Chapter 8
Love – The Careful Making of Technologies

As explained in the introduction to Part II, academic accounts of making mainly focus on craftwork and manual labor. In the following, I show that scholars distinguish between making as a manual and affective practice, and developing technology as an abstract and rational action, by continuously referring to crafting or DIY (do-it-yourself) projects when speaking of making. My empirical insights into the presence of the emotion of love during the making of technology show, in contrast, that engineering practices also entail strong affects. Against this backdrop, I transfer the academic insights on crafting's socio-materiality to the socio-technical collaborations of makers, technical components, digital fabrication tools, and prototypes involved in carefully turning an abstract idea into a tangible technology.

Craft, bricolage, and DIY practices are mainly analyzed by using research methods such as auto-ethnography, observation, and interviews (e.g., Bardzell et al. 2012; Davies 2018; Peppler et al. 2016; Price and Hawkins 2018). Researching the actual work done by crafters and makers, the sensory attributes – or "hand tasks that emphasize touch and feel" (Gibson 2016: 62) – come to the fore and highlight the interaction between makers and their material which is often described as a dialogue. Bardzell et al. (2012: 13), for example, describe how their research partner Jill "allows her materials to 'help' her and become collaborators in the production process" because she herself "does not have a 'preconceived idea' … of what lies ahead". In this regard, craft seems to rely on spontaneous ad-hoc decisions and imperfection (Boeva 2018: 6) whereby the material resources shape the outcome.

As this spontaneity causes the product to be unpredictable, "the quality of the result is continually at risk during the process of making" (Pye 1968/2010: 342). Thus, makers invest "judgment, dexterity and care" in their work with the material (ibid.). Due to the "[h]aptic, tactile skills embodied and embedded in workers' bodies" (Gibson 2016: 82 referring to Sennett 2008), researchers of making observe deeply affectual collaborations between the makers and their materials. The emotional appreciation of the makers' material is exemplified by one of Bardzell et al.'s (2012: 13) interviewees, a famous potter in Taiwan. This potter is so amazed by his craft resource, clay, that "he hopes that his public will also come to appreciate clay – not his work, but *clay itself* – as a beautiful material". The socio-materiality of making practices is summarized as follows:

> [M]aking something entails a different type of mediation with your surroundings, potentially a more sensorial awareness of things (Borgmann 1984), or even a sense of craftsmanship (Sennett 2009) and its values of satisfaction of doing good work, the pursuit of community, and the respect for material reality. (Nascimento 2014: 1)

Although the majority of the literature on making ignores the practices of technology development by focusing on crafting and tinkering, other scholars explicitly differentiate between making as manual and emotional, and technology development as abstract and rational. In this regard, Richard Sennett (2008: 84) argues that since the Enlightenment, "the craftsman [has become] an emblem of human individuality" and that, contrary to mechanical perfection, craftwork is positively valued due to its "variations, flaws, and irregularities". The continuous differentiation between two sets of making practices is also expressed in research agendas that include technology development. Leah Buechley and Hannah Perner-Wilson (2012: 1), for example, conducted a survey with several makers to "compare the experience of making electronics with the experiences of carving, sewing, and painting". They highlight that their interviewees who build electronic devices are emotionally involved during the making of technology, but also emphasize a difference between them and their other interviewees who paint, carve, and sew:

> It is noteworthy then that electronics makers never brought up relaxation or aesthetics in their reflections. Though these makers expressed similar sentiments of enjoyment and engagement, … no maker mentioned aesthetic aspects of their projects in their reflections. (ibid.: 6)

Beauty and aesthetics seem to be the motivation of the other crafts while "electronics builders were much more likely to mention ideas, concepts, or theories than other craftspeople" (ibid.). Therefore, Buechley and Perner-Wilson make the point that electronics makers mainly focus on the functionality of their devices and not on the aesthetics of their designs. To explain this different approach to making, they argue that abstract thinking and systematic planning "is built into the standard tools and techniques of electronics" (ibid.: 17). According to them, the tools and techniques of making electronic devices do not allow for a material conversation and open-ended outcome as in other crafts:

