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Inspired by the regenerative message of Nordmarka's Future Library, whose books will only be printed once the trees planted for this purpose have reached maturity (100 years), we present the Materials Library for the Digital World. This Library will enable access to the invisible world of materials that become our digital technologies. Each material in the Library will become an entry point on a gigamap (Sevaldson, 2011, 2018) that will visualise the complexity of connections between the different sites of resource extraction, manufacturing, use, and discarding of digital devices.

In this paper, we present some background on materials libraries, followed by a short presentation of our design framework and some of the concepts that will inspire the design of the Materials Library. These concepts are *entanglement of nature and technology*, *visualising the invisible*, *open*, *nomadic*, *pluriverse*, and *slow*.

We understand our Materials Library as a creative method to provoke (Jones, 2014)—to question the normalcy and business-as-usual of the digital world and as a design method that enables the conditions for regenerative technologies and systems to emerge.

KEYWORDS: systemic design, gigamapping, materials library

RSD TOPICS: Sociotechnical Systems, Society & Culture

Introduction

The books in Nordmarka's Future Library[1] (Paterson, 2014) will become available in 2114, a hundred years after the trees that will provide the paper for the books have been planted. With books and other things we use, we usually take an advance on nature, and in most cases, we do not return the advance. Modern life has become dependent on the extraction and exploitation of people and the planet. The Future Library thus inspired us in its regenerative message: *Do not take from nature (and its communities) before you know you can give back.*

While studying the digital world, more specifically, digital technologies and digitalisation processes, we are especially interested in the materials of digital technologies. They are often hidden in devices that are impossible to open and repair. Exploiting people and the planet related to these materials' extraction, manufacturing, and discarding is even more invisible, as they occur in distant locations. In the digital world, the word is: *take whatever you need from nature (and its communities), even though you do not know if you will ever give back.*

The creation, use, and disposal of digital devices have negative impacts on both the environment and society, as noted by Gabrys (2013). This is mainly due to the mining and processing of materials required to produce digital technologies, including metals, rare earth minerals, and plastics, as reported by Bookhagen et al. (2017), Taffel (2016), and Valero Navazo et al. (2014). In 2019, e-waste reached 53.6 million tonnes, which has since increased due to the continued demand for electronics (Forti et al., 2020; Shittu et al., 2021). The extraction of metals for digital devices is often linked to worker and community exploitation in developing countries, perpetuating global inequality. The disposal of digital devices is also a significant issue, as used electronics are often shipped to low-income countries and disposed unsafely, negatively impacting workers' health, local communities, and the environment (Wang et al., 2016).

To address these issues and ensure workplace safety, it is essential to regulate the mining, manufacturing, and recycling of electronics. However, resistance to such regulation remains widespread (Taylor & van der Velden, 2019). The constant release of

[1] https://www.futurelibrary.no/

new phone models and software updates also reinforces societal norms of consumer culture and disposability, prioritising individualism and consumption over sustainability and social and environmental responsibility (Gabrys, 2013; Shittu et al., 2021).

To address these concerns, it is necessary to consider the entire life cycle of digital devices, from extraction to disposal. This requires shifting towards more sustainable and socially responsible practices, such as designing easily repairable devices, using refurbished spare parts, and incorporating recycled materials. Companies and stakeholders must take responsibility for workers involved in all stages of production to address the systemic issues in the digital world.

Our project, "A Materials Library for the Digital World," aims to make the connections between materials, people, and planet visible and tangible. We aim to contribute to research and design that support the transition towards regenerative technologies and systems.

Challenging techno-optimism

Technological products are complex assemblies of human labour, materials, connections and relations. Consumers often overlook the social aspects of technology production, for instance, the oppressive human labour in early supply chains (Sullivan & Tarver, 2021). Abstracting away the social context and externalising environmental impacts from technological objects and processes enables techno-optimism, the idea that technology can solve all our pressing problems. This causes consumers and others involved in technology production to avoid asking questions, for instance, about who benefits from and who is exploited by technoscience (Sullivan & Tarver, 2021). The basis of most techno-optimism is stated by Huesemann and Huesemann (2011) to be ignorance. Gabrys (2013) also states how relationships between consumption and disposal are often neglected. A pretty picture of a solution is often presented to the public when technologists, scientists or companies suggest new gadgets, applications, and technology solutions. While both the production and end-of-life aspects of technologies remain “invisible” to the common public, it makes it easier to ignore these parts.

