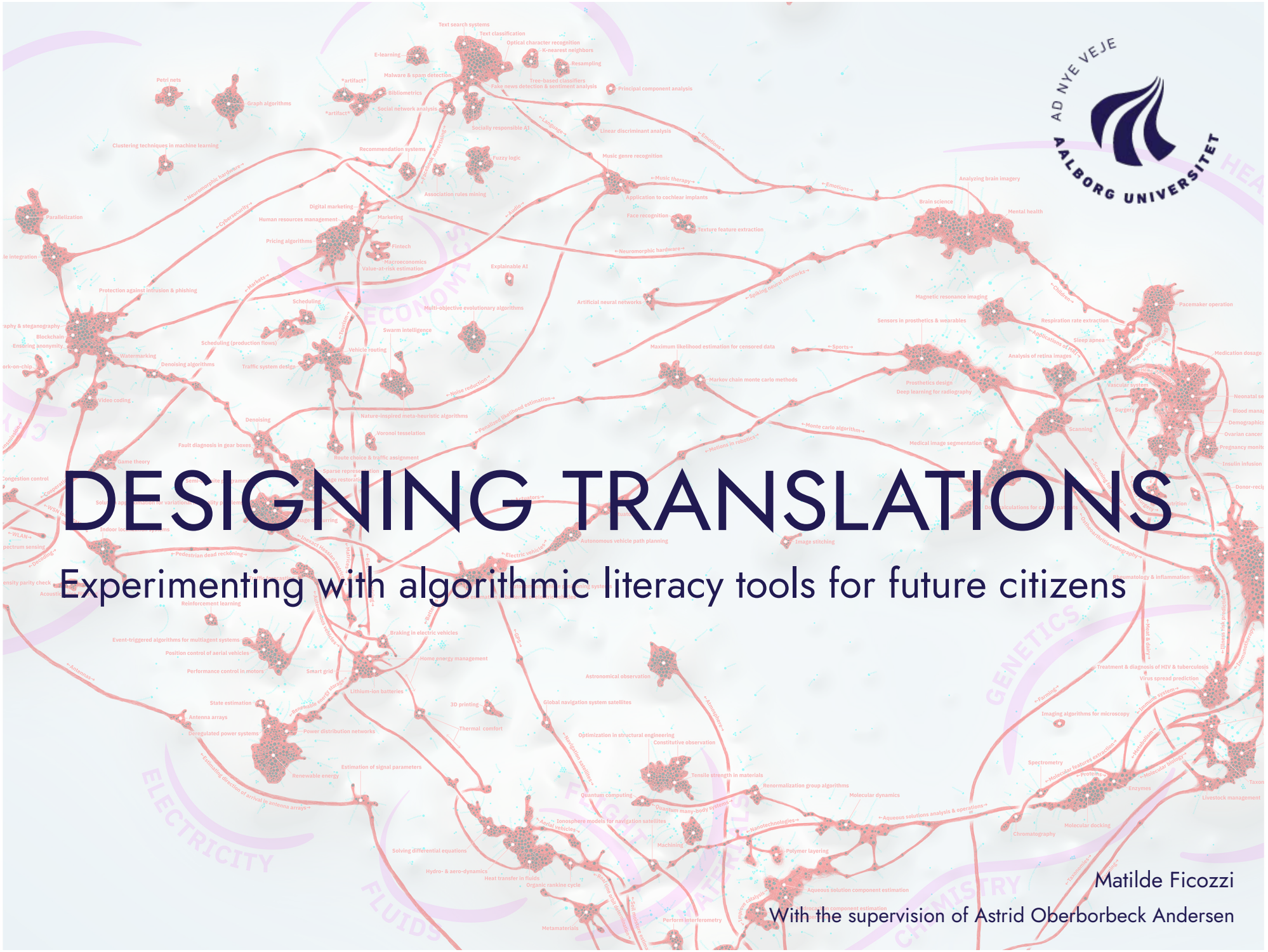

DESIGNING TRANSLATIONS

Experimenting with algorithmic literacy tools for future citizens

Matilde Ficozzi

With the supervision of Astrid Oberborbeck Andersen

Designing translations

Experimenting with algorithmic literacy tools for future citizens

M. Sc. in Techno-anthropology, Department of sustainability and planning

Master thesis by

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Abstract:

