethical considerations

In anthropological research, it is often common practice to anonymise your interlocutors and the location where you are doing fieldwork. However, throughout this thesis, I refer to most of my interlocutors by name. Such a practice follows from a discussion of the impact of using pseudonyms or crediting names in doing ethnography. As Reyes (2019) discusses, using names in doing ethnography can be a way to give more accountability to the researcher in properly reporting their findings. However, she also acknowledges that such a practice needs much consideration and informed consent (2019, 210). Sharing names is of particular use in a setting where people may be easy to guess, both within the community and outside of it: such is the case with the AYAB community.

In referring to my interlocutors by name, I hope to honour their contribution to the production of knowledge with credit. In this research, I wish to emphasise that none of this knowledge would be here without the insights of my interlocutors. In analysing and piecing together what I learnt during fieldwork, *I* am not the sole knowledge producer. To ensure that my interlocutors were happy with being referred to by name, I asked them explicitly at the beginning of each interview, with the context that I would also be referring to the AYAB project by name. Hence, informed consent remained a top priority throughout. There are some people I came across in my research who I didn't interview: these people will remain anonymous.

1.5 OUTLINE

This thesis begins by discussing where everybody who comes to machine knitting begins: the process of learning. Weaving my autoethnographic accounts with perspectives from the interlocutors for this project, this first chapter aims to recount the process of embodied skill

acquisition. Following from other autoethnographic accounts of embodiment in craft, I assess the concept of 'corporeal sight,' and further move to highlight the importance of vision in such skill acquisition. Such sight culminates in the concept of 'reading' knitting, which emerged emically in the field. This chapter concludes through understanding the importance of frustration in embodied skill acquisition, and how making mistakes sets the stage for embodied knowledge to emerge.

The second chapter moves to discuss how this embodied skill is 'put to use' through making. The chapter first follows an emic binary distinction between 'project' and 'process' makers, aiming to identify what these labels mean and how they reflect on the processes of making. I then turn to discuss a binary distinction that arises in literature on craft and form creation, between the hylomorphic and morphogenic models of making. This section follows Ingold's (2010) distinction, and critique on the dismissal of the morphogenic model given by Arentes (2020a), to understand how the machine knitters using AYAB view the process of making in collaboration or in control of the machine. This aspect of collaboration or control is brought further to light through the idea of inspiration, as I discuss multiple cases in which the machine brought inspiration in creating through different means. The chapter concludes to understand the kinds of relationships built with the machine, and how the process of learning and making builds these relationships further.

With this general understanding of craft, making, and embodied skill, in the third chapter I introduce the concept of 'technological craft.' This chapter aims to understand the multiplicity of a craft like machine knitting, and all of the ways in which it can be considered to be technological. This chapter relies on an understanding of technology as material and embodied, and thus first explores work by cyberfeminist and xenofeminist thinkers. First turning my attention to crafting *with* machines, I explore how interlocutors often negotiated themselves between notions of 'handmade', 'machine made', and 'industrial', in a time of automated algorithmic creation and factory-industrial creation. Furthermore, I look at the ways in which the body becomes a part of the machine through working with it in craft. I then turn to look at how the machine itself is crafted, through processes of tinkering, coding, and modification (including 3D printing). Such practices are caught up in discourses of hacking, restoration, and maintenance, and require direct correspondence with the machine. The chapter concludes to discuss the implications of considering the technology on the anthropology of craft.

In the fourth chapter, attention is brought to the ways that the correspondence of crafter and technology, through the process of making, can impact identity formation and ways of viewing the world. The chapter builds heavily on the work of feminist philosophers such as Karen Barad and Rosi Braidotti. Looking at this relational view of understanding being-in-the-world, I unpick binary identities that I often heard in the field: between man and woman, engineer or not, and developer and user. I show how interaction with technology through craft and other means causes these identities to come about, and similarly how interaction within the community and the identity one holds causes change with how technologies are used. I trouble the binaries with fluidity, showing that the way they were spoken about were often unclear and not supposing such neat either-ors in the first place.

Finally, this thesis concludes by looking at how this thesis reflects on the study of craft, the study of technology, and the discipline of anthropology as a whole. Advocating further for the consideration of craft and technology as one, I explore how a relational frame of understanding – in craft and in anthropology – can help us to grasp and research these topics in a way which follows calls for the true co-creation of knowledge in anthropology.

2 PROCESS OF LEARNING

When Quinn and I arrived at their apartment, their knitting machine was already set up. As we opened the door their two small kittens - guaranteed to cause havoc with the knitting machine - rushed up to greet us. Their knitting machine was already on the desk, tangled strips of knitting ('failure noodles', as they called them) lying around. I had come to watch them knit, and maybe help with any issues they were having with the machine. "I hate these things so much," Quinn had told me before whilst we were getting coffee, "if knitting machines were less cool or more frustrating, it wouldn't even be worth it!"

Immediately upon them beginning to knit, raking the carriage with force over the bed, the tension mast became tangled in the yarn - something that had never happened to me. We looked at each other... how can we fix this? At this point, I was still very much a novice machine knitter. We re-threaded up the machine together, instruction manual by our side. I then got a look at the fabric they had been making - it looked more woven than knit, with the stitches so tightly looped that their signature V shape couldn't even be seen. The problem was clearly with the tension: the resistance from the carriage, the tangle in the tension mast, and the appearance of the fabric. The only question now was how to fix it?

My own experiences with setting the tension were very trial-and-error, and so this went much the same way. No matter how much I tried, I could never remember if the higher numbers on the dials meant more tension (for thinner yarn) or were for thicker yarn (and less tension). Consulting the manual again, we compared the yarn size to the diagram inside and reset the tension. The fabric looked much better and the mast had stopped tangling, but the carriage was still very heavy.

We were perplexed... was this just the way it was meant to be? I took over from Quinn and pulled the carriage: it felt nothing like using my knitting machine, at least. "Let's look under the carriage?" I suggested, and lifted it off. Attached to the carriage is a 'sinker plate' consisting of multiple round discs which help the carriage move across the bed. Although they were supposed to spin freely, Quinn's were completely stuck. Suddenly, I remembered a similar incident I had, where some yarn had gotten caught around the discs. I pinched underneath and, sure enough, green yarn came out. Pulling and pulling, yarn had been winding itself underneath for quite a significant period of time. "How did all of that end up under there?" Quinn exclaimed. Once the discs were freed, knitting on the machine felt right again.

If there is one thing that all of the interlocutors for this project agree on, it would be that there is a steep learning curve in machine knitting. This learning curve refers to many things: the sheer amount that there is to learn about knitting machines; how different machine knitting is from any other skill; and, most importantly, the inevitability of making mistakes along the way. Even after years of making with a knitting machine, many report that they are "still learning". Despite this steep curve, how can machine knitting become familiar? What is the process of learning like? Using ethnographic and autoethnographic accounts of embodied skill acquisition, this section recounts the process of learning and making mistakes with the knitting machine.

2.1 EMBODIED SKILL ACQUISITION

The mind and the body are not separate in learning to machine knit: instead, they act together. Such an approach can be understood through the idea of embodied learning. Learning, in this view, is "a situated activity that is animated by dynamic interaction between actors and between actors and the objects, tools, stimuli, and other resources to hand in particular settings" (Marchand 2018, 5). Learning does not only consist of the individual, who ingests knowledge from outside sources in an individual manner; instead, learning is a connected activity where the learner internalises knowledge and skill from a wider context of people, objects, and epistemologies of knowledge. As Marchand (2018) elaborates, practice in a skill of this manner never happens in the same way – action is always adjusted to the shifting context.

Such a study can be seen in O'Connor's (2007) influential study of glassblowing. Coming to glassblowing with no experience, O'Connor is able to trace the process of embodied learning through her own body, coming to understand how the body relates the current skill being learnt to past memories (or the person's habitus) (2007, 190). As someone moves from a novice to proficient, O'Connor argues, the skills that are involved become embodied. In this process of embodiment, the awareness that the maker has moves and "the novice, who, accustomed to serving the instrument, finds the instrument through techniques actually becoming a part of her" (2007, 188). These movements, far from only concerning certain areas of the body or mind, are "sense-full", which inherently serve to form a whole (2007, 190).

When the novice arrives to learn the new skill, O'Connor argues, that they do not arrive empty-handed, instead:

> (...) she arrives at her first day with already equipped dispositions and schema for handling the forthcoming situations, experiences that must bear on her very first moments of glassblowing to greater or lesser degrees (2007, 191).

In this case, ordinary every-day actions, or movements and techniques learnt from different skills, come together to form a new larger whole. This whole is fortified through practice and focus, as a new embodied skill. O'Connor places the mark of embodiment at a disposition she names 'corporeal sight':

> It is only corporeal *anticipation* that can directly bring forth the envisioned object of the practice. The anticipation that marks proficient practical knowledge is not a reflective forward-*looking* gesture. It is a non-reflective forward-*going* movement beyond adaptation: this is the imperative of proficient practice. My body did not have this corporeal sight. (...) My body was blind (2007, 201, emphasis in the original).

Here, O'Connor places real focus on moving away from active reflection and thought whilst making, arguing that instead it is the body which sees what you are doing. Although one may cognitively believe that they are doing something correctly, a lack of corporeal sight can result in a different outcome than expected. In a craft such as glassblowing, where temporal pressure causes reliance on the body's sight and understanding for split-second decision making, an

argument for the centering of such a skill is logical. However, for a craft with less temporal pressure such as machine knitting, does the same importance of corporeal sight apply?

Machine knitting cannot be learnt all alone: a pure process of trial-and-error, with no outside guidance, will likely get you nowhere. As can be seen in Quinn's case, without a little help from the outside, it's difficult to know where exactly you're going wrong - something feeling unfamiliar is not yet a marker of something being askew. Many of the interlocutors for this project used multiple avenues for learning simultaneously. For example, they would combine classes with tutorial blog posts, or the official Brother manual with YouTube tutorials. However, something that all of these methods share is the dominance of sight. Similar to O'Connor's (2007) discussion, it is the practice and repetition of movements that leads to the embodiment of skill. These movements are initially inferred by watching others' movements (in a class or on YouTube), or by written descriptions (in a manual or on a blog post). Movements are first 'marked out', as they are copied precisely and tentatively. Over time, confidence with the movement is gained and speed may increase. As Quinn told me, "you just need to put in the hours."

One example of this comes from Dan, a beginner machine knitter whom I met in the Bay Area. At his home, I've come to watch him work with the machine. Whilst he was working on finishing a gift, a vital tool for his preferred cast-on – the latch-hook tool – had gone missing. Unable to do the cast-on he was most comfortable with, Dan searched on YouTube for a tutorial to do an 'e-wrap'. Initially following the movements in the video directly, the visual instruction ended up providing more use as a prompt and he completed the cast-on using his corporeal memory.

Later in the process, when it came time to cast off, Dan once again pulled up a video. This time, the state of his knitting didn't align with the video: the yarn was on the wrong side. Looking at it for a moment, he contemplated whether he would follow the video or work from the side he was already on. "She's starting on the other side, but I don't know if that matters," he said, "I'll just do the same thing." Knitting an extra row, he then went to cast off, moving one stitch over the other in a move that is notoriously tricky for beginners. "I don't know how she can do it so fast," he said referring to the video, "I feel like if I go faster I'm going to make a mistake." In this situation, Dan very much occupies the situation of the novice. Although weary, he relies heavily on outside sources to assist in the process of embodying the skills. Other skills in dexterity, such as soldering (something Dan, as a vintage electronics enthusiast, is very familiar with) assist in the use of tools - although they appear in the body in a new focus.

Over time with machine knitting, a corporeal sight is certainly developed. Without this corporeal sight, fear and paranoia can easily grow whilst knitting or using the machine. Dan felt this too: when machine knitting, you need to hang weights on the fabric being created to keep the tension of the stitches right. When you need to move these weights, and where you need to put them, is something that you need to learn through trial and error – the feelings that you're looking out for are not easily communicated. When we were knitting, I asked Dan why he was moving the weights. "It's paranoia..." he replied, "I'm fear driven!" In this case, fear served him as he tried not to make mistakes that he made before. However, as some of my interlocutors mentioned, fear is also harboured when one is not familiar enough with their machine. Carson remarked that she

saw many people who were scared of their machines – scared of breaking them, scared of doing something wrong. Such a fear can be overcome by learning how the machine works, how robust it is, and how to fix it if something goes wrong. Such knowledge can create confidence in using the machine that can make learning and experimenting easier.