> The electronics maker works with a set of discrete components – like resistors, capacitors, sensors, and amplifiers – with precisely specified properties. Several of our survey respondents identified these discrete components as essential qualities of the medium and crucial materials. "We are talking about creating circuits/electronic devices from components pre-made. We do not have to worry about making these components themselves" [E1]. "The essential properties of the medium are the basic components" [E7]. (ibid.: 7)

Buechley and Perner-Wilson (ibid.: 8) conclude that "making electronics is characterized by an emphasis on abstraction and discreteness" because it focuses on abstract ideas, specified components, and the functionality of its product. Two other scholars, Sherry Turkle and Seymour Papert (1990: 136), call this affinity to abstraction a "planner's approach". In their study of students who use computers at school or during their first programming course, they describe the students as planners who prefer to work in a "rule-driven system" and solve programming problems by "dissect[ing] it into separate parts and design[ing] a set of modular solutions that will fit the parts into an intended whole" (ibid.). They differentiate the planners from the small number of people, predominantly female, who are "bricoleurs":

> For planners, a program is an instrument for premeditated control; bricoleurs have goals, but set out to realize them in the spirit of a collaborative venture with the machine. For planners, getting a program to work is like "saying one's piece"; for bricoleurs it is more like a conversation than a monologue. (ibid.)

The attributes of bricoleur programming students and makers who sew, paint, and carve emphasized by Turkle and Papert are similar to the craft qualities noted above; all the researched groups seem to be engaged in a dialogue with their material – be it code, wood, fabric, or canvas. The admiration for one's material and its beauty and aesthetics are a motivational source that implies the sensory stimuli gained from craftwork. Additionally, working in a dialogue brings an openness to the outcome of the making process. This means that making consists of spontaneous and probably imperfect acts. Unlike these artistic approaches to making, makers of electronics, often with a background in engineering, are categorized as 'abstract thinkers' and 'planners' whose main goal is the defined outcome of a functional device. The modularized components of a printed circuit board (PCB) do not seem to allow a dialogue with the material and thus, no possibility for the expression of beauty. Engineering is declared as antithetical to crafting, as abstract and functional versus creative and aesthetic, driven by rationality instead of being a highly embodied practice, and resting on the power of machinery while craft celebrates manual work.

To complicate this binary understanding of technology development and craftwork, I argue in the following that engineering practices also entail feelings such as love and admiration. I exemplify the 'dialogue' between maker and material by depicting the socio-technical relationships that care for making PCBs professionally. The affectual and intimate practices of care invested in the daily work done at Kenyan makerspaces highlight first that aesthetics has the same value as functionality when making products because prototypes are only perceived as professional when they are beautiful and functional at the same time. Second, intimate feelings of love and empowerment are present in human-machine relationships that collaboratively materialize an idea into a product for the capitalist market. Overall, the emotion of love makes us understand that beauty as well as the functionality of a prototype are signifiers of professionalism and that the work of building professional products is a precious one.

8.1 The Art of Making Technology

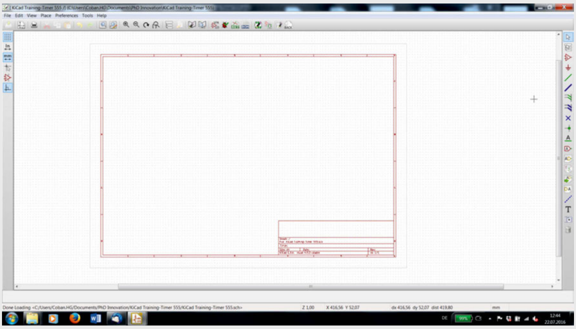
When making a printed circuit board, the achievement of a specific arrangement of the components is crucial: "Electronics are a precise media. It cannot work unless the elements are in exact order" (interviewee cited in Buechley and Perner-Wilson 2012: 7). Thus, it seems that a technology developer has to stick to the rules and standards inscribed in the specific components, tools, and machines to achieve a functional PCB. However, I disagree with the scholars cited in the previous section who sideline creativity and affects during coding and building electronics and claim that the aim of technological functionality leaves no room for aesthetics. In this vein, the vignette below illuminates how working with electronics makers in Nairobi taught me that the very ordered arrangement of PCB components can, indeed, represent beauty and aesthetic pleasure.