In an era where algorithms are increasingly woven into our daily lives, the importance of algorithmic literacy continues to grow. Algorithms shape daily activities, from driving cars to using AI-powered assistants. However, this rapid integration into our lives has left many users unfamiliar with these algorithms and their impact. This lack of understanding restricts individuals' ability to engage with the algorithm-driven world effectively. To address this challenge, this thesis follows the design process of an atlas of algorithms, a tool specifically designed for teachers and students, with the aim of enhancing algorithmic literacy. The research journey encompasses three key dimensions: algorithmic literacy, knowledge translation, and format design. Through literature reviews and interviews with high school teachers, this study navigates the complexities of algorithmic understanding, offering insights into its relevance to the Danish education system. The atlas's potential as a timely educational tool for algorithmic literacy stands in its base contents from academic sources, aligns with user interests, and demystifies algorithms for classroom use. This research represents a collaborative journey that emphasises the importance of translating academic knowledge into accessible and engaging tools for educators and students. While rooted in Denmark, the study's relevance extends globally as it addresses the growing integration of algorithmic systems into everyday life, fostering a deeper understanding of AI and its role in our society.

“Viaggiammo per millenni tra gli splagi
giù giù nei criptoporni stranidiosi,
lontano fosforivano gli Arcagi
o i Mongi teloprènici e quidiosi.
Aiuto, orrore! I gàstrící, gli smébri,
s’aggrécciano sugli énfani druniti,
o calano bustrènici gli affèbri
coi fòrnici viturpi ed allupiti…
Fuggiamo, via! ammòrfido l’encatro
sbaveggia una sughèfida melissi,
ovunque drogo accàncrena lo sfatro.
Eppure – ahi meraviglia – tra gli spissi
gramosi e blastifèmi, sul bovatro
svettiscono zirgendo gli acrolissi.”

Circuito dell’anima - Fosco Maraini (1994)

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What does it mean?

The traditional thesis' structure has been altered to better represent the nature of this research.

This study follows the coming of age of an intervention showing the research and the design processes that have been taken simultaneously. The chapters' structure aims to replicate the procedure of constantly moving from one process to the other, guiding the reader through a similar path that as researchers we had to take while experimenting with the design of a tool to help with the provision of algorithmic literacy in higher schools.

In picture 1, the chapters that portray different moments during the research or design process have been divided in two columns to visually facilitate the understanding of the study's structure. To visually indicate this separation while still presenting the two processes together, the pages of this thesis have been given different colours. The white pages are the ones that zoom-out from the work processes and present reflections that only serve the thesis formation; the red pages are the ones that explore the research process and all the foundational knowledge that allowed the study; the blue pages present the design process and the hands-on moments of this experiment. These colours (red and blue) are a reference to the colours that have been used to render the map that will be introduced later in this thesis, where different colour lenses facilitate the navigation: the red one to see the base map and the "clean" data from the dataset; the blue one to see the annotations, the qualitative work.

The proposed thesis will contribute to the ongoing discussion about the importance of promoting algorithms literacy and awareness among citizens by providing a detailed analysis of the building process of an atlas that maps scientific literature about algorithms, and provides educational content about the topic. Furthermore, the intervention contributes to the reorientation of the public discourse on artificial intelligence and algorithms, enriching the view and therefore the understanding of these.