A developed corporeal sight is seen clearly with Adreienne, who is renowned in the Bay Area for her large amount of knitting machine knowledge. She described machine knitting as mostly second nature - "it's a thing I know how to do," she said. In her knitting, she demonstrated a strong corporeal sight, anticipating issues far before I, as a novice, would. Tangles and knots in the yarn, for example, were untangled before they could ever be an issue. Over her decades of machine knitting, her experience helps to demonstrate the applicability of embodied knowledge to the case of machine knitting.

2.2 VISION, READING AND EMBODIMENT

When discussing embodiment, great emphasis is put upon the non-visual senses: touch, sound, smell, and taste. These senses are specifically highlighted in these situations due to the rebellion of embodiment literature against the sense that has been superiorly used and described: sight. However, as Grasseni (2004) argues, the sense of sight can form a vital core to embodied skill. As she writes:

> Skilled vision implies an active search for information from the environment, and is only obtained through apprenticeship and an education of attention. The insight that derives from sharing a practice is not the result of holistic adhesion but of attentive and analytical apprenticeship. (2004, 53).

As she explores through her fieldwork with bovine breeders, vision (and learning what is worth paying attention to) is also something that is learnt through practice and person-to-person skill transfer. She points out here that the insight is not developed through 'holistic adhesion,' identifying how skilled vision, much like skills learnt through other senses, happens over time and requires a large amount of attention.

Further discussion of vision in the development of embodied skill can also be seen in O'Connor's (2007) glassblowing exploration. Contrasting with Grasseni, through her experiences she argues that relying on sight to 'read' the skill is the mark of a novice maker.

> When the interpretive effort of 'reading' the practice, understanding how the parts fit into the whole, remains salient to that practice, as essentially a semantic understanding of meaning it forms an immense barrier to the *lived* experience of the craft as meaningful. (2007, 190, emphasis in the original).

Here, she argues that an over-reliance on sight in practicing a skill removes a maker from their bodily practice and can provide a block for the maker in further developing their skill in a 'lived' and 'meaningful' way. Such a view against reading and sight in crafting stands in contrast to what I heard from my interlocutors. Such was the case with Nicole, who is a lecturer, wood turner, and textile maker. Speaking about knitting, she told me that someone should *always* be

reading the stitches that they are knitting into. "I know what I'm looking for," she told me, "and I know what it means when I find it." When reading a stitch, there are many things that you can be reading: including whether the stitch was knit or purl, its colour, whether it was twisted, or its space in relation to a wider pattern. Such a view of reading knitting relies on knit stitches being 'meaningfully encoded', or having the ability to hold information.

Such information provides a base for the view of knitting as a site for the production of knowledge. As Arentes (2020a) writes in her broad examination of knitting as a craft:

> As a technique used to transform threads into surfaces and eventually into wearables, knitting is a site of the production of knowledge. When body, mind, and matter join, then sensory, numeric, proportional, and aesthetic knowledge are in the making (2020a, 194).

In her view, the processes of knitting encapsulate not only prerequisite information (for example, bodily measurements), but they also form an arena for the production of knowledge. This knowledge especially relates to the creation and remembrance of aesthetic and folk knowledge, for example through the patterns that are knit into the fabric.

In reading knitted textile it is not only sight that is employed. To the contrary, touch emerges as a main sensory channel through which knit information is communicated. This is something that I initially noticed in my conversations with others – when we would show each other textile, we would immediately hold it out for the other to touch it. There is a certain understanding of the behaviour and property of textiles which can only be understood through touch, which constitutes an important part of reading textiles. An example of this is understanding the best way to care for the garment. If, through touch, you can understand the fibre composition and construction of a garment, then you can take the best suited actions in cleaning and caring for it. Understanding through touch and sight in this manner is not rudimentary; it is a skill developed alongside learning to knit and spending time with the fabrics that you create.

2.3 FRUSTRATION AND TROUBLESHOOTING

Among the interlocutors for this project, frustration presented itself as an almost ubiquitous emotion in the process of learning machine knitting. In machine knitting's high learning curve, mistakes are constantly made: 'tension loops' form on the side of the knitting, for example, or stitches fall off, unravelling multiple rows of knitting in an instance (Figure 2).

Such frustration can be discouraging for new knitters, but it is often persevered through asking for help from more experienced knitters and building the (embodied) skill through practice over time. As a beginner, therefore, making mistakes can be tolerable. As Carson - an experienced machine knitter with a popular machine knitting focused YouTube channel - highlighted, once you are no longer early in the learning process, making mistakes becomes considerably *more* frustrating. Whereas before making mistakes was a part of the embodiment process, as one learns how the machine works and how they can make alongside it, later mistakes become purely human error.

Figure 2: Knitting a sock on my knitting machine. Some stitches from the heel have inexplicably fallen off the needles. Photo taken by author.

Many of my interlocutors would often say how knitting with the machine felt like magic, especially in the machine's complex working and fast creation of textile. However, such 'magic' can often make it very difficult for beginners to understand what is happening when something goes wrong. Oftentimes, such as in the example of the sock (Figure 2), I would just rip the knitting off and hope that it wouldn't happen again - usually, though, it would. In order to learn from the experience, the problem needs to be diagnosed.

In his introduction to the volume *Craftwork as Problem Solving*, Marchand (2016) addresses the importance of making mistakes to the development and learning of craft skill. As he writes:

> Learning does not usually arise when making mistakes, but rather (...), the making of mistakes offers critical starting points for learning and improving. Learning arises in spotting a mistake has been made, identifying and understanding it as a problem for which a strategy can be devised or a tactic executed to remove, resolve or work around it, and, hopefully, to move on with the knowledge that the experience has afforded (2016, 11).

Throughout the chapter, he argues that mistakes create a fertile ground from where learning can take place. The process of diagnosis is not where the work stops for the learner: upon learning what went wrong, the maker must embark on a process of learning how to overcome their problem and eventually build up the related corporeal sight (O'Connor 2004). Marchand

describes the process as a "self-generated dialogue" (2016, 18), where the maker works on and tests solutions to their problems. Oftentimes I found this process to also be collaborative.

Such diagnosis, or troubleshooting, is collaborative in two ways: between the maker and the machine, and with a wider community of machine knitters. An example of troubleshooting can be seen in the introduction to this thesis, where I consulted the #help channel of the Machine Knitting Discord server to understand why my knitting machine wasn't knitting. Through a series of photos, videos, and messages with multiple more-experienced machine knitters, a problem was identified and a solution was found.

Trouble is not only found in using the machine, but also in setting up and beginning to use AYAB. Wishing to understand this idea of troubleshooting more, I spoke with Jonathan, who provides a lot of help to beginners in using the AYAB project. In the troubleshooting process, Jonathan often goes back and forth with the person who needs help, asking them to perform diagnostic tests to help gain a better collective understanding of what the problem may be. One example of this happened in conversation with Maelle, who was having issues in getting their AYAB-modified machine to pattern correctly. In this situation, Jonathan talked them through operating and reading a multimeter, to determine whether there was electricity coming to the machine. Upon discovering that there wasn't, he then asked some questions about whether the electronics worked in the machine before installing AYAB, and the background of modification and maintenance with the machine.

With these questions, and the multimeter, the problem was identified: a resoldered capacitor wasn't connecting with the copper. Once resoldered again, everything was working. When Maelle asked Jonathan how they can thank him, he responded, "I'm just happy when a machine works." Speaking with Jonathan, he told me how much he enjoys the process of helping people. He described it as a process of problem solving that felt almost like a game. Although it can sometimes be frustrating, as it can be difficult for beginners to communicate technical knowledge that they do not yet know much about, it provides an extra layer to the challenge that makes helping people in this way fun.

In the process of making mistakes, blame is often negotiated and assigned between the maker and the machine. Revisiting my initial vignette once again, the way in which I negotiate blame can be seen. Initially, when my machine wasn't knitting in the way that I desired, I hoped that there was an issue with the machine: that it was broken, or there was something with the machine that I needed to fix. In fact, I needed to 'take the blame', as *I* misidentified the quality of the sponge bar. Learning to take on blame in situations with technology was something that my interlocutors also identified. As Zoey mentioned, working with the knitting machine has taught her a lot about collaboration, making mistakes, and beginning again after you fail. Although there is perhaps a tendency to want to assign complete blame to oneself or their machine, in reality the causes of mistakes are complex and multifaceted – they can only be understood more fully through the building of embodied skill over time.

2.4 CONCLUSION

Learning is an essential part to learning a new skill, and it is often something that happens over a long period of time. This section has shown that learning the skill of machine knitting fits within the wider discourse of embodied knowledge in anthropological skill acquisition literature, with a specific focus placed on touch and sight. With the informational nature of textile taken into account, knit textiles can be 'read' during and after their making - with such a reflex for touch being common among knitters when presenting textile to each other. The key moments in which machine knitting is learnt is when it is most frustrating: when mistakes are made. However, I find that such a phenomenon also aligns with other work on the learning of craft skills. In moments of mistakes is where the most collaboration in machine knitting can be seen, as struggling knitters seek the guidance of the more advanced. In the constant collaboration between knitter and machine, blame is negotiated when things go awry – however, the blame hardly ever falls to just one party.

As the skill of machine knitting - and the knitting machine itself - are embodied through this process, a gap opens up in the binary between 'traditional craft' and 'modern technology'. Such a gap provides a space for fluidity in consideration, and for play between commonly held understandings and stereotypes. Such fluidity often happens in practices of collaboration and correspondence, further practiced through the idea of making. The subsequent chapter highlights making, aiming to gain an understanding of the flows and dialogue of creativity.

3. MAKING

My machine knitting was coming along. By 'coming along', I mean that I could regularly create a serviceable *swatch*, or small piece of trial fabric, with the yarns that I had. I was limited in my making choices by the fact that the electronics in my machine simply did not work (one day, in turning my machine on for the first time and leaving the room, I discovered that the capacitors had exploded by returning to the distinct smell of burnt popcorn). This presented me with a choice: do I keep on swatching and practicing my skills, or do I try to put it to use and make a garment? Much as I would in the case of hand knitting, I decided to attempt to make a garment: a sock, constructed from a pattern generator that my interlocutor had made. What follows are some excerpts from my field notes.

20.01.2025, Leiden, 11:59
My writing was disrupted yesterday. Tiktok was banned briefly, but came back. Today is Trump's inauguration. I leave for San Francisco on Sunday. There's a lot going on. Yesterday, I made it my mission to knit something on the machine to practice my skills. I looked on Carson's pattern generator website and found my pattern for a single bed sock. It took some time to get the hang of it, it took 4 attempts to get to the end of the pattern. I kept doing stupid things, like pushing the needles back after they're in hold before putting the stitch back in the hook, or dropping stitches after something was caught in the gate pegs. But I noticed my skills getting significantly better! I can move stitches with the transfer tool a lot easier, including hanging stitches. I only have two claw weights, but I find it pretty simple to know when/where I need them, but usually not until it's too late. When I move them, I do notice myself thinking a lot about videos I've seen of people machine knitting. It's imitation. When I cast the sock off and seamed it up, I was left with what looked like a sock, but it didn't really feel like a sock. I've knit quite a few socks by hand, but that didn't really feel like it... It fit, but I saw a dropped stitch after. I may try to make another today (a sock is no use without a pair!), or I may make a hat for my partner.

22.01.2025, Leiden, 12:39
Yesterday I was trying to write about the experiences of knitting I had on the 20th. I decided that I was going to knit socks until I knit the perfect one. So I sat down at the machine and just started. It was going really well. I found the stitches you are actually meant to pick up when hanging a hem, which made it a lot simpler. I was thinking about how Sarah did it with such ease after marking the row before, and it all made a lot more sense. I kept going, the heel was perfect, the foot was perfect, the toe was going great and then BAM! Half of my stitches fall off the needle. I don't even know why. It was so frustrating. I just sat there looking at it for a while. Every time I tried after that, including yesterday, things just kept going wrong. Let's hope today is better.