Getting Trained in KiCad and to See Beauty in Order

Today, I arrived early at the makerspace to participate in a training offered there for the first time. It was about printed circuit board *computer-aided design* (CAD) using the software KiCad 4.0.2. Martin, an electrical engineering student working at the makerspace, offers this training and I registered for it to try to better understand what every electronics maker does at their computer day after day. We were a group of about 10 participants trying to squeeze into the 'computer lab' that consists of four tables and six computers arranged in one corner of the makerspace. Martin gave a 16-page handout to everyone. I flipped through the pages and did not understand a word: "EDA", "555 timer IC based circuit", "schematic file", "external resistor network", "Gerber file", … I was the only person without an engineering background at the training, thus, I tried to absorb every single word Martin said.

He started with an enthusiastic introduction to KiCad: KiCad is a software for EDA (Electronic Design Automation) "which helps to bridge the gap between one's idea and the actual prototype". He emphasized that if we have "a problem in our head that we want to solve, then we have to develop a concept as a solution and KiCad helps us to materialize this exact idea". Everyone in the computer lab listened attentively to Martin's words while sitting in front of computer and laptop screens. After his introduction about the importance and advantages of EDAs in general, and KiCad as open source software in particular (Figure 6), he gave us the task of composing a "schematic file" for a "555 timer".

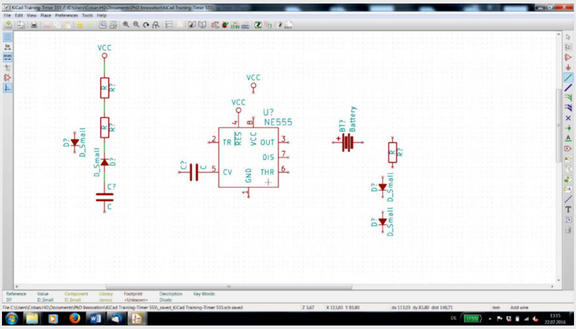
Figure 6: Screenshot of a first blank page of a schematic file in KiCad 4.0.2. (Research Diary, July 22, 2016).



Martin added, "Put the components on the page. But not in an order. And don't connect them to anything yet". I did not know where to start: GND, THR, OUT, VCC, C, D_Small? I was confused. What did the abbreviations mean? I needed a reference point and looked at the figure of the "555 timer" in our handout. I tried to find out which abbreviations stand for what in order to look them up in the component library of the software. From time to time, I asked Martin, "What will each component do? Why are these specific components important for the electric circuit? How do they relate to each other?" Without this knowledge, I could not imagine how to place the components in the best way: for example, if a certain arrangement makes more sense than others do. I started to connect my components to each other, as it felt like the only possibility for me to gain a sense of order and comprehension.

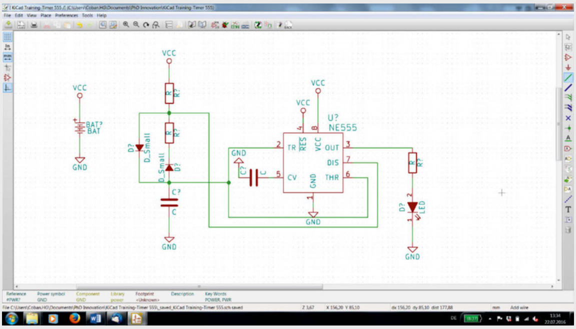
And I failed, dramatically.

Figure 7: Screenshot of my failure (Research Diary, July 22, 2016).