The status of materials must be established as finite resources. This means taking responsibility for digital devices and the materials they contain. Increasing use of digital

devices results in increased metals consumption (Fairphone, 2021). This poses the responsibility of addressing the social and environmental material chains, such as mining and recycling. Repair and re-use of digital devices would help to keep the materials in a cycle, decreasing the need to mine more materials. Mining materials will continue as only small, incremental shifts are being taken towards a circular economy (Raworth, 2017). With the increasing global material use, certain minerals are estimated to grow exponentially (Fairphone, 2021).

Repairing and recycling digital devices do not pay off economically for consumers or companies. This leads to many materials of post-consumer products being lost and not part of a potential cycle. The value of these materials can be brought back into the cycle through urban mining. An urban mine refers to electronic waste in a society where urban mining is recovering materials from discarded products (Fairphone, 2021; Shittu et al., 2021).

A material library will visualise the social and environmental concerns at stake to encourage discussion outside digitalisation policies.

Defining a materials library

One way to communicate and understand materials is through materials libraries. A materials library is a repository presenting physical materials to make their knowledge accessible and interactive (de Campos & Dantas, 2009; Dehn, 2014). The concept of a materials library has existed since 1997 (Miodownik, 2007), where archives and collections of materials have been incorporated into traditions and cultures for centuries. The concept of a library, rather than an archive, can be considered more interactive and open to the public. Libraries play a democratic role, making knowledge accessible to everyone (Aabø, 2005). Compiling archives is needed in the initial and more vulnerable stages of projects, as the focus is collecting, preserving and maintaining knowledge. The oldest materials archive is nature (Kramvig & Kvidal-Røvik, 2022), so nature can also be seen as a materials library.

Most modern materials libraries target architecture and (product) design. As architects and designers of products and spaces are responsible for what they put into the world (Fry, 2017), material libraries can present available knowledge when making material

decisions. The role of materials libraries often takes place in the initial parts of new design projects, contributing to the first steps in making new things. Examples of such materials libraries are Material ConneXion (Material ConneXion, n.d.), Raumprobe (Raumprobe, n.d.), and Materialbiblioteket (Materialbiblioteket, n.d.).

Whereas these materials libraries offer numerous choices of materials to browse for new products, the Materials Library for the Digital World will visualise materials that are already in use in existing digital technologies but that are often hidden in devices that are difficult or impossible to open. The Materials Library will make these hidden materials visible and tangible. It will show the connectedness between materials, communities, and ecosystems through gigamaps (Sevaldson, 2011, 2018). These gigamaps will be a digital extension of each physical material and will enable the visualisation of the complexity of the life cycle phases of each of the materials.

Designing the Materials Library for the digital world

The current technological development is not going in the right direction regarding the social and environmental aims for sustainability. Extinction is a real threat to our planetary systems, and our resources are becoming critical (Hankey & Diez, 2022; Lo, 2023). Relating to sustainability as a goal might not be enough to untangle the unbalanced relationship between humans and nature, as this allows for continuing business as usual. To attempt to reverse the damage, there is a need for a shift in ways of thinking and living, for instance, by shifting from thinking in terms of user- or human-centric towards thinking life-centric. This is addressed in methods of regenerative design. Where sustainability aims to create balance, regeneration aims at a steady point where social and ecological systems can maintain a healthy state and continue to evolve in the right direction (de Rooij & van Hattum, 2022). The Materials Library for the Digital World will aim to create conditions for regenerative technologies and systems to emerge through systemic design. Systemic design is not inherently regenerative but depends on its values, directions, tools and currencies (Swat et al., 2019). This incorporates designing to maintain and restore resources and their functionalities actively.

Our “Materials Library for the Digital World” project aims to increase awareness about the environmental and social aspects of the life cycles of digital technologies among

consumers, designers, developers, and researchers. The library will facilitate investigating, visualising, and organising the material aspects of digital technologies by connecting the journeys of the materials, from mining to recycling, through systemic design. Mapping out the stories and journeys of materials will help visitors and participants of the library to understand the past, present and future of the materials in their digital technologies. Emphasising the complexity of everyday digital products will invite different stakeholders into discussions on current challenges and problems.

We are still in the process of designing our materials library. Our overall design approach is broadly located in a critical, ontological, and systemic design framework. Regarding critical design, the materials library is an intervention in business as usual regarding digital technologies. Critical design is stated by Bardzell and Bardzell (2013, p. 3300) to be “a design research practice that foregrounds the ethical positioning of designers; this practice is suspicious of the potential for hidden ideologies that can harm the public; it optimistically seeks out, tries out, and disseminates new design values; it seeks to cultivate critical awareness in designers and consumers alike in, by means of, and through designs; it views this activity as democratically participatory”.