The next day was, in fact, better, and I made a pair for my sock without any dropped stitches. In the end, I also did make the hat before leaving for San Francisco that weekend.

In a craft like machine knitting, where the learning curve is recognised as so steep and ongoing, one very often starts trying to make creatively before they feel like they have learnt everything. As I have previously demonstrated, such making is tied to embodied skill created through tutorial,

collaboration, and making mistakes. However, the ways in which my interlocutors viewed this embodied skill as relating to a process of making was also far from simple. This section explores two different dichotomies of making: one emic (being a 'project' or a 'process' knitter) and one etic (hylomorphic or morphogenic models of form creation). Furthermore, I will explore some of the technological sources of inspiration from my interlocutors, such as the boundaries of punched cards or the expressing of research data.

3.1 PROJECT AND PROCESS

Pedro and Tanya are a husband-and-wife duo who both enjoy machine knitting: but for quite different reasons. Tanya has been a hand knitter for a long time, but began machine knitting after being introduced to it by Pedro's mother. It was Pedro, who has a history of electronics and open source work, who found AYAB. Soon, machine knitting became one of the many hobbies that they have together; joining a long list of craft projects that they do to creatively solve problems around their house. Despite sharing these crafts, they approach them from very different angles: Tanya describes herself as a "project" person, whereas Pedro describes himself as a "process" person.

Such a distinction arose quite commonly throughout my discussions with machine knitters, as they placed themselves between being centred around the 'project' or the 'process' in crafting. If someone is 'project' focussed, it often means that they make with the goal of creating something specific, for example a spoon or a pullover. The value and excitement of craft, as it was described to me, comes from having these finished objects - from having the finished surface from the material. However, someone who is 'process' centered would likely be more interested in the skills and time spent making something, than the finished object itself.

A distinction between a project or a process oriented person lies less in *what* they choose to make, and more in *why* they would choose to make it. For example, say that someone wanted to make a sweater with cables (the twisted rows of knitting that you can see in a lot of Scandinavian-inspired knitting). A project oriented knitter would describe that they would learn to knit cables in order to make the sweater, as the sweater is the central focus point of the making. However, a process oriented knitter may make the sweater in order to learn how to do cables, as learning and discovering new points in the process of making is considered the most important part. For both makers, the process and the result is very similar: they have learnt to knit cables, and they have a sweater at the end of the process.

Therefore, it seems that whether someone deems themselves to be a 'process' or 'project' knitter (or maker in any regards) comes from what they draw the most enjoyment and motivation from in deciding what to make. Being either kind of maker is also not something essential and unchanging: many people described their position on being process or project oriented shifting – especially in relation to their knitting machine. As Carson noted with me, her hand knitting is process oriented, whereas her machine knitting is more project focused. This does not mean she doesn't enjoy machine knitting - she has a YouTube channel dedicated to the craft.

Although I met many machine knitters who considered themselves to be process oriented, I met many more who would deem themselves project oriented. A large reported reason for this was

temporal. Compared with hand knitting, machine knitting is considerably faster, and so the time put into the making of a garment is a lot less. With hand knitting, a very different kind of patience is required; patience is key to handling mistakes and frustrations in machine knitting, whereas the repetitive action of hand knitting is where patience comes into play. There is a lot more time to enjoy the process with hand knitting, whereas a project-focussed knitter may become frustrated at the lack of results. Tanya came to machine knitting with skepticism, saying how she viewed the craft as 'cheating' from her background as a hand knitter. However, as a project-oriented knitter, she quickly used it as a different way to knit – and now she mostly makes garments with her machine.

Process-oriented machine knitting does not only manifest in the learning of new skills, but also in developing a different kind of relationship with the machine. As in Pedro's case, his process was often focussed on hacking the machine, and developing a deep understanding as to how it works. Although this machine-knitting-process is different to the act of knitting itself, the core of enjoyment in working with the machine stays the same.

3.2 HYLOMORPHIC AND MORPHOGENIC MODELS OF FORM CREATION

This view of project and process making is further nuanced by Ingold's (2010) models of hylomorphic and morphogenic making, which he explores to understand the "textility of making" (2010, 91). To highlight the importance of exploring these aspects, he emphasises reading crafts *forward*, from the beginning to the end, instead of starting with the finished project and reading backwards from there (2010, 91). He first lays out the hylomorphic model, which he argues against by laying out a morphogenic model of form creation.

In his hylomorphic model, Ingold argues that it is common to see the act of craft as exerting internal images and ideas of forms upon materials, "thus rendered passive and inert" (2010, 92). He argues that, instead, one should "follow the materials" (2010, 94). In doing so, he hopes to highlight that one is not acting *against* materials, nor is material acting *against* us: instead, materials are "*possessed by the action* (...) they are swept up in the generative currents of the world" (2010, 95, emphasis in the original). The act of creation is not something that comes only from the head of the maker, but instead comes from attunement with and heightened attention to the creative powers imminent in the world itself (Ingold 2014). Therefore, making in the morphogenic model involves a moving-forward and a correspondence between the maker, the material, and the flows of living: it is impossible, in Ingold's view, to perfectly enact any pre-planned vision upon the world at all.

In this light, the role of making between the maker, their knitting machines and their materials (yarn) can be seen as a collaboration, where you are working together. Such can be seen in my conversation with Cristina, a Berlin-based textile artist. She told me that there was an interesting process - a correspondence, between her hand, her head, and the machine. Through the embodied knowledge that she's acquired through learning with her machine, by paying attention (with her hand and her head) she can hear feedback from her machine: "If you're focussed," she said, "you can see, feel, and predict [something] before it happens." She described really having to be present with the machine - "if you are not paying attention, something will inevitably go

wrong." However, when you are focussed, the correspondence between you and the machine becomes clearer, and the collaborative nature of the making comes to light.

The correspondence does not only happen between the maker and their machine, but also with the other crafting materials. In machine knitting, this is especially so in the case of yarn. The biggest issue when it comes to yarn in machine knitting is that it is non-standardised: the spinning of yarn is a craft in its own right, and yarn can come with different plies, weights, and fibre contents that can drastically change its behaviour with the machine. Returning to Grasseni's (2004) notion of skilled vision, understanding and predicting the behaviour of yarn before you begin to knit - and understanding how to set up the machine in accordance - was considered to be one of the most important and difficult skills to develop by my interlocutors. As can be seen in the vignette at the beginning of this chapter, Quinn and my experiences with setting the tension shows the extent to which it is initially a guessing game. However, through experience, the maker can first begin to make 'educated guesses' about the correct tension for the yarn and its behaviour when knitted. Eventually, instinct presides and the settings and corresponding behaviour can be intuited.

In my meeting with Cristina, she decided to experiment with using a new yarn: a blue mohair, which is significantly more difficult to knit with due to its primary property of being incredibly fluffy. "This yarn is tricky" she told me, as she threaded the machine and set the tension low. She would be trying to weave with the mohair – a technique that is much more common with machine knitting than by hand. As she began knitting, she moved slowly, guiding the mohair with her hands to ensure it didn't snag. She was testing this to see how the machine reacted to the mohair, and to experiment with the textures of the created patterned textile. "There is something interesting to it... I think" she said as she cast it off and steamed it, allowing the stitches to settle.

In this instance, the collaborative nature of machine knitting can be seen. She reacts not only to the machine, but also to the yarn, allowing extra caution where she feels necessary. When making this small test of fabric (a swatch), she did not know what to expect on the other side: however, as the surface came into being, with the maker only playing part of the whole, the co-creative effects that the machine and the yarn had on the process more fully come into understanding. This is why many machine knitters consider swatching to be a vitally important part of the process: without testing and 'blocking' the fabric (such as when Cristina steamed her swatch), the true nature of the textile cannot be understood.

Despite this collaborative nature, not everyone sees their work with their knitting machine as such. Instead of the machine-as-collaborator, for some the process of learning and embodiment can result in the view of their knitting machine as a tool. As the maker understands more about the machine, it can be viewed that the maker can exert more agency and authority over the machine as they can better predict its movements and what was initially unexpected. In doing so, the maker can more effectively bring their ideas into reality.

This idea came about in my conversations with Matei. Despite having been machine knitting for over three years, he doesn't yet feel like he can be creative when he does so. Consequently, he

hasn't yet *made* any garment with the machine. As he told me, "you really start making when you're only held back by your ideas, not by your abilities." Trying to be creative before he is finished learning, he says, will only cause frustration as his expectations won't align with reality. Therefore, when Matei sets up to knit in his kitchen once a week, he focuses mostly on developing a new skill or technique – trying to understand the precise movement of the carriage and operations of the machine.

Such a view of creativity differs greatly from Ingold's argument for the morphogenic model of making. In Ingold's language, Matei's view of making is hylomorphic, as he wishes to bring his ideas into the world. However, his approach does rely on the embodied knowledge of morphogenic making, where he aims to understand everything that the machine does to predict and react to its movements. Although Ingold's argument for the morphogenic model of making is representative in many cases of making, it is a reduction to say that this is the case for *all* craftspeople and that it is only non-makers who view making in the hylomorphic way. Regardless of the 'true' nature of material interaction in making, conversations and observations with my interlocutors show that some do consider their ideal process of making to be hylomorphic.

Furthermore, as Arentes (2020a) shows, all knitters must consider a form of what they make before they start. Critiquing Ingold's morphogenic model, she shows how knitting is an example of a craft where "it is crucial to guide [its] execution based on expectations with reference to form and appearance" (2020a, 195). As something is being knit, it is continually and intentionally taking its final shape. This is, in large part, due to what she terms "numerically bound form creation" (2020a, 196). She continues:

> The numeric basis of knitting means that form is a continuous practice. The numeric is not only a concept or an abstract basis of form. It originates in the tool-grounded movement. Knitted things are manifestations of number relations that go beyond them, constituting a textile translation of bodily measurements. The counting and calculating - the concrete handling of numbers - should therefore be understood as the materialization of numeric thought. (2020a, 196).

As the shape of knitted garments cannot change in the process of making them - and in fact, as they shift somewhat uncontrollably in their shape after they are made - meticulous planning needs to be taken into account in all knitting to ensure that the garment being made (for example) fits the intended body, or that the project communicates as it is expected to. Even machine knitters who considered themselves in collaboration with their machine planned and accounted for form ahead of time, through the process of swatching. Although Ingold's morphogenic model of form creation accurately describes some of the process of collaboration between knitter, machine, and material, the nature of knitting as 'numerically bound' certainly makes a lack of forward-thinking difficult.

3.3 INSPIRATION AND THE MACHINE

Through making and learning with the machine, through being together, a relationship with the machine is formed. Some of my interlocutors described their machine as "always around," as it

was always in their eyesight whenever they were in their workspace or home. Some even gave their machines names. For my interlocutors who have collected many knitting machines, they would often describe the machine that they first learnt with to be their favourite. For some of my interlocutors, the machine and technology would also provide a source for inspiration and creativity.

This was especially the case for Cristina, who described punch card knitting machines as a source of inspiration. She described how creativity, for her, arose out of the constraints that they felt using the punch card, as it has the 24-stitch repeat. This is a sort of constraint that does not exist with AYAB or other hacks – sometimes, the feeling of being able to do anything means that you are not able to do anything at all. Another aspect of limitation with the machine that inspired Cristina was working with difficult yarn. As I previously discussed, Cristina enjoys experimenting with more 'difficult' yarns for the machine to handle. As working with these yarns requires slower movement, she told me, she feels more liberated to work with each stitch individually instead of working purely on the scale of the row.

Danny told me something similar: you need to design with the machine in mind. He was a hand knitter before he was a machine knitter, and going into machine knitting he expected that he could make things in the same way that he did before. However, as he soon discovered, these ways of making are actually very different. You need to design to the machine's strengths and limitations, he told me, which you learn as you go though making mistakes. Some design features just have to be practical.