I only recognized my failure because, once connected to the main square in the middle of the schematic file, I could not move my components anymore (Figure 7). Martin reminded me that he told us not to connect the components: “There has to be a wire between every component, one cannot connect them right away”. He explained that the wires are called ‘traces’ and they represent very thin conducting strips made out of copper, which will connect two components on the tangible PCB substrate. I was angry with myself that I did not follow Martin’s instructions from the beginning, but instead followed my impatient impulse to connect the components in order to arrange everything ‘neatly’ according to my gut instinct. I had to delete everything and add every single component to the page again. Some time and several confusions and mistakes later, I was the proud owner of a schematic file! (Figure 8) Everyone in the group looked at their finished schematic files and Martin enthusiastically exclaimed, “Look! A PCB is artwork – it is in order and beautifully organized like an image!”

Figure 8: Screenshot of my finished schematic file of a 555 timer (Research Diary, July 22, 2016).



This extract from my research diary gives insights into the first step of assembling a printed circuit board, namely the creation of a digital file that is then used by other digitally automated machines to fabricate the tangible PCB. When I reread my diary notes after the research stay, I was astonished that during the training I had so quickly connected the components to each other although the trainer had explicitly said not to do so. I obviously wanted to order and connect everything in my schematic file, as the extent of my knowledge was that the electrical circuit would function only through the connection of the components. I longed to achieve a functional electronic device, the "555 timer".[1] In this regard, Lucy Suchman (2009: 10) claims in her work on human-machine interfaces that the specific materialities of a medium spark affective effects. This means that the software KiCad and its intrinsic aim of designing a circuit board evoked my wish for connectivity and order. I was prompted to think in an abstract way, trying to connect the modular components to "fit the parts into an intended whole" (Turkle and Papert 1990: 136).

Nevertheless, I failed to achieve the desired outcome of a schematic 555 timer at first because it was impossible for me to imagine the final PCB while

1 The '555 timer' is an integrated circuit (IC) that is able to produce applications with a time control, for example, delay timers, alarms, LED flashers. The IC got its name from its three internally connected 5 kilo-ohm resistors (Electronics Tutorials 2021: n.p.).

lacking the knowledge about the abstract configurations of this technical device.[2] Yet, the specific requirements of the components were my only anchor in a wild sea of terms and concepts that I did not understand. As such, I used the opportunity to search online for the components' specifications without really understanding the physical laws of why specific components have to be connected to each other in order to create a functional PCB. With the help of the standardized specificities, I was finally able to achieve a functional schematic 555 timer. This intricate process of building a digital PCB illustrates how my lack of technical knowledge and skills resulted in me sticking rigidly to the abstract specifications of KiCad's materiality. As such, it did not occur to me to leave the specified functionalities and prescriptions of the PCB aside.

My lack of expertise is also a reason for why I did not initially recognize the beauty of my schematic file, and Martin had to explain it to me. Contrary to the literature's assumption that functionality is more important than aesthetics for makers of electronics, Martin's enthusiasm about the schematic files as artwork clearly shows that order and the specific arrangement of PCB components are perceived as beautiful. Yet, only a few researchers claim the prevalence of embodied affects usually ascribed to craftwork in scientific technology production. Natasha Myers (2008: 169) is one, and explains that:

> scientists' movements, gestures, and affects as they work with their objects … [blur] the boundaries between automated machinic productions and the skilled work of scientists, and between the intellectual and physical labor of research.

Thus, she tears down the dichotomy between manual craftwork and abstract engineering. Drawing on her case study of the relationships between protein crystallographers and their three-dimensional protein models, Myers (ibid.) argues that "modeling practices challenge narrow conceptions of 'thinking' as a cerebral activity, and make visible the craftwork, creativity, and embodiment of scientific reasoning". Similar to my empirical observations in Nairobi which show the perception of a digital PCB model as beautiful art, Myers states that "a crystallographic protein model is an artisanal object" (ibid.: 188). In this man-

2 Sebastian Dahm (2017) who autoethnographically learned how to code describes the same kind of failure; he failed to code a pentagon because he followed his instincts without knowing the abstract specifics of coding.

ner, Jonathan Bean and Daniela Rosner (2012: 88) argue that "design is a form of craft":

> The design of a mobile phone or a building is anything but disembodied, impersonal, or generic. Design requires working with one's hands in the "soil" of computing infrastructures, just as crafters handle wood or clay. (ibid: 87f.)