Ontological design inspires us because it understands the design of technologies as designing “the conditions of our existence and, in turn, the conditions of our design" (Escobar, 2017, p. 110). Systems oriented design or systemic design guides us through the complexity of designing the materials library, focusing on complexity and connectedness and using gigamapping as a visualisation tool (Sevaldson, 2018, 2013).

Based on this framework, we can identify some of the concepts that will inform the design of the materials library.

Entanglement of nature and technology

Where Indigenous communities have held the concepts of nature and culture intertwined for centuries, Haraway (2003) coined the term *natureculture* to provoke the dominant scientific view that separates these two domains (Latimer & Miele, 2013; Malone & Ovenden, 2016). Natureculture can help to raise awareness of how humans have had dominant relationships with the material world (Latimer & Miele, 2013).

Incorporating such views can help to move towards ontologies of connections (of the human and non-human) rather than division.

Like all humans, Indigenous groups such as the Sami depend on natural resources, but this is practised where resources are utilised according to need, as opposed to greed. The foundation for this perspective lies in the belief in an equal relation between humans and nature. For instance, the Sami language does not have a term for *nature* to the same extent as the English or Norwegian languages (Sannhet- og forsoningskommisjonen, 2023). Neither is there such a distinction between nature and culture (Kramvig & Kvidal-Røvik, 2022). Instead, as an example, the term Meahcci embraces both natural resources and their human use.

Looking at nature and humans as intertwined rather than separate will help us understand the complexity of the materials' stories and journeys and enable the exploration of technology as, in, and with nature.

Visualising the invisible

There are several definitions and directions of what materials can hold. Anthropologist Tim Ingold (2007, s. 1) addresses materials as “the stuff that things are made of”. The materials of a mobile phone and other technologies are often invisible to the user. Making physical materials visible, in addition to their stories and relations, will help create awareness and understanding of how modern and capitalist structures maintain and feed the complex systems of digitalisation and technologies.

Material libraries targeted at architects and product designers offer the possibility of getting to know materials by seeing and touching their qualities. Offering such sensory experiences is important when making choices of products, human surroundings, and interior environments. This differs when telling stories of materials within an object by taking it apart. Instead of promoting softness, balance and harmony, the Material Library of the Digital World will expose materials' raw and harsh sides. Contributing to communicating knowledge at the end of a product, rather than in the initial stages, the materials library will aim to understand the materials rather than feel them. The visualisation will be done by creating igamaps (Sevaldson, 2011) for the relevant materials.

The Materials Library will make the otherwise invisible visible by telling stories about the materials, helping to draw connections within their ecosystems and networks.

Open

While materials libraries are usually only available to architects and designers, our Materials Library will be public. The target audience of the Materials Library will be the consumers of digital technologies, the general public, as well as procurers of digital technologies, people and organisations involved in digitalisation processes, unions representing electronics workers, regulators of digital technologies, etc.

To reach these audiences to facilitate the openness we envision, we will create publicly accessible events around the Library that may focus on particular aspects of the materials and their life cycle. For example, a discussion around sustainable procurement, child labour in the life cycle of digital devices, how to repair your mobile phone, etc.

With technology and digitalisation constantly changing, the Materials Library must also be open to change to accommodate different discussion topics, specific materials and digital devices, curation, audience, and physical environment.

The concept of open (openness) allows the Materials Library to invite a broader spectrum of audiences, creating richness to discussions while contributing to public awareness of social and environmental challenges of the Digital World.

Nomadic

The nomadic concept is inspired by Joar Nango's project 'Girjegumpi: The Sami Architectural Library' (Nordic Countries Pavilion at Venice Architecture Biennale Highlights Sámi Architecture, 2023). Girjegumpi conveys knowledge of Indigenous architecture, design and postcolonial theory to facilitate and engage in discussions. "Girji" means book, while "Gumpi" is a portable hut/cabin. Its nomadic form lets the library travel from space to space to invite discussions in different environments. This makes the content of the library and its discussions more available. After opening to the public in Harstad in 2018, the library has travelled to Jokkmokk, Bergen, Helsinki, Oslo,

and Venezia. Nango has described the nomadic as something place-specific rather than something “placeless”, taking root in the capability of the nomadic people of Sápmi to adapt to the landscape on nature’s premises (Gressnes, 2022).