Figure 3: One of Moira's Fair Isle colour experiments, using AYAB and her knitting machine. Photo taken by Moira.

Such limitations are not inspiring to everyone, however. Such was the case with Moira, who enjoys knitting intricate, traditional Fair Isle patterns (figure 3). She told me how, at this time, she was spending a lot of time working with colours, trying to find which ones *knit up* best together. She found the limits

of punch cards - in their ability for colour selection - to be especially frustrating. AYAB, and the freedom it provides, proved to be the perfect addition to her knitting machine, which she further modified by setting up eight tension masts (in comparison to the standard two or four) to handle the colours. For Moira, the machine gives her the ability to create these colourful, traditional textiles which she finds more beautiful and artistic than the Fair Isle patterns you can find for sale. As she told me, "if it's made with artistry, it will never look mass produced."

3.4 CONCLUSION

This section took two binaries often seen in making, one emic and one etic, to show how a view of correspondence and dialogue between person and materials in making can create fluidity and impermanence between them. Although the binaries do appear neat, in reality makers move around within them depending on the craft that they are doing. The ways in which the machine, the yarn, and the crafter interact are further highlighted through the idea of gaining inspiration *from* working with the machine, which was something highlighted by multiple of my interlocutors. Through looking at the processes of learning and making with the machine, many binary ideas held about craft are broken down, and their true fluid nature is seen. However, what if we move from taking distinct binaries between 'traditional' and 'modern' in the binary between 'technology' and 'craft', and begin to see technology and craft as a distinct category?

4. TECHNOLOGICAL CRAFT

As I previously discussed, anthropology has seen recent underrepresentation of craft studies within the discipline. However, it also appears that within the current work on craft, much of it tends to focus on ideas of heritage and tradition. Work especially seems to centre how people are transmitting and practicing traditional craft knowledge today, and how these crafts make up parts of national culture. When I began researching with AYAB, I quickly began to notice how emic notions of craft and making clashed with what was being presented in much current literature: machine knitting is a craft that has only come about relatively recently. Additionally, the making practices of those within the AYAB community do not only include machine knitting: the craft is tangled up in a myriad of other practices, such as 3D printing, mechanical tinkering, circuitry, and coding. This stands also in addition to the technological aspects of using a knitting machine in the first place. This section thus aims to explore what can make a craft technological, and the implications of viewing them as such.

4.1 CRAFTING WITH MACHINES

4.1.1 Hand crafts

A common thing that I heard from machine knitters is that hand knitters often view using a machine in the creation of knit fabric as 'cheating'. It was often quite embarrassing to share with my interlocutors that I used to hold the same view. I remember first stumbling across the idea of machine knitting on YouTube. At first, the idea didn't interest me: what initially drew me to knitting was doing something with my hands, something traditional that people before me did. I wouldn't watch the videos – working with machines didn't interest me.

It was only when I started actually watching the videos, and learning more about machine knitting, that I learnt something that many other converts (from hand to machine knitting) also came to realise: that machine knitting and hand knitting are *completely* different crafts. Although they both result in knit fabric, many of the skills and techniques learnt are entirely different. As can be seen through this thesis so far, and as I saw when I began learning about machine knitting, it has far more to do with the body than 'machine' (a word often caught up in ideas of automation) may imply.

Oftentimes, I found my interlocutors negotiating their crafts between ideas of 'handmade', 'machine made', 'industrial' and 'automated'. In my conversation with Moira, we spoke about the creation of a traditional hand knit textile (Fair Isle) with a knitting machine. "Machine knitted kind of counts as hand knit," she told me. For her, whether a knit garment was handmade had more to do with the finishing than the creation of the textile itself – distinguishing it from industrially produced garments. If something is still seamed and constructed by hand, then it will always be distinguishable from mass-produced work. Furthermore, her work in choosing colours gives her machine knit garments an 'artistry' that she doesn't see in industrially made garments of the same style. In this case, Moira places her work intentionally away from the industrial and the automated, focussing on what is still done manually: construction and colour choices.

However, for some other of my interlocutors, automation also featured as an important part of their crafting process. When Brother was still manufacturing knitting machines, they also sold two accessories which had the ability to move to a carriage by itself: a garter carriage (which has a motor inside), and a motorised drive (which moved the pre-existing carriage). For many, the use of the body and the hands in using the knitting machine cemented it as a craft. But, for others who regularly used these accessories, craft can take on a new meaning.

Victoria, who owns a space called the Electronic Textile Institute Berlin, also has a motor drive for the knitting machine that she principally uses. These accessories both make the knitting machine more accessible for those who can't usually knit or operate a knitting machine in other ways – a mission that is of high importance for Victoria. Many people come to machine knitting because they can no longer do the craft that is important to them (hand knitting). Providing more options for accessibility means that anyone can create knit textile if they desire to. Furthermore, Sam - who helps to develop the AYAB project - has collected multiple garter carriages. The garter carriage "walks around on the bed", they said, "it has a behaviour." Such accessories cannot be left on their own to knit, I was told. Instead, they must be 'babysat' to catch mistakes and issues that may grow larger if left on their own.[8] Human intervention and expertise is thus still necessary in these instances of automation, correspondence and communication still lay at the heart of making here.

Danny also pointed out this negotiation between handmade, machine made, and industrial making. "With the things I make," he says, "I don't even know what handmade means." His craft practice extends outside of knitting, incorporating many of the more technological crafts that will be further explored in this chapter. This sentiment doesn't stop him from feeling like what he is making is hand crafted, but he recognises that others may not hold the same view. Although what he principally makes is handmade, he feels like they are too precious to sell: if he ever wanted to sell a project, he would have it industrially produced. "Right now, I feel like the line for handmade falls between machine made and industrially made," he told me, "but if I industrially produced things in the future, I might change my mind." Much of this seems to relate to what Danny told me previously, about the importance of designing with the machine in mind. Even if he has sent his designs to be industrially produced: craft labour and expertise, formed through the processes of trial, error, and correspondence, are key to creating a successful project that turns out the way you intend it to.

However, the use of automation has its limits. This is most evident with the use of large language models (LLMs), as well as image generating AIs. In conversation with Emeline at a makerspace in San Francisco, she showed me some of the knitting she'd done based on images created by DALL-E 3. It was an interesting experiment, she said, which she had done when models with image generation capacity had just become available to the public. With the current ethical dilemmas about the replacement of artists with LLMs, though, she said she would be more hesitant to do it again. There is still current negotiation happening, finding where LLMs and AI models fit into creative practices - nothing yet is set in stone. As new technologies are developed and older technologies are restored, the meaning of 'handmade', 'machine made' and

[8] A good example of this comes from Carson's YouTube channel: https://www.youtube.com/watch?v=ACaUhFKMuKQ&t=723s

'automated' or 'industrial' change – a process of negotiation must occur as crafters decide whether something crosses the lines between these labels, depending on what they are comfortable with. For my interlocutors, however, it is clear that human intervention and expertise are still required for craft making but this still happens in the case of machines.

4.1.2 Embodying the machine

As can be clearly seen, a large part of the reason why working with knitting machines can still be considered a craft is the process of building embodied skill and expertise that is necessary to do it. In some ways, when enacting this process, the body becomes a *part* of the machine. Many of the movements performed when machine knitting feel mechanical in nature: they need to be done repetitively and precisely. This was explained to me by Nicole. Knitting machines, she told me, are "functionally a computer" when used with the body in this way. Your hands, when doing these precise and repetitive movements, are moving algorithmically. The carriage, as you press all of the necessary buttons and move it over the bed, is performing an operation; guiding the needles through a maze of metal and flaps to achieve the intended output (Figure 4)

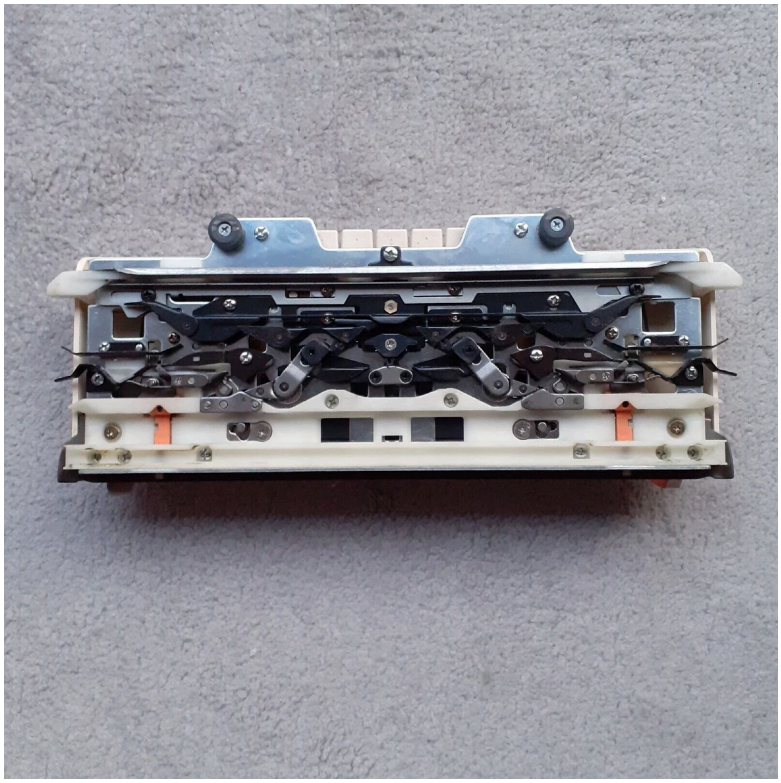


Figure 4: Underside of a knitting machine carriage, photo taken by knitmachineparts.co.uk

Following Haraway (2017[1985]) it can be said that machine knitting is almost like a cyborg craft, blurring the boundaries between human and machine. In her Cyborg Manifesto, Haraway blurs boundaries between human, animal, and machine to follow a line of thinking which highlights the unique states of feminism in the 1980s. Her thinking, however, was inspiring to many in considering entangled relationships with technology, where the line between machine and

human is blurred. This is a blur which comes from observation of modern technologies at the time:

> Late twentieth-century machines have made thoroughly ambiguous the difference between natural and artificial, mind and body, self-developing and externally designed, and many other distinctions that used to apply to organisms and machines. Our machines are disturbingly lively, and we ourselves frighteningly inert. (2017[1985], 309).

As humans began to become more mechanic, and machines gained more liveliness, the distinctions that we held between them in social reality must be readressed. Such a redress helps us also to consider questions of 'woman' and 'female', and the exclusionary box-creating that such a project aims to create. Haraway concludes:

> The machine is not an it to be animated, worshipped, and dominated. The machine is us, our processes, an aspect of our embodiment. We can be responsible for machines; they do not dominate or threaten us. We are responsible for boundaries; we are they. Up till now (once upon a time), female embodiment seemed to be given, organic, necessary; and female embodiment seemed to mean skill in mothering and its metaphoric extensions. Only by being out of place could we take intense pleasure in machines, and then with excuses that this was organic activity after all, appropriate to females. Cyborgs might consider more seriously the partial, fluid, sometimes aspect of sex and sexual embodiment. Gender might not be global identity after all, even if it has profound historical breadth and depth. (2017[1985], 328).

The notion of embodiment as explored with crafting with machines in this thesis thus goes further, reflecting on our interactions with machines. Recognition of the cyborg-nature of this craft allows it to be broken from gender stereotypes which deem hand kitting as a "metaphoric extension" of female embodiment (through reproduction and domesticity), and to be recognised as a unique form of craft (and identity) embodiment in its own right.

4.2 CRAFTING THE MACHINE

As I have mentioned previously, AYAB is not only about machine knitting. Instead, working with knitting machines with AYAB also incorporates mechanical tinkering, circuitry, soldering, and coding. Many of my interlocutors did not come to AYAB as knitters, but instead as life-long tinkerers who have now become hardware and software engineers. Through my conversations and interactions in fieldwork, the ways in which coding and tinkering can be considered as crafts came to light. Such an idea relies heavily on the idea of the digital as material brought forward by cyberfeminist thinkers, as will also be discussed in this section.