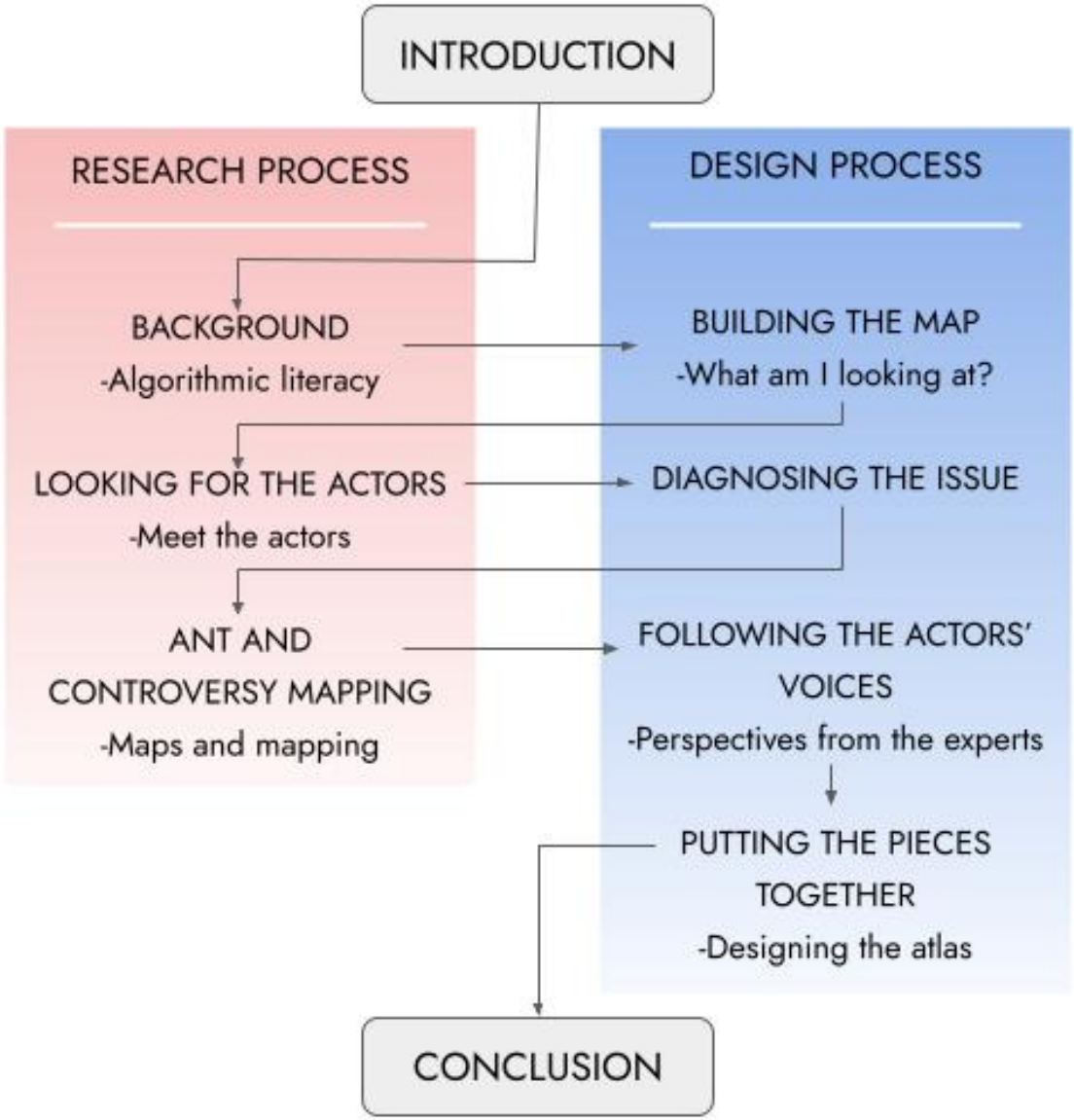


Figure 1. Reading guide for the thesis. The two columns show the division of the research and the design processes within the chapters.

An algorithmic language barrier

I was going to start my fieldwork the following day, and, partly out of nervousness, partly to be sure I wasn't missing anything, I seized the opportunity during lunch break to ask Anders and Mathieu if they had any advice for the interviews I was going to conduct.

"*Just let them talk, and in no time they will drag you into their class routine, you'll see. They are teachers, after all.*" Anders suggested. Mathieu added "*Also, it will be interesting to see how much time it will take them to start talking about ChatGPT!*".

I welcomed the challenge; it seemed like an intriguing insight for my study. All I needed to do was refrain from mentioning it first.

I knew what Mathieu was alluding to. Our project never mentions ChatGPT, the dataset we have based our work on is not even up-to-date enough to include data about it. However, since its release, a few months before, ChatGPT was saturating

the news all over and it was all everybody was talking about. Surely, talking about algorithms would have triggered this type of conversation.

The interviews began. I introduced our project and the teachers shared insights into their daily routines and responded enthusiastically to my questions. As anticipated, without me ever broaching the topic, all of them, at a certain point of our discussions, brought up ChatGPT. They told me about school discussions on how to manage the situation and regulate it. It sounded like, in recent months, hardly any other topic had been discussed with their co-workers. Conversations bore a mix of confidence from those who had heard and discussed this subject daily in school hallways, and concern from those that didn't know how to deal with it. However, despite the fact that everyone wanted to talk about it, the lack of a common understanding of this tool made it feel like we were just not speaking the same language.

