Making: The Careful and Calculative Manufacturing of Professional Products

"Hardware is tough", technology developers often complain (Interview, May 2016). They bemoan the fact that building hardware is "very resource hungry" compared to software development because it needs more material and machines to iteratively prototype a product idea (ibid.). In addition, there is less funding available for hardware projects than for software development. These circumstances apply to the development of hardware globally, but Kenya's positionality as a peripheral place for technology development complicates the making of hardware there even more. The lack of state support, difficult access to global commodity flows, and scarcity of investors who dare to invest in hardware made in an African country result in time- and money-consuming processes of technology development.

This second part of the book's empirical analyses shows how Kenyan makers invest care and calculative work in the making of technology in order to survive in the competitive world of technocapitalism. I analyze the bodies and affects present when makers and machines collaboratively design, make, and assemble technology and show that the feelings of empowerment, liberation, love, amazement, and fear arise out of the fact that Kenyan tech entrepreneurs deal with colonial trajectories and neoliberal responsibilization affectively and socio-materially.

With this research focus, I broaden and challenge current studies on making. First, I show that making hardware in Nairobi cannot be compared with the more commonly researched post-industrial contexts where making mainly happens as anti-capitalist practice, leisure time activity, or craftwork such as carpentry, sewing, and pottery. Instead, I argue that feelings of empowerment in contexts that have not undergone an industrialization along European and North American models are evoked by the possibility of building professional-looking and marketable technology and not by an anti-capitalist appropriation

of manual labor. As such, making in Kenya implies the development of professional technology with the help of digital fabrication tools in order to become independent of Western technology imports and finally shift Kenya's positionality in technocapitalism.

Second, I challenge those STS and making studies that draw dichotomies between engineering and making by describing one as rational and abstract and the other as emotional and creative. Instead, I show that making practices of technology development inhabit both affects and abstract calculations. Thus, emotions and rationalized work processes are interdependent, so that the making of new technology in Kenya consists of care *and* calculations to make professional technologies in a resource-constrained context. I am inspired by Kate Cairns' (2013) and Daniel G. Cockayne's (2016) approaches to understanding the affectivity of neoliberalism and I claim that only the investment of care *and* calculative practices makes it possible for Kenyan technology developers to generate technology that they consider professional. By looking at the practices of knowledge production such as the joys of creation or the struggles of everyday work, I shed light on those aspects that are missing in the stories about Nairobi's tech scene and overall in studies on science and technology (see Chapter 3; Myers 2008; Puig de la Bellacasa 2011; Waldby et al. 2006: 4f.). As such, the following chapters highlight the affective making practices that are demanded of places, bodies, and machines in resource-scarce contexts (see Chapter 1; Coban and Wenten 2021).

(Re-)Making Positionalities by Performing Professionalism

The majority of academic and popular accounts on makerspaces and making emphasize empowerment through manual labor that is inclusive and often anti-capitalist. Thus, makerspaces are described as places that foster education (Blikstein 2013; Benton et al. 2013; Halverson and Sheridan 2014; Martin 2015; Vossoughi and Bevan 2014) and the inclusion of grassroots groups in technological development (Kera 2012; Smith et al. 2013). The participation of diverse people in experimenting with scientific knowledge and technologies is seen as a democratization of science development (Kera 2012; Lindtner et al. 2014: 442; Ratto 2011). In this context, the widely praised increase in "user control over technologies" shows the appreciation of the political power of maker- and hackerspaces to raise awareness about existing developer-technology-user relations (Maxigas 2014: 11). Thus, research foci are often

set on makers who want to maintain "control over the final product, directly criticizing preexisting commercial structures" (Grimme et al. 2014: 434). In this vein, makers are often quoted as saying that making represents their self-expression instead of "an attempt to develop (let alone bring to market) a serious product" (ibid.: 439). These so-called *critical making* approaches direct attention towards empowerment through manual labor that is self-determined, at best critical of capitalism, and aimed at small-scale manufacturing rather than standardized mass production (Boeva 2018: 6; Zoran and Buechley 2013: 5).[1] All in all, making is generally depicted as a:

> semantic and ontological shift from manufacturing and craft towards … an attempt to reframe debate about 'economy' (Massey and Rustin, 2014), to capture the need to move onwards from the modern capitalist paradigm of profit-driven, high-throughput production of physical things, towards other ways to furnish humans with material comforts. (Carr and Gibson 2016: 299)

Touching upon the entrepreneurial engineering practices of makers in Nairobi, I make the point that the academic understanding of making as a practice of relearning manual labor and unlearning the consumption of mass-produced products is a legacy of research done primarily in post-industrial contexts such as Europe or the USA. Embedded in these contexts, making reconnects the dichotomy of "'mind' and 'body' in the sites and processes of production" (Carr and Gibson 2016: 300) which was fortified during industrial revolutions:

> Since machines could replicate the work of the hands, the manual dexterity and expertise required to construct objects lost value. Meanwhile, the work of the mind – the ability to envision and plan for the construction of objects, to design – was elevated. (Zoran and Buechley 2013: 6)

1 Besides critical making and DIY research, some scholars also research the commercialization and institutionalization of making practices; see, for example, the contributions in the special issue 'Makerspaces and Institutions' in the *Journal of Peer Production* (2018). In this vein, academia breaks away from the binary notion of making as *either* anti-capitalist *or* capitalist practice and turns increasingly to the variety of practices that making includes. In this manner, Sabine Hielscher (2017: 66) summarizes makerspaces as places of "diverse sets of socio-technical configuration of digital fabrication", meaning that makerspaces include various visions and practices – from leisure time activities, to political motivations, and entrepreneurial endeavors.

This "mind-body dualism indicated in the superiority of drawing over construction established forms of labor division" (Boeva 2018: 73), so that reappropriating the process of building things by hand – from design to production – is claimed to grant agency to makers (ibid.: 6).

In contrast to a context where goods have lost value and society has lost the need for craftwork and manufacturing, makerspaces in Kenya are situated in a national context which did not undergo an industrialization based on mass production. Therefore, manual making does not have to be reinvented in Kenya (Kenyatta 1938/1971: 41ff.) where *jua kali*[2] – entrepreneurs, artisans, and other workers who drive the informalized economy – have existed for decades (King 1996a: 24ff.) and constitute about 80–90% of the Kenyan hardware manufacturing sector (makerspace employee, November 6, 2015). Although the jua kali sector has been affected by global trends of formalizing economies (King 1996b), it consists mainly of manufacturing microenterprises that 'informally' employ apprentices to repair or make almost everything. Drawing on these characteristics, my research partners describe jua kali as inefficient and of a low skill level because the sector is devised to "create as many jobs as possible" (Research Diary, November 6; 25, 2015).

Makerspaces in Nairobi are established to cater for the needs of predominantly university-educated engineers who have professional ambitions of inventing a technology to earn money. Therefore, Kenyan makerspaces function as workplaces of (institutionalized) entrepreneurship where prototypes come to life and engineers are trained to persist in the capitalist market. In the following, I illustrate that makerspaces aim to enhance their makers' daily work of building hardware and to enable them to make *professional* technology to integrate Kenya in global economies and therein position it globally as a place of technology development.

Empowered by Professional Technologies

In Kenya, where the manufacturing sector is driven by the informalized sector and where high taxes do not allow beginning entrepreneurs to import components to prototype high tech, makerspaces are perceived as empowering because they offer machinery not available elsewhere and the possibility to make a 'professional' product from scratch. In this regard, a makerspace member, at

2 Kiswahili for 'hot sun'.

that time still an engineering student at one of Nairobi's universities, told me why he thought that a makerspace "is one of the best places on earth":

> In Kenya, what normally happens is that we have repairs, which is the main work offered out there. So, for an engineer, you study, you understand a lot of concepts, but the only work that you get is to maintain what others have designed. … I would like to work in places which deal with more interesting and challenging things, like coming up with solutions, again empowering others to come up with solutions, which is exactly what is being offered at [the makerspace]. (Interview, July 2016)