4.2.1 Tinkering as craft

Tinkering, broadly defined, refers to working and playing with machinery and electronics. It infers processes of breaking things, putting them back together, and fixing or improving things

over time. Such activity is heavily related with both ideas of hacking and craft. As Beltrán (2022) writes:

> Hacking can include some aspects of repurposing technology for means other than for what it was intended; playful tinkering (which usually involves computation); technical competency; or remixing old and new media infrastructures with grassroots organizing. Across its various expressions, hacking can be seen as a site where craft and craftiness converge (Coleman 2017a, 161). (Beltrán 2022, 2)

Coleman's ideas of hacking as craft will be further explored in the following section. The practices of tinkering and remixing take both considerable technical skill and creativity. Many of the interlocutors for this project described themselves as tinkerers, or at least as tinkering when working with their machines. Such an identification with tinkering often starts in childhood, with breaking things and eventually learning how to put them back together again. As I repeatedly heard from my interlocutors, through tinkering over time you can gain confidence that you could fix anything eventually – and so you can take anything apart. Tinkering thus forms the backbone of a certain kind of creative problem solving which is complementary to the problem solving required for learning machine knitting (or other embodied craft skills).

> Engineers and other craftspeople, such as repairpersons, also deploy similar problem-solving skills rooted in tinkering: they must engage with the limits, possibilities, and constraints of various material objects, and fiddle around to find a nonobvious solution. (Coleman 2013, 100-101)

The skilled material engagement and problem-solving techniques of tinkering makes characterising it as a craft obvious. As AYAB is an electronics modification project which works with vintage machines, tinkering is a necessary part of the process. However, for many it is also a highly enjoyable part of the process and becomes the point of working with knitting machines at all: such can be seen in Pedro's case presented above. Even people who started with machine knitting can also come to take most of their enjoyment in machine knitting from tinkering. As Adrienne (a long time machine knitter) told me, she spends more time tinkering and swatching now than knitting full garments. Tinkering with the machine and tinkering with the fabric become somewhere analogous, where experimenting and play are prioritised throughout the whole hacked machine knitting process.

4.2.2 Code as craft

The concept of technological craft moves beyond knitting and machinery, and into the realm of code. In order to understand this, it is useful to compare code to written language. Code can be used for the communication of instructions, between the user and the computer. However, much like language can be shaped into poetry, code can also be shaped into something elegant. As I explained in the conceptual underpinnings, this thesis aims to understand technology as something that is both materially situated and capable of carrying subjective situational social meaning. Furthermore, the view of coding taken in this thesis relies on cyberfeminist understandings of our relationship with technology.

Cyberfeminism, and the xenofeminist movement that grew out of it, aims to bring consideration of the body – especially the feminised body – back to computing. Arguing against the common narrative of 'jacking in' to the computer, where the user completely loses themselves in the computer and loses touch with their body and the outside world, early purporters of cyberfeminism gave the body power over the computer once again.[9] Australian art collective VNS Matrix' *A Cyberfeminist Manifesto for the 21st Century* is an apt example of this (Figure 5). In both of these ways, in technology's inherent materiality and in the corporeal physicality in using it, coding as a craft begins to emerge.

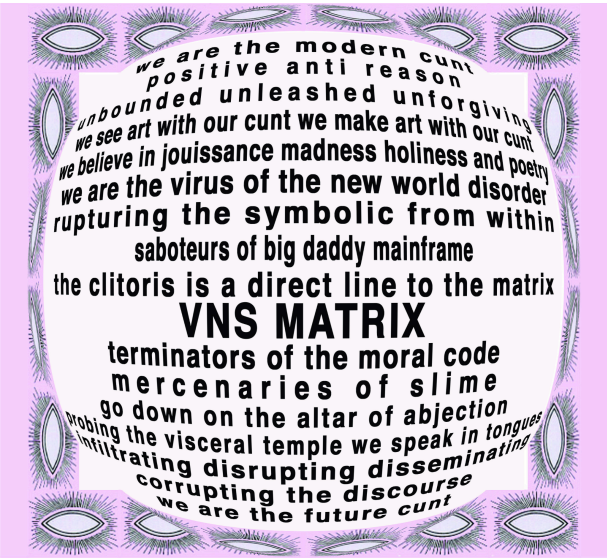


Figure 5: *A Cyberfeminist Manifesto for the 21st Century*, by VNS Matrix

Sadie Plant, another supporter of cyberfeminism, also highlights the false truth of 'virtual reality' as a separate, 'actual space', as well as its patriarchal ringings:

> This actual space is not merely another space, but a virtual reality. Nor is it as often appears in the male imaginary: as a cerebral flight from the mysteries of matter. There is no escape from the meat, the flesh, and cyberspace is nothing transcendent. These are simply the disguises which pander to man's projections of his own rear-view illusions; reproductions of the same desires which have guided his dream of technological authority and now become the collective nightmare of a soulless integration. Entering the matrix is no assertion of masculinity, but a loss of humanity; to jack into cyberspace is not to penetrate, but to be invaded. (Plant 1995, 60).

[9] The idea of 'jacking in' was originally found in William Gibson's 1984 novel *Neuromancer*, which inspired much of the later science fiction in the cyberpunk genre (such as Blade Runner and the Matrix), which in turn inspired academic work on the topic. I bought my copy of Neuromancer before my flight back to the Netherlands from San Francisco, immersing myself in it on the long flight. The book, and the cyberfeminist theory that sprouted in conversation with it, have been very guiding in writing this thesis.

In the thinking of cyberfeminists, there is no virtual world or society, waiting behind the screen. To lose yourself completely in technology is not to be above, it is not to transcend. Instead, to recognise the "materiality of data space" (Plant 1995, 59) and to reclaim the material body in the correspondence of the machine is to have power. The idea of code and material and something that could be embodied rests heavily upon these notions.

As hinted above, Coleman (2013) also puts forward an argument for code as craft. In her ethnography of hackers, she argues that hacking – and specifically the ways in which hackers write and use code – falls between craft and craftiness. As she writes:

> Hackers value cleverness, ingenuity, and wit. These attributes arise not only when joking among friends or when hackers give talks but also during the process of making technology and writing smart pieces of code.
> (Coleman 2013, 93).

Such a process is a way for hackers to demonstrate their technical abilities with code and also highlight the importance of play and humour. Giving the example of a hacker who reduced 6 lines of code into 1, elegant line, she writes "with this transformation of "prose" into terse "poetry," the developer displays a mastery of the technical aspect of the language" (2013, 94). Such moments of crafting, she argues, reflect on the hacker's own skill and identity. I argue that such a characterisation of code as craft can transcend the identity of hacker, being applicable to many people writing code for creative means.

Some of my interlocutors for this project shared similar sentiments of code playing a core part of their creative processes. Such was the case for Carson, who currently works as a software developer in Silicon Valley. She often writes codes to create knitting patterns or designs for the textile, such as a python script for a 'face scarf' which would have an image of your face to line up perfectly when you wear it.[10] As she explained to me, the art *is* the software she writes, but it's difficult for people to see and recognise that. In this process, code is not only written using the body but also becomes embodied and made of material through the process of knitting it, and the information that knit fabric can hold.

4.3 MODIFYING AND DISCOVERING THE MACHINE

As it plays a part in the creation of AYAB, code also plays a significant role in the modification and restoration of knitting machines. For some of my interlocutors, they spent much more time modifying their knitting machines than actually knitting with it. Modification thus forms a crucial backbone to many people's creative practices. This modification – which could also be called hacking in this context – comes both in the form of developing AYAB and more personal modification projects.

[10] Information about the scarf can be found in this YouTube video:
https://www.youtube.com/watch?v=kZS1wTaiG0E

4.3.1 Restoration versus improvement

After having learnt the basics of machine knitting, the obvious next step was to actually turn it on. Lots of machine knitting skill does not require electricity at all – instead, the electronic components were only needed for patterning. *Let's give it a go,* I thought, as I plugged it in, turned it on, and walked out of the room for a few minutes.

Walking back in, I was greeted by the very distinctive smell of burning popcorn. I ran to the wall outlet, yanked out the cable, and turned the machine off. The small LED display was still working fine, but the smell really panicked me. *What on earth happened?* I opened the window to attempt to diffuse the smell, which would stay around for the next three or four days. I was convinced, if I hadn't caught it earlier, that I would've burned my house down.

Later that day, I joined the AYAB development meeting. When they asked how my machine knitting was going, I shared my story from earlier. "It's nothing to be afraid of," they said, "it just sounds like your capacitors have popped." I was told to get in contact with Victoria, the person who sells the AYAB shield kits, and ask her to send me some replacements. I may not have to replace them, Jonathan said, but then Adrienne replied: "You kind of want to replace them... put it back the way it was supposed to be."

The modification of knitting machines can have two overarching aims: either to restore the machine and make it functional in a modern context, or improve the machine and give it functionalities it didn't have before. It is widely recognised that Brother knitting machines are very reliable — attested to by the fact that many of them are still operational today. Even the least reliable part, the electronics, still work in many machines. An exception here can be made for the KH-910, which was the first electronic knitting machine that Brother made (and the one that I own). Unlike their later electronic machines which featured a plug for a floppy disk reader, the KH-910 has a mylar sheet reader to load patterns into the machine. This is one of the only parts of the machine that hasn't stood the test of time. Many people, who believe that the machine is useless without this, sell theirs for very cheap. Even machines with a floppy disk reader port become somewhat redundant, as the proprietary floppy disk reader is difficult to come by.

These problems are solved by AYAB, as the project enables patterning to be sent from the computer to control the machine, row by row. AYAB thus forms an important part of keeping these machines usable and alive, which many of my interlocutors cited as an important reason as to why they do what they do. The work being done on AYAB does not only mean that knitting machines can continue to be used today, but the fact that the project is open-source means that AYAB can keep being adapted and built upon much into the future. As Jonathan told me, the difficulty with continuing to develop AYAB is not that the vintage technology is changing – it will always stay the same. The hard part comes with how the other technologies (laptops and microcontrollers, for example) are constantly changing. Thus, keeping knitting machines 'restored' means constant work to keep them compatible with our modern-day technologies.

Restoration also happens on other fronts, including cleaning, repairing, and replacing things that were originally there – such as in the case of the capacitor from the beginning of this section. Many of these restorative actions could be considered as tinkering, as machines are taken apart, fixed, and put back together. However, restorative modification is also performed through the 3D printing of old, widely unavailable accessories.

Figure 6: A 3D printed, modified cover for an electronic knitting machine. The cover allows for space for more tools and the AYAB hack. Printed by Victoria, photo taken by author at ETIB.

3D printing is a common craft among the machine knitters that I spoke to in researching this project. Many of my interlocutors had 3D printers, or had access to one through a makerspace. 3D printing is an interesting way of creating, as the surface is brought to fruition from lines of filament, directed by a digital 3D model.[11] When posed with the question, many of my interlocutors had long lists of modifications that they would like to make for their machine – the majority of which would be 3D printed. These ranged from old accessories which are currently very expensive (such as an electronic colour changer, which allows for the easy management of more than two colours whilst knitting) to completely new ideas, such as covers with extra space for tools (Figure 6).

Modified covers for the machine are a very common modification, especially for machines which have been hacked with AYAB. This is because the Arduino and shield version of the hack, which is typically more common and accessible, does not fit snugly within the existing casing of the

[11] There was contention between my interlocutors, as to whether knitting with AYAB was comparable to printing. Some argued that it was, as both involve the transfer of digitally created images into material space. Others would argue that it wasn't: one (knitting) is far more involved and intricate than 3D printing.

knitting machine. AYAB is typically an entirely reversible hack, meaning that the old electronics (and therefore the old casing) can be reinstalled on the machine without any damage. This is a benefit for some people, but others do not place so much value in the hack being reversible. This seems to be the case with Mark, who installs AYAB in old machines that he finds and sells them on as a retirement hobby. To make the hack fit within the original casing, he uses a dremel tool to hollow out the insides. In this arrangement, the old electronics will never be able to be used with the machine again. To solve the same issue, others have designed 3D printed cases for the electronics, with a larger area so that it can fit inside. These cases are not officially designed by the AYAB developers, but are also openly available on 3D model sites such as Thingiverse.