Due to the affective entanglements between a crystallographer, designer, or electronics maker and their work, the resulting digital model resembles "a craft product of labor and love" (Myers 2008: 188). As an example, Myers refers to her research partner's anecdote about publishing a 'birth announcement' when a digital model is finished:

> I don't know, some other people say that they want birth announcements when the structure [is coming out] … because it is kind of like being in labor. … And often a building process will take nine months. … [Y]ou're all of a sudden, 'Oh! Look at where that conserved patch is. … [S]o it's sort of this unveiling. And then you finally give birth to your molecule. And what I've started doing is putting our structures on refrigerator magnets and so then for Christmas you can share with your family and friends. Everyone sends out their pictures of their kids and you send out pictures of your kids. (ibid.)

Returning to Nairobi's technology developers: their motivation for making electronics may not be primarily to express themselves artfully, as in pottery for example, but to build a marketable product. However, the practices of making hardware are saturated with amazement regarding models, designs, and materialized PCBs. Both aesthetics and functionality of a technical device are strived for, as an electrical engineer who developed a PCB which is able to signal the necessary renewal of chemical solutions by measuring the solutions' acidities explained (Figure 9):

> Designing the PCB is a nice part of assembling the components on the PCB. For example, all connectors for the sensors [which will be immersed into the liquid chemicals to measure their concentrations as seen in the photo] are in a row at one end of the PCB. The two tiny blue things that look like pearls are resistors. The largest component is the micro controller. That is the most important thing because as the name says, 'it controls everything'. (Research Diary, June 28, 2016)

Figure 9: Testing a PCB, 2016 (author's photo).

In this quote, and in the vignette above, the assemblage of the components on a PCB constitutes the beauty of it. The specific arrangement of sensors, resistors, and the micro controller on the tangible board, as well as the order of components in a digital PCB model engenders amazement. As such, loving affects characterize the engineering process of transforming an abstract idea into a visible and tangible prototype. Makers are proud of their products and satisfied by an outcome that is accurate and functional.

The blending of aesthetics and functionality made me interested in what exactly 'beauty' stands for in technology development. Thus, I was attentive to further feelings of pleasure and wonder as in this conversation with Martin some days after the KiCad training:

> Martin showed me the schematic file of his work. I asked him how he decides which component is connected to which component – if it is a trial and error process or a design decision or something else. He answered that all the connections that he builds are based on research; he uses Google to search for the specific datasheets of every component in order to read about their values. However, he went on to say that he knew from the beginning that he wanted to have the connections for the sensors on one side, the LCD [Liquid Crystal Display] above, and the button below. Enthusiastically, he exclaimed: "People want to see professionalism; they want aesthetics to make

their board look wonderful. Yes, they want it to be made even to that level!" (Research Diary, July 25, 2016)

This conversation highlighted that the aesthetics and functionality of a PCB cannot be seen separately because a specific arrangement of components make the board work in the intended way and additionally presents a 'wonderful look'. Martin stated that the beauty of a board signified 'professionalism'. As such, aesthetics has the same value as functionality because technology only represents professionalism if it is beautiful and functional at the same time.