Physical spaces and meeting points are crucial to conveying and discussing knowledge within Sami cultures. The research project “OKTA: Kunst og friksjonsfylte fellesskap i Sapmi» explores how art in public spaces, such as Girjegumpi, can open up for Sami cultural landscapes and artistic expression to be negotiated and articulated in public spaces (Danbolt et al., 2022). It emphasises the importance of creative expression in public spaces within and outside Sapmi. Cultural festivals such as Festspillene i Nord-Norge in Harstad, Márkomeannu in Gállogieddi and Vintermarkedet in Jokkmokk are some of the arenas that have been researched, as these facilities for travelling art projects within a Sami cultural context. The travelling art projects presented at the cultural festivals can be mirrored through the traditional nomadic culture of the Sami people. This creates a space of opportunity where Sami public spaces and cultures are created to meet and break with the Nordic majority public.

Such temporal cultural platforms open space for knowledge creation, development and mediation. These platforms are crucial when preserving and maintaining knowledge within materials. It allows for discussion not only *about* these materials but also discussion *with* them. The temporality of these exhibitions helps create a necessary intervention for these discussions to be initiated. As discussed by Danbolt, Kramvig, Guttorm and Hætta (2022), this can also be seen as an árran (a campfire), a place for community negotiations and discussions.

A nomadic library invites discussion across borders of both land and time, including pasts, presents, and futures. Mirroring the travelling materials of digital technologies, the Materials Library will move from location to location to create dialogues in different environments.

The concept of nomadic will help us design a materials library that is moveable to reach different audiences with different interests, worldviews, and knowledge.

Pluriverse

Digital technologies are global technologies. Besides having an almost global reach, their life cycle covers many countries and communities, from mineral mining in Africa, the melting of these minerals in Asia, the manufacturing of the technologies, mainly in Asia, but some in Europe and the US, to the discarding of these devices in countries all over the world.

The life cycles of digital technologies are connected with human rights abuses, worker exploitation, environmental pollution, community uprooting, lost livelihoods, economic development, resilient communities, etc. Different communities know and live with these technologies in different ways. To do justice to these different ways of knowing and living with digital technologies, we propose the concept of the *pluriverse*.

The term pluriverse was first mentioned by the Zapatistas as "a world in which many worlds fit" (Escobar, 2018, p. xvi) and was developed to critique hegemonic notions of development. The pluriverse opposes the idea of a single universality and calls for epistemic diversity, acknowledging and respecting the different ways of knowing and being in the world.

The pluriverse concept will help us design a materials library that enables different ways of knowing its materials.

Slow

The concept of slow has inspired important critiques of globalisation, such as the slow cities and slow food movements (Mayer & Knox, 2006; Parkins, 2004). We define *slow* as “constructed as a deliberate subversion of the dominance of speed” (Parkins, 2004, p. 364). The slow movements of nature also inspire us. The Future Library, with its 100-year time frame, is a good example of how we can start to think about slowness in the Materials Library. The concept of slow also refers to the Slow Tech movement, inspired by the Slow Food movement in Italy. The Slow Food movement has three characteristics: good, clean, and fair. These three characteristics are by Patrignani and Whitehouse (2015) translated to fit the world of information and communication technology (ICT):

Good technology is designed “by placing human beings centre-stage. Good ICT introduces an explicit awareness of a balance between the increasing speed of ICT and human beings' more limited information processing speed. Thus, good ICT is to be designed by considering human limits.”

Clean technology “means ICT that considers the whole life cycle of the materials, energy and products used to create, manufacture, power and dispose of ICT.”

Fair technology "is based on the equitable use of ICT. It is similar to the fair use initiative in food consumption or fair trade more widely.”

The slow (Slow Tech) concept will help us design a materials library that inspires us to explore how digital technologies can be good, clean, and fair.

Concluding remarks

The goal of the Materials Library for the Digital World is to generate, through its materials, gigamaps, and events, conditions for the design of regenerative technologies and systems. The design of the Materials Library is, therefore, an important enabling factor. Our design approach is based on a conceptual framework including, among others, entangling nature and technology, visualising the invisible, open, nomadic, pluriverse, and slow. Although the Library has yet to be physically built, an interdisciplinary project group is currently working on its design. Through design workshops, we will determine how the Library and its materials and gigamaps will be structured, organised, and made accessible.

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