4.3.2 Discovering the machine

In order to modify the machine - especially in regards to the actual functioning of the machine - a lot of work needs to be done in understanding how the machine actually works. This sounded simpler to me than it actually was in practice. "I do like to think I know how they work... a bit..." Matei says to me, having been working on the AYAB project for the last three years. According to him, it is trivial to get to the stage where you can send a pattern to the machine, but beyond that it gets significantly more complicated.

Much of what is going on inside the machine can be figured from the service manual for each machine, which was designed to help fix the machine should it become broken. A lot of knowledge that we have about how knitting machines work come from these manuals. However, there is also a lot happening inside of knitting machines which is not included in the manuals, and that we just cannot know for sure. These small aspects are "lost in the minutiae," as Mattei described. "It's amazing how anybody designed these in the first place," he said, "they're so brilliant and weird."

One thing that remains unknown is how the original firmware of the knitting machines worked: this can cause a number of issues. For a while, Carson told me, the understanding that the AYAB community had of how belt shift worked in the KH-910 was only slightly wrong. As they were working under this assumption for quite some time, it was the cause of some bugs in what they had developed. The fact that it was wrong was found just through trial and error, of hours of letting the garter carriage (a motorised knitting carriage) walk back and forth, back and forth. Then, by matching and comparing the patterns created in the textiles, the community were able to come to a clearer understanding of how the belt shift actually works. According to Carson, this process of hypothesis testing is very similar to how she usually views software development. However, she said, software engineers often do not want to admit that they don't know something in its entirety. This can cause problems of its own, as something can work for a reason that you do not expect.

One current project in discovering how knitting machines work is with the KH-970, which works in a significantly different way to the other Brother electronic knitting machines. As the KH-970 has less electronic boards, removing the main board means that there is nothing to plug AYAB into. As Jonathan described to me, the console, or 'brain', sits outside of the machine, with a separate display. Adapting AYAB to be able to hack the KH-970 was going to be a challenge, as

they needed to reverse engineer the communications from the console to the machine: especially as finding a KH-970 with all of the necessary parts was rare.

With two of the active people in the AYAB community having complete KH-970 machines, Matei - with his electronics knowledge - met with both machines to record the way that patterning information was sent between the console and the machine. These recordings are called 'traces'. Matei then sent the traces to Jonathan, who replayed them with his incomplete KH-970. "Everything mostly made sense," he told me. "There were a few places where I don't know what it's saying... and a few places where I have to send a message, but I don't know what it means." These communications then helped Jonathan and Matei to write some new firmware[12] for the AYAB shield, which 'translates' the typical AYAB patterning information into a 'language' that the machine accepts. With these discoveries, the development for AYAB compatibility with the KH-970 is well underway.

These two stories of discovery and development demonstrate the extent to which modifying and tinkering with the machine is not a process of autonomy and control - much the same as making. Instead, in modification and hacking, a process of communication and correspondence with the machine is key. Such practices of correspondence have implications over the relationship that people build with their machine, with the process of getting-to-know building familiarity and fondness over time. The next section will explore this further, bringing together technology and craft and understanding its implications in the craft discourse as a whole.

4.4 THE IMPLICATIONS OF TECHNOLOGICAL CRAFT

As demonstrated throughout this chapter, technological crafts share many characteristics with the processes of crafting and making with machine knitting more generally. This is especially true of the importance of embodied skill and knowledge in doing each craft, and also the correspondence-based nature of the interaction between the person, the machine, and the craft. Such a correspondence impacts the ways that people create, and what they choose to do. In the case of the AYAB community, these more technological crafts are not removed and separate from the creation of knit textiles: instead, it all happens together under the umbrella of machine knitting.

The concept of technological craft diverts from the narrative of 'traditional' and 'heritage' crafts which need preservation, aiming to highlight the ways in which people are making things today. In other words, the concept may help us to focus less on what people *used* to do every day, and instead what people *are* doing today. The concept of technological craft does not aim to take away from the importance of understanding how people relate to ancestral crafts, and the ideas of culture around it. Instead, the concept hopes to be useful in understanding the changing dynamics in craft and creation at the edge of technological development. Understanding technology as something that may not only be crafted *with*, but instead as something craftable in and of itself, may provide a useful starting point in analysing how communities interacting with craft and technology view this intersection.

[12] Firmware is a program which is embedded directly into hardware devices, which executes low-level functions.

Furthermore, understanding technology as something that is easily intertwined with craft, instead of something inherently different, can help us to more comprehensively understand the material impacts that technology can have. Such blurring of the boundaries between 'craft' and 'technology' is therefore beneficial in a number of ways, especially in the consideration of how technology can be experienced in an embodied way.

Through these first three chapters, the ways in which people and technology come together in a correspondence to create has been explored and understood. The connections between textile and technology have provided a fertile ground to understand how crafters relate with both simultaneously, instead of taking them each in turn. The last chapter highlights correspondence and relational identity formation in how crafters view technology, and simultaneously how working with technology in a community of others can also impact how one views the self. Binaries are truly seen as fluid as relational, cyclical processes of identity formation occur. The chapter unpacks multiple binaries that people often placed themselves between, with the intention of understanding the ephemeral nature of our social selves in relation to the technologies and materials around us.

5. KNITTED BINARIES

5.1 BINARY CONSTRUCTIONS

In Sadie Plant's initial explorations into cyberfeminism, she notably uses the concept of the 'binary' as a starting point for discussing the state of the patriarchy in a technological late-20th century period. Drawing a connection with binary code, she equivocates women as representing 0 and men as representing 1:

> It takes two to make a binary, but all these pairs are two of a kind, and the kind is always kind of one. 1 and 0 make another 1. Man and female add up to man. There is no female equivalent. No universal woman at his side. The male is one, one is everything, and the female has "*nothing* you can see." (Plant 1997, 35, emphasis in the original).

Women, she argues, are devalued in their subservience to men, similarly to computers and machines. In making this comparison, Plant aims to highlight how women can reclaim control over patriarchal expectations, by also reclaiming power over technology. Plant's ideas have been criticised for pushing a sort of gender essentialism, as in this metaphor she sticks closely to binary, sex-based ideas of gender which are widely argued against in feminist and queer spaces (Wajcman 2004, 73). This push for more non-binary ideas of gender and technology resulted in xenofeminism, which will be further explored in the subsequent section.

Throughout this research, I often found that my interlocutors would place themselves in binary identities: in binary gender stereotypes, as engineers/developers or knitters, or as open source advocates or not. Some binaries, such as process or product makers, have already been explored. This section aims to show how such binary identities are never as simple as 'either/or', as 1 or 0; there is always something more complicated, and identity is never simple and static.

Furthermore, this section follows the idea of correspondence developed throughout the thesis in exploring the relational process of identity formation alongside matter and technology. In doing so, I follow feminist scholars Karen Barad and Rosi Braidotti. Coming from a background in physics, Barad posits that phenomena come into being through their 'intra-action' - they are always related: "Matter and meaning are not separate elements. They are inextricably fused together, and no event, no matter how energetic, can tear them asunder" (Barad 2007, 3). In other words, our material world and the meanings that it creates always happens in a correspondence – they are always, no matter what, dependent on each other. Furthermore, Braidotti draws on the idea of posthumanism in understanding how being in relation with technology can radically change one's idea of what the self can mean (Braidotti 2013). In conversation with these ideas, this chapter aims to understand how the act of correspondence - specifically in (technological) craft – impacts identities that crafters take on.

5.2 STEREOTYPES OF GENDER BINARIES

As mentioned previously, the existence of a gender binary - and the roles typically associated with each half of it - once formed the backbone to cyberfeminist theory. However, as many people

hope to move away from such rigid binary performances of gender identity, a theory of technological feminism which accommodated this was developed. This line of thought is xenofeminism. Conceived in 2015 with the publication of *The Xenofeminist Manifesto*[13] by collective Laboria Cuboniks, xenofeminism spins around three axes: "technomaterialism, anti-naturalism, and gender abolitionism" (Hester 2018, 3). Through these lenses, xenofeminism moves beyond binary explorations of gender through positing that there is nothing essential and precious about something that is 'natural' – including in gender. The concept of technomaterialism, already explored greatly through this thesis, recognises the material powers of technology in changing social meanings (Hester 2018, 7). Thus, through this framework, technology can be seen to have liberating effects in not only freeing women from patriarchy, but freeing *everyone* from limiting gender and sex structures.

This section aims to explore how notions of stereotypical activities within binary gender are perceived by the interlocutors for this project. Although I did not ever explicitly ask about gender, the explicitly gendered nature of both knitting and hacking often led to discussions (either explicitly or implicitly) about gender in our conversations. This chapter will first explore how gender stereotypes are transgressed through working with AYAB, as more women gain experience with technology and as men begin to see themselves as knitters. Gender dynamics, however, are always complicated, as some tend to reinforce gender binaries instead of breaking them. The 'solid' binary gender stereotypes therefore become a playground for fluidity, where the impacts of interaction between crafter and technology can be seen – on both how technology changes a view of the self and how gender changes a view of identity. Finally, in this section, the xenofeminist idea of liberation through technology is then evaluated in this case, coming back to the ideas of relational identity construction as previously described.

5.2.1 Breaking gender stereotypes with machine knitting

When the topic of gender was brought up in conversation, I was often told about the diverse gender distribution present in the AYAB community. This is different to other open source projects, where women and people who present femininely are underrepresented for a multitude of reasons (Dunbar-Hester 2020; Brooke 2024). Carson said similarly: "there's a good gender balance," she told me, "which you never find in software." This is attributed to the nature of this project: unlike many others, the AYAB project combines what is often considered masculine with textile work, which is certainly considered feminine.

Those who identify as women, and who have little previous technological experience, often come to the project with the interest to expand their knitting capabilities further. Working with the project, they can learn a lot of skills they may otherwise have not, such as soldering and troubleshooting techniques. However, they are often emboldened to do so due to the safety net and accessibility provided by both the community (where some people offer pre-soldered shields, and others provide extensive help across Discord, Facebook, and Github), and that are inherent in projects AYAB builds upon, such as Arduino.

[13] https://laboriacuboniks.net/manifesto/xenofeminism-a-politics-for-alienation/

Whilst speaking with Victoria, who distributes kits and pre-soldered AYAB shields in Europe, she told me how she also had little hardware experience before beginning to sell for AYAB. Her background as a 'newbie' allowed her to advise the development team what others with little technical background may want, or what they could find too difficult. When she began pre-soldering the shields, she tapped into a whole new market with AYAB: she reckoned that three quarters of her pre-soldered customers wouldn't have bought them otherwise. Such accessibility allows people – often women, and including myself – to develop new skills and relationships with technology. These new developments in the perception of technology and the expansion of technological skills allows for feminine-presenting people to break away from a performance of woman-as-non-technical, instead allowing for a transgression into a broader, unstereotyped space for gender identification.

Hacking knitting machines does not only break open the stereotype of the feminine as non-technical, but also the masculine as non-textile. Many masculine people that I spoke to told me how they originally viewed knitting to be something that elderly ladies did. When discovering machine knitting, and the project to hack it, knitting generally became much more appealing. Although originally drawn to machine knitting because of its mechanical aspects, multiple interlocutors told me how they became interested in the specifics of knit fabrics: how to form different stitches, for example, or the creation of different patterns. When Dan told his friends about his interest in machine knitting, they were at first surprised. "When I explained everything, though, it made sense," he told me. In the combination of purportedly 'masculine' and 'feminine' activities, the performance of gender stereotypes are broken down, allowing for a more liberating view of gender expectations.

5.2.2 Reinforcing gender binaries with machine knitting

Although the combination of gender stereotypical activities and learning more about technology could feasibly help to liberate oneself from the gender binary, I didn't observe this when it came to all of the machine knitters I spoke to. In my conversation with Adrienne, she told me a rumour of how heterosexual couples often came to work on machine knitting together.