Based on the depicted empirical insights, I claim that both qualities – aesthetics and functionality – are entangled and not dichotomous as claimed by those scholars who distinguish between the creative artwork of craft and the rational approaches of engineering. Technology developers in Kenyan makerspaces assemble and order technical components in a standardized way and find pleasure in building both an aesthetic *and* functional prototype – because both attributes signify a professional technology. The fact that I was not immediately able to see the connection between beauty and order indicates that the aesthetics and functionality of a technical assemblage, and thus, the professionalism of a technology is only visible to the trained eye. Kenyan makers passionately learn and apply globally standardized technical skills and knowledge in order to produce technology according to global norms. Thus, the art of making technology consists of achieving a desired professionalism that is able to compete in global technocapitalism.

8.2 Caring Human-Machine Relations

The vignette concerning the KiCad training demonstrates that the ordered assemblage of a PCB is beautiful to a knowledgeable contemplator and that precisely this aesthetics of order is a crucial element of the professionalism of a technology. In addition to these insights, the vignette also hints at another facet of loving feelings, namely the intimacy and care between makers and the tools that they work with. I show in the following that the human-machine relations in Kenyan makerspaces are built upon love and trust for machines which accurately transform an abstract idea into a tangible device and upon the machines' fast and precise work for makers who suffer from limited manual capabilities. The perceivable love signifies the preciousness of professional technologies as they enact the envisioned future of being included in techno-capitalism.

During the introduction to the KiCad training, Martin's chorus of praise about the software's benefits took up a lot of time. Therein, he expressed his gratitude towards the software that, he said, assists a maker in materializing the idea in their head. This admiration of technological support to "bridge the gap between one's idea and the actual prototype" (Research Diary, July 22, 2016) is also mentioned by Turkle and Papert (1990: 131) who seemingly joined the optimism about the rise of computers in the early 1990s:

> At the heart of the new possibilities for the appropriation of formal systems is the computational object, on the border between an abstract idea and a concrete physical object. In the simplest case, a computational object such as an icon moving on a computer screen can be defined by the most formal of rules and is thus a mathematical construct, but at the same time it is visible, almost tangible, and allows a sense of direct manipulation that only the encultured mathematician can feel in traditional formal systems. The computer has a theoretical vocation: it can make the abstract concrete; it can bring formality down-to-earth.

The computational object, in our case the software KiCad, helps to make an abstract idea and the formalities of electronics concrete through their materialization into a digital PCB model. Thus, the gratitude towards KiCad is understandable – it takes over the task of materializing one's idea by ordering and assembling PCB components; even in a beautiful way.

Suchman (2009) has also analyzed such emotional relationships between engineers and software. She claims that within the mutual relation between computer-aided design (CAD) images and their users, the CAD interface constitutes "a particular configuration, a specifically enacted site of extended, heterogeneously constituted human/nonhuman capacities for thought and action" (ibid.: 10). Further, she draws on Laura Marks, a film theorist, who writes about a "'three-dimensional intimacy' among persons, images and their materiality, and the worlds to which the images connect" (2007: 279). Where Suchman uses the three-dimensional intimacy frame to illustrate especially human interaction with CAD imaginary, I show that intimacy can also be found in every other human-machine interaction in a makerspace (see Ehn 2011: 57). This intimacy is characterized by a mutual care for making professional technologies. Relating to Maria Puig de la Bellacasa's (2011:

93) understanding of socio-material care, I argue that the human-machine care for building prototypes signifies the importance of making professional technologies (see Puig de la Bellacasa 2012: 198 and Chapter 4). Love and care are invested to realize the political endeavor of making products for the local market in order to dispense with imported technology.

In this regard, the following empirical insights show that love, as component of an intimate relationship, is not only felt towards KiCad, but also towards other tools of the PCB production line which help to make an abstract idea of a PCB visible and beautiful. The vignette focuses on the most intense feeling when a model of a PCB becomes concrete and tangible: excitement.