This makerspace member feels "empowered" by prototyping with digitalized machinery because, as an engineering student, he hopes for a job other than repairing and maintaining imported goods. His devaluation of the maintenance and repair of machinery resonates with the opinions of many other research partners:

> I don't like doing the maintenance of machines because I don't feel like I'm growing. But [the makerspace] gives me the platform to grow because we have projects that make you think, explore, and adventure in your career. … Tomorrow there is a project about a car. The next day there is a project about a pump. So, you are always constantly upgrading yourself – reading and studying. You find that only at [a makerspace]. (Interview, makerspace employee, April 2017)

Both quotes show that the emergence of makerspaces that materialize global aesthetics, discourses, and role models of technology development imply a different type of entrepreneurial activity than that present in the current manufacturing sectors: technology entrepreneurship "relies heavily on science innovations and therefore a strong technology skill and knowledge base" (de la Chaux and Okune 2017: 270). As such, makerspaces are places of advanced qualifications and knowledge production which stand in contrast to maintenance work. The appraisal of innovative high-tech work in Kenyan makerspaces and the overall devaluation of manual labor is openly expressed by makers who embrace digital fabrication tools and their "professional" output:

> Many others who make PCBs [Printed Circuit Boards] are astonished when they see a PCB made from here: 'How on earth did you make that casing?'

> or 'How on earth did you do this PCB? It looks so quality'. Then they show theirs made with an electric iron and their own chemicals. They etched it at home and they drilled it with a hand-drill. It looks so imperfect. And they see mine, I drilled it with the CNC machine, I etched it with the wonderful etching station, I tinned it, I placed a solder mask, I soldered it, I tested it, I've done everything: it looks so professional. (Interview, makerspace member, July 2016)

The overwhelmingly positive emotions towards machines that produce aesthetic and functional prototypes are discussed in Chapter 8. The point I want to make here is that the term 'professional' directs us to the engineers' aim of making products. Kenyan makerspaces and their members focus on product ideas that are scalable and suitable for mass production instead of the re-appropriation of manual labor or craftwork to act against capitalist economies.

Performing a professional image is crucial for Kenyan makerspaces. Shortly before Nairobi's first makerspace was about to open its doors in 2015, one of its managers told me that they distanced themselves from the description of being a 'makerspace' "because it tends to have a connotation that is more amateur-ish or DIY or tinkering or hacking and not professional engineers" (Interview, November 2015), referring to his carpenter friends in New York who distance themselves from being makers because this self-description would devalue their work. Talking to the same manager some months later, I asked him why the term 'makerspace' had suddenly become very prominent on the organization's website. He explained that the term was a new one in Kenya and he saw the chance to endow the concept of a 'maker' with a "positive connotation" through the space's professional approach (Research Diary, August 4, 2016).

This 'positive' connotation about the making of professional products was present in all my conversations with makerspace members. The makers were enthusiastic about making things that "qualify for the market" (Interview, makerspace member, July 2016), while also being aware that having a "wonderful idea" does not automatically mean that it can be easily introduced to the market at a later stage (Research Diary, July 28, 2016). In their opinion, only access to a makerspace leads to the transformation of an idea into "something that is able to convince people" (Interview, makerspace member, July 2016). Thus, the 'professional' work executed by a makerspace's machines is an important stepping-stone to making a "meaningful circuit" (ibid.) that solves a problem and can be sold.

The makers' goal to build economically scalable products is also represented by the makerspace itself. An internal document about the makerspace's objectives and milestones states that it aims to be "a world-class prototyping facility and training center" (Gearbox 2016: 6) with "cutting edge knowledge of design and fabrication techniques" (ibid.: 1). By offering these resources to the makerspace's members, they will be exposed to global quality standards of manufacturing and competitiveness in order to "help … [them] bring new inventions and products to market quickly and efficiently" (ibid). The makerspace's highest aim is summarized in their first objective, namely "[t]o help inventors and entrepreneurs bring innovative, locally relevant products that serve the needs of the poor to market at world-class quality standards" (ibid.: 6). In order to achieve these ambitious goals, one of the makerspace's managers recounted how the team in charge travelled internationally to look at various makerspace models and the machines they offered to get inspiration for the composition of Kenya's first makerspace. In regard to the machines for making printed circuit boards, he explained:

> In fact, the PCB line that we've put up is unique. I didn't find any makerspace anywhere that had this PCB production. And part of the reason is, if you live in the United States, you find most electrical engineers that have 20 or 30 years of experience, but have never made a PCB by hand themselves. There is no reason that you ever would because you draw or design with your computer and send it off to a company in China who produces a copy for ten dollars and ships it to you three days later. In Kenya that's not so easy. Shipping is a lot more expensive, can be prohibitive in fact for many people, but especially if you are just experimenting. Being able to create PCBs was the number one demanded service of anything in our service. … The PCB is your standard building block of all electronic devices. If you don't have that you don't have anything. (Interview, November 2015)

He explained the makerspace's vision further: "Ideally, you go from start to finish without ever having to leave the room. You should have every tool that you need to create just about anything within that facility". In reply to the observation that this sounded like the old Ford factories, he stated, "that's the goal" (ibid.).

Overall, the professionalism of a technology is determined by various factors: for Kenyan technology developers, the means of production, the technology's intention, its aesthetics, and its marketability are signifiers of

professionalism (see Chapter 8). As such, a locally manufactured technology should be made with automated and digital fabrication tools, its intention should be innovative and societally impactful, it should look polished and fulfil global quality standards, and it should be marketable and scalable to the whole African continent.

The Particularities of Postcolonial Making

Contrary to many studies on making in post-industrial contexts, I argue that Kenyan making represents a *performance of professionalism*. This means that tech developers perceive only professional technologies, as defined above, as liberating of precarious circumstances.

Grimme et al. (2014) explain the Kenyan makers' feelings of empowerment evoked by building electronic devices and hardware as feelings that occur in places of "limited finances, geographic isolation, [and] barriers of entry created by a need for formalized education" (ibid.: 438). In such places, they claim, the access to tools and knowledge empower makers to "explore their world by making" (ibid.). In this vein, a research partner of mine declared that he felt powerful because he is able to make abstract things into physical objects. However, he also observed that this agency of makers should be handled with care: engineers "have to be responsible how they make a thing appear in the world. It should not be something which just appears, but something which is going to be meaningful and useful" (Interview, electrical engineer, November 2015).

This seriousness with which Kenyan makers face the development of technology points to the meaningfulness of their intentions. Toombs et al. (2014: n.p.) explain the significance of making thus:

> [mechanical] tools connect human understanding to the material world through the possibility of change; they extend or augment, sometimes radically, human capabilities; they require us to change our physical behaviors, skills of imagination, and judgment to learn how to use them well; and, if all of this happens, they empower us to envision and pursue new futures.

It is precisely the intention of makers to pursue 'new Kenyan futures' that makes technology development such a meaningful and serious endeavor. In Nairobi, technology development is a political endeavor of re-making Kenya's positionality as an active participant in technocapitalism. As such, Kenyan makers feel empowered by locally developed technology that is aesthetic,

innovative, and profitable because it presents Kenya as independent of the epistemological and material supremacy of Western technology. The work of 'professional' technology development and its marketable products promise independence from tech imports and the refutation of stereotypes that depict African contexts as exoticized places of improvised low-tech handicrafts.

The particularity of the aspired futures in Kenya signifies that making is a context-specific phenomenon, situated in "circuits of people, objects, capital, and skill, … [while taking] on a particular character within a local landscape of production forms" (Ames et al. 2018: 16). Because various circuits and temporalities situate making practices, technology cannot be judged in a binary way, for example, either as a neutral tool for development or as the root of inequalities (Schurr and Verne 2017). Instead, I follow Ames et al. (2018) in their understanding of making's visions, effects, and politics as multiple and ambivalent. According to them, making practices are not:

> purely mechanisms of empowerment (as commonly envisioned), but also mechanisms for positioning oneself in relationship to serious (and seriously disempowering) constraints, including those associated with neoliberal modes of governance as practiced across a growing range of global contexts. … [The scholars] neither wish to romanticize modes and cultures of technology production driven by necessity nor do … [they] argue that … [their] sites are simply yet another form of innovation. Rather, … [their] goal has been to demonstrate how making across … [their] sites functioned as a mode of intervening in and positioning oneself in relation to existing social, economic and political structures. (ibid.: 17)