The rumour, as she told it, went as so: *From around 1960-1985, when knitting machines were still actively produced, husbands would sometimes surprise their wives who enjoyed knitting with one. Their wife would try to use it, but she just can't get the hang of it! Maybe it's too technological, maybe she's dissuaded by the noise, or possibly even the fact that it's not portable and easy to work on in small moments. Knitting machines were, and still are, a pretty large investment. To save that money from going to waste, the husband would begin machine knitting, or they would work together.*

Such a story feels exaggerated and generalised, but these dynamics are easy to imagine within the social frameworks that existed for the relationship of women with technology in the mid-late 20th century (Hicks 2017). Similar dynamics do play out today, although in a much less exaggerated way. Some of my interlocutors who are frequently involved in development and support in AYAB reported to me that, anecdotally, there are many husbands and sons who help women get started with using the AYAB hack.

Furthermore, such heterosexual partnership teams still exist within machine knitting, where instead of one person learning new skills and interests to modify their knitting machine, a set of partners combine their separate interests. Such can be seen in the example of Pedro and Tanya, which I discussed previously. Despite these partnerships possibly reinforcing existing stereotypes, they also do allow for different interactions with technology for everybody involved - which allows for different relationships with technology and the self to come about. Although Tanya is less involved in hacking her knitting machine, her stance towards technology and creation did change. This case (or ones similar) demonstrates how technology and one's interaction with it can also impact one's identity – pushing them further into the model they hold about themself or leading them to question ways in which they have identified in the past.

5.2.3 Liberation through technology and relational identity

As I referred to before, xenofeminism offers a solution to oppression under gender structures through the use of technologies. Some examples given by xenofeminists as to what a liberatory technology is include ones which allow people to reclaim "bodily autonomy and reproductive sovereignty" (Hester 2018, 4). However, from this research, it seems that technology can also help with liberation from social structures, stereotypes, and expectations in relation to gender.

As people use and hack their knitting machines, the way that they see themselves relating to gender stereotypes change. Feminine-presenting people can gain understandings of technology which they once may have felt dissuaded to interact with, and masculine-presenting people can become more open-minded as to who knitting is for and who gets to do it. Staying close to the autoethnographic portion of my research, I can see how machine knitting changed my gender-stereotypical expectations of myself; as in my own eyes I became someone capable of doing things I considered 'technological,' whereas before I feel as if I limited myself because of my gender expression.

When I was in San Francisco, my laptop broke. Doing digital ethnography is not the best time for your laptop screen to stop working, and so I quickly needed to figure out a replacement. My old laptop was a MacBook - it felt safe to me. However, now beginning to trust myself as able to understand technological knowledge, I felt like I could do better. I decided to do something that I truly wouldn't have had the confidence to do before: I ordered a laptop in which I had to place all of the components myself, and I decided to run Ubuntu (a Linux-based operating system) on it. In this case, I not only subverted and liberated myself from the gendered stereotyping I had been subjecting myself to, but also took the opportunity to liberate some of my technology from patriarchal, monopolistic technology corporations. As technology changed the way I viewed myself, the way in which I interacted with technology continued to change, highlighting the fluid, cyclical, and dialogic nature of this sort of relational self-perception. The confidence I gained through working with the AYAB project, in this way, really has felt liberating.

The next section moves from the topic of gender to discussing the relational formation of identity labels taken within the community, including 'engineer,' 'developer,' and 'knitter.' The section takes each in turn, examining how these identities come about, their interdependent nature, and the consequences of taking them on.

5.3 ENGINEERING AND KNITTING

5.3.1 Being an engineer

As I previously mentioned, there are generally two groups of people who are attracted to the AYAB project, being knitters and engineers. This is due to the project's multifaceted range of skills: with hacked machine knitting, everybody has the opportunity to learn something new. 'Engineer' is a term that many of my interlocutors described themselves with, whether they were hardware engineers, software engineers, or textile engineers. Essential to the identity of an engineer seems to be an 'engineer mindset,' which is distinct from other ways of thinking. This mindset provides unique positions on two of the aspects of machine knitting discussed in this thesis: learning and making.

Emeline teaches machine knitting at a makerspace in the Bay Area. Her classes tend to attract a mix of people with knitting experience and engineers. Engineers and knitters are interested in learning about different things, she said. Knitters tend to have more understanding of how the knit fabric is created, and therefore they come to the class to learn about how to operate the knitting machine. Engineers, though, tend to be more interested in how the machine works, as they are attracted to the class by exactly that. "It allows for a different perspective on knitting," Emeline told me.

Danny echoed this to me. For years he worked as a software engineer for a large technology company, and now he dedicates his time to making things for his own life. He learnt to machine knit from YouTube videos. He told me that he especially likes to learn from YouTube videos made by engineers: "we think in similar ways," he told me. Much of this has to do with gaining an understanding not only of *what* to do, but also consciously knowing *why* to do it. Understanding why the mechanisms move like they do and the full process of the machine allows for a process of troubleshooting which is more informed by knowing than guessing before the action can be seen by the body. Therefore, when Danny makes a mistake, he wants to know exactly why it happened before moving on. This also leads to an interest in all of the different kinds of stitches you can make in (both hand and machine) knitting – something also told to me by other engineers.

In this situation, the identity of engineer is taken on in correspondence with the knitting machine. Being an engineer is not an identity which appears in a vacuum, or purely out of a textbook education. Instead, 'engineer' is a title which is taken on in correspondence with what you engineer – depending on the mindset with which you approach it and the actions that you take. However, being an engineer does also relate to other factors, such as a job title, degree, or place within a community. All of these aspects act together to create an 'engineer': a position which is continually reinforced by the interaction with technology and others around you.

5.3.2 Developer and user

Many of the engineers that I met through this research also gave time to developing the AYAB project. For these people, their time with their knitting machine is much more divided than those who aren't spending time developing new features or testing them. A lot more time is given to modifying than knitting, which as discussed has its own roots in craft. In this assemblage of craft

and activity within the AYAB community, many of my interlocutors noticed a split between developers and users. As those with professional software experience noted, such a split is very common in this sort of development.

As Jonathan told me, this split tends to play into tensions between using and hacking the machine. Although machine knitting with AYAB is, as I have shown, a practice which incorporates many different craft skills, I have also shown that people take enjoyment from different parts of the process. Within AYAB there are many people who enjoy the hacking process, but there are also those who just want to knit. Jonathan identifies three different sub-sections of the AYAB community: the developers, who volunteer time to test and develop the AYAB hack; the users, who want to use AYAB to reliably expand their knitting abilities; and artists, who are interested in both a stable modification and pushing the technological boundaries. Therefore, this split comes from their backgrounds, their motivations, and their perspectives on interaction with technology. The relationship they have with the machine, and their experiences using them, certainly inform identity further.

Sometimes, Jonathan says, this split can cause consequences for the development. The last official AYAB release before I began my fieldwork in January 2025 was in 2019, when version 0.95 was released. Although the development team expected version 1.0 to be released in 2020, it took another 6 years for 1.0 to finally be released in March 2025. As the team kept developing the new features for 1.0, not enough testing was being done as people were not actively knitting with the new code. Fixing something would break something else – there were just way too many bugs to have a release. Recruiting a main tester, Adrienne, was a good start. From there, beta versions of 1.0 were released and the community at-large could test the new features. The release of 1.0 in early March was a feat, and it was well received by the community.

Some people are truly positioned between developer and user. Either way, regardless of the amount of time one spends with AYAB, many of the developers do use their machine knitting skills to create things outside of the remit of development and testing – even if that making is more tinkering in nature. In this process, the kind of making one engages with impacts their position within the community – however, it is more complicated than a pure binary approach. The split between 'developer' and 'user' has less to do with the amount of time one spends using the knitting machine, and more to do with the engagement one has with their machine and the types of crafts done alongside it. As with the other examples, these fluid binary identities of 'developer' and 'user' are developed in relation to the knitting machine, the AYAB project, and others in the community. The identity that you develop further informs your role in the community, which continues to impact how you spend your time with your knitting machine.

5.3.3 Free and Open Source Software

This thesis has throughout referred to the notion of 'open source', or F/OSS. As Coleman (2013) writes:

> Free and open-source software (F/OSS) refers to nonproprietary but licensed software, much of which is produced by technologists located around the globe who coordinate development through Internet-based

projects. (Coleman 2013, 1).

As Dunbar-Hester (2020) elaborates, F/OSS stands within a wider culture of "*open technology*, where makers, programmers, and hackers mingle (online and off) to circulate knowledge and cultural goods, share technical problems and solutions, and generally revel in exploring technical puzzles related to coding and craft" (Dunbar-Hester 2020, 2, emphasis in the original). AYAB is a project that is rooted within open source culture, starting as a project by members of the Chaos Computer Club and still maintaining its open source ethos throughout.

Many of the interlocutors for this project heavily valued open source technology, including both users and developers. As Danny told me, making things open source critically helps in development as you cannot do everything alone: if a project is open source, you can distribute the burden of upkeep and help across many people. However, something being open source can also place *more* pressure upon developers, who are often volunteers, to write and present code that is easy to understand and maintain. As people come together to work on open source projects, the craft of writing code becomes vitally more important.

Gaining more familiarity with open technology also changes the relationship that you have with the technology around you. Although open-source seems to be about *giving* your code and knowledge, in reality it has more to do with *owning* it. Multiple of my interlocutors told me that you only really own your technology once you can change and use it completely. As Matei told me, "computers were meant to be used!" The ability to truly use and own a computer, in this sense, requires that you have the means and will to do whatever you want on it – unlimited by technology corporations who attempt to control from the outside with, for example, subscriptions to access key features. "Lots of people take terrible actions from companies as challenges," Matei told me, to adapt, hack, and take ownership of their technology. Therefore, the relationship that one can build with an open source technology is inherently different that which could be built with a proprietary one – and the ways in which it can reflect back on you can also change.

Despite AYAB's firm open source nature, the combinatory nature of the project means that it also attracts users with less open source experience. Some of my interlocutors identified this as a small issue in making all of the users happy. As most people come to own AYAB hardware through purchasing an interface or kit, there can sometimes be a feeling that one has transferred money for a complete AYAB product instead of the hardware to perform an open source modification. With some of these people being less familiar with F/OSS culture, there can sometimes be disputes over bugs or service, and it can be difficult for the developers to explain that they are volunteers, not a paid team for a product. These discussions can cause tension between the community.

Someone's familiarity with and support of F/OSS impacts the ways in which they therefore come to use technology, as they strive to gain more ownership over their devices and share their work more openly. Furthermore, such activity can embed you more solidly within groups of open source users and developers, further strengthening your identity in this way. The example I gave

at the end of the gender section shows this: as I gained more familiarity with F/OSS, my behaviour with technology changed, which further shaped how I viewed myself and my abilities.

5.3.4 Conclusion

Building upon the space-making in binary constructions throughout this thesis, this final chapter has aimed to show how such binary identities appear for people in a process of embodied, performative correspondence. The identities that people bring on are impacted by their interactions in the world around them, and similarly the ways in which people interact is influenced by their identity. Thus, this process of identity making is always cyclical. Binary identities do exist for people within a large fluid space, where there is also room to identify outside of it and move between poles. Binaries thus act as markers, waypoints that you simultaneously find and that draw you closer through processes of interaction and correspondence. We always negotiate with binaries and social ideas, whether we hold them as true to ourselves or not. This section has thus aimed to demonstrate this process, through gaining an understanding of the ways in which the machine knitters I spoke to identified themselves.

6. CONCLUSION: BINARIES AND ANTHROPOLOGY

This thesis has presented an argument for considering craft and technology together as one, instead of two separate things which come together. United through body and relational experience, technology, craft knowledge, and crafters correspond and come together to create knit fabric, shape machinery, and shape the body in turn. However, craft and technology are often held in very different lights, and are presented in very different disciplines. This applies especially within anthropology but also notably beyond.