Entering the Darkroom of Excitement

Every single day, the engineer Joy has a new project to build and every evening, she researches the following day's project: a 3D printed belt that holds several cables together, a laser-cut glass, or a PCB that controls LEDs. She was very keen to introduce me to the work process at the makerspace and so one day she took me to the darkroom for the first time and said, "This must be very exciting for you, now". Indeed, I had never entered that room before and had wondered what was in it. As we entered the small gloomy room, I saw a scanner in front of us. This machine comes next in the PCB-line after modelling and testing the PCB file on a computer. We closed the door and Joy placed a transparent folio with her PCB model printed on it and a photovoltaic PCB substrate onto the scanner. The substrate lies on the scanning glass, on top of it the printed folio. Joy put a plastic layer on them and turned a vacuum pump on. The plastic fixes the arrangement so that nothing is able to move. We put down the lid and turned the scanning light on for one and a half minutes. I read and translated the button labels on the scanner – "*Kopie oben*"[3] and "*Kopie unten*"[4]; Joy was thrilled because she hadn't realized before that the scanner was able to do a double-sided PCB.

At the makerspace, Presensitized Copper Clad Boards are used to make PCBs. These boards have a thin photosensitive coating that reacts to UV light. Thus, "the artwork" as Martin called it, namely the digital PCB model that gets printed on a transparent paper, acts like a mask to the UV light of the scanner. This means that the scanner produces a kind of photo negative of what the traces between the components will be on the PCB. After we left the darkroom, Joy guided me to the 'SplashCenter', an etching station that consists of two containers filled with chemicals. These are the developing chemicals and

Joy told me that they are extremely corrossive, and we would get a serious skin rash if we made contact with them. I remembered the graphic description of another electrical engineer telling me that "the chemicals will eat the exposed copper away, leaving only the intended copper traces on the substrate". Joy put on plastic gloves and dunked her PCB plate into the developer chemical. I had to leave for 10 minutes to fulfill another task. When I returned, Joy had already finished. I was surprised how quickly she got a tangible PCB (Research Diary, July 13, 2016).

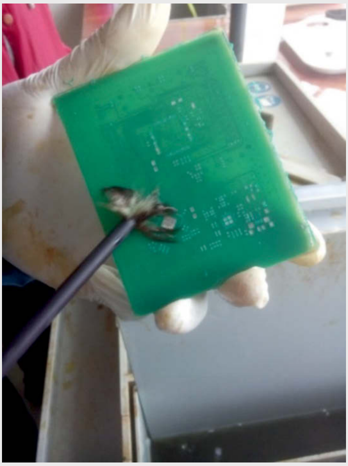
Fortunately, I was able to observe the etching process several more times, as the sound and smell of the etching station were daily companions while working at the makerspace:

> Tsch, tsch, tsch, tsch. In the corner next to the darkroom, three guys are 'painting' liquid on a plastic screen. (Research Diary, June 28, 2016)

> In the corner in front of the darkroom, two makerspace employees are wearing gas masks and doing something with big bottles of liquids. It smells sweet. (Research Diary, June 30, 2016)

> I went to a guy who was developing his PCB. He wore plastic gloves and put the board into the brown liquid for some seconds, took it out, and used a brush to remove the plastic on his circuit. It looked fascinating. The traces slowly became visible. I felt as if I was watching a magician conjuring up a PCB. (Research Diary, July 8, 2016)

Figure 10: Etching a PCB, 2016 (author's photo).



The above empirical snapshots show that making a PCB is part of the daily work of Kenyan makers and that transforming one's idea into something tangible is accompanied by feelings of excitement about how the digital model that took a long time to design will come out in reality. After designing the PCB, it took Joy only half a day until she held it in her hands, ready for the components to be mounted on it. This fast implementation of an idea into something tangible evokes love for the machines that materialize the PCBs:

> I can easily come here [to the makerspace] and within a very short span of time, I move from my manufacturing file – my PCB file – all the way to a board that I can touch, mount my components, and use. So one of the machines I really love is the [etching station called] SplashCenter which gives me the board that I want: a professional version of a printed circuit board. (Interview, makerspace member, July 2016)