In the case of Kenya, the practices of making technologies are entangled in global discourses and local context specificities. The professionalism that technologies should enact responds to global technology standards that make technology from Kenya convincing for (international) investors (see Chapter 6). In Nairobi, the feelings of empowerment do not come from the endeavor to appropriate the capitalist means of production as in post-industrial maker movements. Instead, histories of colonialism and subsequent development experiments shape the future vision of a Fourth Industrial Revolution that leads to national progress (Birkelo 2017; Gachigi 2017). Postcolonial technology entrepreneurs and Kenyan makerspaces aim to gain independence from Western technology imports that prescribe what a former colony supposedly needs and desires (see Chapter 2). Therefore, the local making of professional

technology represents neither the appropriation of manual labor nor a simple copy of Silicon Valley's innovation culture, but – as well as the work of storytelling – the attempt to make Kenya a place of technology development.

The following chapters illustrate the emotions that are dominant in an environment where the transformation of an abstract idea into a tangible and professional product is not a self-evident practice. Amongst others, I examine the fear of failure and the love of machines and prototypes to show that the performance of professionalism in Kenya needs caring socio-technical relations between makers and machines. Overall, the affects prevalent in Nairobi's tech scene illustrate that technology developers vacillate between humble desires for a work life with automated machines and glorious visions of Kenya's future driven by a Fourth Industrial Revolution.

Overview: The Making Chapters

Chapter 7 gives insight into the hustle of the actual technology development in Kenya by illuminating the context-specific challenges of an ambiguously situated place in technocapitalism. I depict the daily challenges that hardware entrepreneurs face when trying to make new technologies. In particular, the lack of capital and resources, worsened by missing state support and investors, difficult access to global commodity flows, and colonial legacies, characterize the difficulties inherent in the development of hardware in Nairobi.

In Chapters 8 and 9, I analyze what 'professionalism' means for Kenyan tech developers and show that the making of professional technology is a precious endeavor. In this vein, I examine the feelings of love and fear in makerspaces in depth, and show that the value of building technological products stems from the envisioned future of changing Kenya's positionality through local high-tech development. Chapter 8 reveals that loving affects are perceivable during the artistic making of technology in which the order and preciseness of technologies are seen as beautiful. Love and trust characterize the human-machine care relationships that collaboratively contribute to the possibility to make professional products locally.

However, love, amazement, and collaboration are not the only components of making marketable technologies. Chapters 9 and 10 depict the emotions of fear and resistance in order to analyze "where creativity and innovation rub against precarity and marginalization" (Ames et al. 2018: 2). In Chapter 9, I show that the fear of failure is a maker's constant companion. They fear that

their prototype will be unprofessional due to 'human error', but also because of the lack of adequate high-tech material. And they fear the theft of their idea. To counter the fear of failure, makers invest a lot of time into *calculative making*, the thorough planning of transforming a digital model into a tangible prototype. Consequently, Kenyan makers focus on an efficient design process not only to pursue control (see Alexander 2009: 1012) and prevent theft, but also to deal with the scarcity of prototyping resources.

Having highlighted the care and calculation invested during technology development, Chapter 10 illustrates those aspects of work that are incalculable and not cared for. I reveal the hierarchies within makerspaces and startups to show that they make technology development a laborious process: managers' decisions make projects unpredictable and their missing appreciation of intangible design work invisibilizes makers' work efforts. Insights into makers' appropriation of prototyping methods to challenge the hierarchies at their workplace show that they not only use technology development to rework Kenya's positionality within global technocapitalism, but also to position themselves within their workplace.

Finally, I conclude this empirical Part II on making by arguing that postcolonial technology entrepreneurs are responsibilized to care – not only about their own income, but also about enacting national visions (see also Chapter 2). As such, Kenyan makers have to invest affects and establish socio-material relations to handle the neoliberal entrepreneurialization of (technology) development.