To approach machine knitting, and all of the ways in which I found it to contrast widely-held notions of craft, technology, tradition, modernity, gender stereotyping, and developing, I used the framework of the 'binary'. By identifying and analysing binaries presented in the field and in literature, I showed the fluid space that exists around binary labels. Binaries are never stagnant and unchanging: instead, there is negotiation and correspondence that happens in these spaces. As I have shown in this thesis, this applies to identity binaries (such as gender or 'process'/'project') and binaries shown in the literature ('traditional'/'modern', or 'hylomorphic'/'morphogenic'). People's individual understanding of such binaries, and how they apply to their lives, communities, and creation appear through processes of correspondence, made possible through the effect of embodiment in learning and making. The cyclical nature of performance-based identity means that what is taken for the self from materials through embodiment (the identity one holds, for example) simultaneously impacts the way in which one conducts themself in relation to their materials. It is in this way that binary identity can never be stable.

In this thesis, I have attempted to demonstrate the productive nature of considering craft and technology seriously together, showing the social insights that can come from fully considering their inter-related nature. Additionally, this thesis has aimed to show that considering relationality in methodology is also important and productive. I have shown how in studying global, complex, and hybrid social settings, methodologies and approaches which consider the self alongside interlocutors as co-creators of knowledge in a wide interdisciplinary space is incredibly helpful. The nature of what someone is researching ought to necessarily determine how someone studies it, and additionally how we write about it. This thesis has aimed to follow relational paths, pulling at threads from a number of differently woven tapestries, to bring together a novel understanding of machine knitting and creation alongside technology.

To conclude in this space-between-disciplines, I will show ways in which this thesis may reflect on work being done in the discussion of craft and technology. Much of this, it seems, can be brought together through the consideration of time scales and materiality/immateriality.

The study of craft is so often considering the past, and the preservation and transmission of skill. Such work focusses on heritage and tradition, looking at how people bring localised ideas of identity to the present day. Looking at craft and technology as one challenges such narratives to consider what practices we are currently doing everyday, which may be considered as traditional or worth preserving in the future? Such a consideration begs the question of how traditions are formed, and brings to attention the importance of speaking to those who are using current and developing technologies to craft, and taking their insights on crafting seriously. Furthermore, the

view of craft through technology also highlights the informational and mathematical nature of textile craft, which is often obscured by theories of crafting which highlight creative currents and making-in-flow. Such a consideration of the embedded information and mathematical structures of knit pieces in particular helps to cement knit fabric as a site for the production and storage of knowledge.

The view of craft and technology as one also reflects onto a view of technology which is often concerned with the future, and asks what about the past – and what about the body? Using the concept of craft with technology brings about ideas of maintenance, care and skill which argue against the current trend of technology which is disposable and transient within the user's life. Technology today is often discouraged from being *owned* and *used*; a view of craft can help to argue against this, a view which causes both rising amounts of e-waste and a reliance on 'big tech' corporations who rarely have user's best interests in mind. Furthermore, the view of technology as craftable also highlights important contributions from feminist scholars on technology, as the material view of technology is able to come more into light.

The final reflection that I'd like to make is not into craft or technology, but into anthropology as a whole. Anthropology and ethnographic work has so often spoken about the other, even in its attempts to be cocreative. Highlighting the autoethnographic experience and the relational nature of both the social and material creation of knowledge begs the question of whether more anthropological work should consider *relationality* more than *subjectivity*. Such a reflection moves beyond paradigms of cultural translation and separate ontologies, which try to understand Indigenous peoples and 'others' as having their 'own ontologies'. Instead, I hope that we can try to imagine an anthropology where *we are all in the world together,* where the ways in which we view things differently emerge through deep relational intra-actions with our large and shared world, where "we are not just in relationships: we *are* relationships."[14] Anthropological knowledge is also created and shared in these relationships – these relationships which form so much of ourselves. Such an approach requires, it seems, a deep understanding of the ethnographer's own position and personal experiences, which I have tried to achieve through this thesis using the method of autoethnography. Such an approach, I hope, has the ability to truly highlight our interlocutors' knowledge alongside our own: a great challenge in anthropology today.

[14] In the writing of this thesis, I had the opportunity to present some of my findings at SIEF 2025, in Aberdeen. On the second day of the conference, Indigenous Studies professor Shawn Wilson gave a keynote speech. In the presentation, Wilson delivered this quote, which resonated with me in understanding what I was trying to achieve with the methodology of this thesis. In the talk, he advocates for Indigenous knowledge beyond Indigenous land and for the objective of creating thoughtful and loving relationships with one another through which knowledge can emerge.

REFERENCES

Atkas, Bilge Merve. 2019. "Using wool's agency to design and make felted artefacts." *RUUKKU: Studies in Artistic Research* 10.

Arentes, Lydia Maria. 2020a. "Unraveling Knitting: Form Creation, Relationality, and the Temporality of Materials."*Journal of American Folklore* 133(528): 193-204. https://muse.jhu.edu/article/752757

Arentes, Lydia Maria. 2020b. "On knitted surfaces-in-the-making." In *Surfaces: Of Bodies, Materials and Earth*, edited by Mike Anusas and Cristián Simonetti. Routledge. https://doi.org/10.4324/9781315646947

Barad, Karen. 2003. "Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter." *Signs: Journal of Women in Culture and Society* 28(3): 801-831. https://doi.org/10.1086/345321

Barad, Karen. 2007. *Meeting the Universe Halfway*. Duke University Press.

Batteau, Allen W., and Mark Jazayeri. 2018. "Technology." In *The International Encyclopedia of Anthropology*, edited by Hilary Callan. John Wiley & Sons. https://doi.org/10.1002.9781118924396.wbiea1678

Beltrán, Héctor. 2022. "Hacking, Computing Expertise, and Difference." *Just Tech.* https://doi.org/10.34540/JT.3029.d.2002

Braidotti, Rosi. 2013. *The Posthuman*. Polity.

Boellstorff, Tom. 2015. *Coming of Age in Second Life: An Anthropologist Explores the Virtually Human*. Princeton University Press.

Coleman, E. Gabriella. 2013. *Coding Freedom: The Ethics and Aesthetics of Hacking*. Princeton University Press.

Denicola, Alicia Ory. 2024. "Craft." In *The International Encyclopedia of Anthropology*, edited by Hilary Callan and Simon Coleman. John Wiley & Sons. https://doi.org/10.1002/9781118924396.wbiea2431

Dunbar-Hester, Christina. 2020. *Hacking Diversity: The Politics of Inclusion in Open Technology Cultures*. Princeton University Press.

Ehn, Billy. 2011. "Doing-It-Yourself: Autoethnography of Manual Work." *Ethnologia Europaea* 41 (1): 53 - 63. http://www.mtp.hum.ku.dk/details.asp?eln=300309

Ellis, Carolyn and Arthur P. Bochner. 2000. "Autoethnography, Personal Narrative, Reflexivity: Researcher as Subject." In *Handbook of Qualitative Research (2nd Ed.),* edited by Norman K. Denzin and Yvonna S. Lincoln. Sage.

Elson, Diane, and Ruth Pearson. 1984. "The Subordination of Women and the Internationalisation of Factory Production." In *Of Marriage and the Market*, edited by Kate Young, Carol Wolkowitz, and Roslyn McCallagh. Routledge.

Grasseni, Christina. 2004. "Skilled vision. An apprenticeship in breeding aesthetics." *Social Anthropology* 12 (1): 41-55. https://doi.org/10.1017/S0964028204000035

Greiner, Clemens, and Michael Pröpper. 2016. "Hands, Skills, Materiality: Towards an Anthropology of Crafts." In *Migration - Networks - Skills: Anthropological Perspectives on Mobility and Transformation,* edited by Astrid Wonneberger, Mijal Gandelsman-Trier, and Hauke Dorsch. Transcript.

Griffiths, David, and Alex McLean. 2017. "Textility of code: a catalogue of errors." *TEXTILE* 15 (2): 198-214. https://doi.org/10.1080/14759756.2017.1298308

Hahn, Hans Peter. "Material Culture." In *The International Encyclopedia of Anthropology*, edited by Hilary Callan. John Wiley & Sons.

Haraway, Donna. 2017[1985]. "A cyborg manifesto: Science, technology, and socialist-feminism in the late twentieth century." In *Science Fiction Criticism: An Anthology of Essential Writings*, edited by Rob Lantham. Bloomsbury.

Harlizius-Klück, Ellen. 2017. "Weaving as Binary Art and the Algebra of Patterns." *TEXTILE* 15 (2): 176-197. https://doi.org/10.1080/14759756.2017.1298239

Hester, Helen. 2018. *Xenofeminism*. Polity Press.

Hicks, Mar. 2017. *Programmed Inequality: How Britain Discarded Women Technologists and Lost Its Edge in Computing.* MIT Press.

Howes, David. 2019. "Multisensory Anthropology." *Annual Review of Anthropology* 48: 17-28. https://doi.org/10.1146/annurev-anthro-102218-011324

Ingold, Tim. 2007. "Materials against materiality." *Archaeological Dialogues* 14 (1): 1-16. https://doi.org/10.1017/S1380203807002127

Ingold, Tim. 2010. "The textility of making." *Cambridge Journal of Economics* 34: 91-102. https://doi.org/10.1093/cje/bep042

Ingold, Tim. 2014. “The creativity of undergoing.” *Pragmatics & Cognition* 22 (1): 124-139. https://doi.org/10.1075/pc.22.1.07ing

Keane, Webb. 2003. “Semiotics and the social analysis of material things.” *Language & Communication* 23: 209-425. https://doi.org/10.1016/S0271-5309(03)00010-7

Marchand, Trevor H. J. 2016. “Craftwork as Problem Solving.” In *Craftwork as Problem Solving: Ethnographic Studies of Design and Making*, edited by Tevor H. J. Marchand. Routledge.

Marchand, Trevor H. J. 2018. “Embodied Learning.” In *The International Encyclopedia of Anthropology*, edited by Hilary Callan. John Wiley & Sons.

Mouraviev, Ivan. 2024. “London Dubstep Culture in an Online Discord Community: The Mediation of Bass, Space and Place.” *Dancecult: Journal of Electronic Dance Music Culture* 16 (1): 51-71. http://dx.doi.org/10.12801/1947-5403.2024.16.01.04

Nakamura, Lisa. 2014. “Indigenous Circuits: Navajo Women and the Racialization of Early Electronic Manufacture.” *American Quarterly* 66 (4): 919-941. https://doi.og/10.1353/aq.2014.0070

Niles, Susan A. 2007. “Considering Quipus: Andean Knotted String Records in Analytical Context.”*Reviews in Anthropology* 36 (1): 85-102. https://doi.org/10.1080/00938150601177629

O’Connor, Erin. 2007. “Embodied knowledge: The experience of meaning and the struggle towards proficiency in glassblowing.” *Ethnography* 6 (2): 183-204. https://doi.org/10.1177/1466138105057551

Plant, Sadie. 1995. “The Future Looms: Weaving Women and Cybernetics.” *Body & Society* 1 (3-4): 45-64.

Plant, Sadie. 1997. *Zeros + Ones: Digital Women + The New Technoculture*. Fourth Estate.

Reyes, Victoria. 2017. “Three models of transparency in ethnographic research: Naming places, naming people, and sharing data.” *Ethnography* 19 (2): 204-226. https://doi.org/0.1177/1466138117733754

Rosner, Daniella. 2018. *Critical Fabulations: Reworking the Methods and Margins of Design*. MIT Press.

Rosner, Daniella, Samatha Shorey, Brock Craft, and Helen Remick. 2018. “Making Core Memory: Design Inquiry into Gendered Legacies of Engineering and Craftwork.” *CHI ‘18: Proceedings of the CHI Conference on Human Factors in Computing Systems*: 1-13. https://doi.org/10.1145/3173574.3174105

Torell, Viveka, and Anneli Palmsköld. 2020. "Dwelling in Craft: Introduction: A Call for Studies about Craft." *Journal of American Folklore* 133 (528): 131-141.

Wahl, Robert S. 2018. "The History of Punched Cards: Using Paper to Store Information." In *The Routledge Companion to Media Technology and Obsolescence*, edited by Mark Wolf. Routledge.

Wajcman, Judy. 2004. *Technofeminism*. Polity Press.