3 German for 'copy above'.

4 German for 'copy below'.

As analyzed above, this quote illustrates the positive emotions felt towards professionalism, but also that the machines which support the materialization of an idea are loved and appreciated because they enable makers to make beautiful and functional prototypes. In this vein, makers often emphasize the specific characteristics and loveable benefits of a machine that assists them to work more precisely and faster than they could do manually. A common comparison is made between automated machines and the "normal way" of manufacturing a PCB:

> The CNC machine is able to drill the holes that I want. … There are other versions of drills, like there is one called the Dremel that is a hand-drill. You use your hand. Some standard bits come with [the drill], you plug them in and then you use your hand and drill. Now imagine if your board has a thousand holes, you sit down and drill a thousand holes of different sizes. It limits you. We use other forms at home, like etching your PCB with the normal, traditional way of using an electric iron to iron out your board. … For someone like me who wants to … come up with quite complex boards that can be applied to solve a lot of problems, I prefer machines that are able to do those things in the fastest way possible and to expand my scope of doing things. Not like a Dremel which limits me to a hundred holes. … The makerspace has a collection of very important tools, like that Computer Controlled Drilling, so that I just need to export my drill files from the KiCad software … and send the coordinates to the machine. And I just sit back and wait as my machine drills all the holes in the right sizes on the board. Even if there are a million holes, it will drill it for me in the shortest time possible and with a precision that you cannot achieve with a hand-drill. And my etching station is able to achieve very fine tracks, very thin tracks that I'm not able to achieve at home. So you find that these are special machines which can really assist me and empower me to come up with my prototype in the shortest time possible. (Interview, makerspace member, July 2016)

Complaints about the 'normal' "tedious and very manual" processes that "do not give professional results" (ibid.) join the praise of the accessible machines in makerspaces. These machines assist the makers through the speed and precision of their work, thus, releasing them from the usual manual constraints such as working with a hand-drill or an electric iron. The makerspace member quoted above sees the expansion of his scope of doing as empowering. In other words, mechanical tools are felt to empower the human maker, who is subject to limited capabilities, to build things quickly and precisely. Sennett (2008: 85) calls such tools "robot tools" and describes them as "ourselves enlarged" by being stronger, working faster, and never tiring. In this regard, the quote above indicates that the emotion of love results from the liberation from hard manual work and from the machines' strength, speed, and stamina. These mechanical qualities are loveable because they help the maker to keep up with the pace of the current innovation paradigm and build technical devices that are acknowledged to be professional.

In addition, the loving machine-human relationships are characterized by care and trust. The feeling of trust is expressed in the maker's statement above, that while working with the CNC machine, he is able to "sit back and wait" as the machine drills all the holes. This ability to relax while watching the machine shows the trust in the machine's capabilities. In this context, Andrew Pickering (1995: 158) explains that a tool such as a milling machine is "a prototypical device for capturing nonhuman agency [as] one can accomplish things with a lathe that naked human agency could never accomplish". Nevertheless, he concedes that these machines need human volition to be operated. Thus, he describes human-machine relations as a "dance of agency" whereby human and material agency are reciprocally 'tuned' with alternating roles of activity and passivity (ibid.: 21). The example of the maker's trustful interaction with the CNC machine illustrates Pickering's argument more clearly: the maker first worked as an "active, intentional being" who instructed the machine and then took on a "passive role, monitoring the performance of the machine" (ibid.). Therefore, the quote above demonstrates that the relationship between technology developers and a CNC machine is not only based on gratitude for the mechanical support, but also on trust in collaboratively taking care of prototypes.

8.3 Conclusion: The Socio-Technical Care for Professionalism

The loving and intimate human-machine relations at Kenyan makerspaces carefully transform an attentively and precisely designed idea into a tangible device. Although every interaction between a maker and the various machines in the PCB line is unique, they all strive to make professional products that are both beautiful and functional. This professionalism should achieve inclusion into global technocapitalism and, with that, societal progress in Kenya. Overall, the feelings of gratitude, trust, and love that characterize the agential dance between makers and machines signify that technology development is by no means a purely abstract and rational practice of making.