More than a chatbot based on large language models, ChatGPT seemed to appear as a magical tool, the functioning of which was impossible to understand. One interviewee went so far as to ask me, "*I'm not even sure if you could actually talk about algorithms within ChatGPT. Can you?*"

The intensity with which discussion around this technology had permeated all spheres, and the immediate media coverage it had received, left many feeling alarmed and disoriented, with a tool that was almost too easily in their hands, but that they could not understand. The public debate instantly took agitated turns, with countries deciding to completely ban it, schools going back to paper assignments, and influential figures warning the public against serious dangers linked to artificial intelligence. The narrative around algorithms is, in fact, often reduced to a few tools that get a foothold on large crowds, and their potential dangerousness for society.

As this field is in rapid and continuous change, staying up-to-date requires active engagement and constant learning. As a result of this change, algorithmic literacy changes as well and makes citizens face new challenges over and over. This is also because mainstream media outlets only offer a partial view of the ongoing research and scientific advancements on algorithms while these are increasingly integrated in all parts of our lives.

In this scenario, algorithmic literacy that takes into account new developments and applications becomes a necessary skill for citizens, as these technologies are here to stay.

Let's take a step back.

Introduction

Algorithmic literacy has become increasingly important in today's society, where algorithms are used in various domains such as social media, finance, healthcare. Development of artificial intelligence has been so rapid and widespread over different domains that everyday activities such as driving a car, using autonomous vacuum cleaners, as well as listening to music through an AI assistant can be operated by machine learning algorithms.

However, despite the variety of applications, the speed at which this technology has become prevalent in our lives has resulted in a large portion of users being unaware of how it functions and unfamiliar with the notion of algorithms and the extent to which they shape their daily lives (Ma et al. 2023). This lack of understanding often leads citizens to face challenges in navigating and fully engaging with the algorithm-driven landscape of our society. Therefore, it is crucial to provide algorithm literacy and awareness to individuals from a young age (Swart, 2021; Jeong et al., 2022). In particular, teachers have a determining role in promoting algorithm literacy among young students. Many teachers themselves, however, may not be familiar with algorithms, and may not have access to appropriate tools to teach this topic effectively.

To address this issue, the design of an educational tool about algorithms, specifically thought for teachers and young students, might help the process. This thesis covers the process of building an atlas of algorithms, presenting an analysis of the ways this project can become a reality, reflecting on three focus points: algorithmic literacy, knowledge translation, and format design.

First, a literature review provides an overview on relevant work and studies on issues related to the three focus points: algorithmic literacy, with a particular attention on digital education in high schools in Denmark, public involvement in scientific research and democratisation of knowledge, and data visualisations.

The research will make use of data collected during my internship at Tantlab and network visualisations created at the same time. In addition, I conducted interviews with high school

teachers, pictured in my study as possible future users, in order to shape themes and design requirements according to their necessities.

Design based chapters will use the generated material from interviews, looking for narratives beyond the map, taking inspiration from the discussions around algorithms in schools right now, ideas about what should be implemented in education, concerns about the speed of technology development and how this creates a problem around literacy.

These chapters will have different focuses: an analysis of the schools' requirements and the state of the education through the eyes of the teachers to understand how young citizens are educated on algorithmic literacy; an analysis of the stories that are relevant for the teachers and their courses, investigating, in addition, the tools that are used and discussing what could enhance and improve the discussion. Lastly, an analysis of the ways that, as researchers and mediators of this intervention, we translate our work and the data generated from the interviews into a tool that is understandable and suitable for students, facilitating a conversation between academia and young citizens.

As the thesis only depicts the design process, it will conclude by proposing a possible solution for our case that will have to be created in the future. Limitations and necessary future work are addressed.

It is important to address that this study is specifically situated in a Danish context. The project has its roots in a Danish research initiative and makes use of fieldwork conducted within the Copenhagen area with teachers working in Danish higher education programmes in order to investigate possible solutions to be implemented in this environment. The case of Danish high schools was thus chosen because of connections established during the initial phases of the projects but also for research and fieldwork possibilities. Furthermore, the Danish context appears to be highly compatible with the research efforts carried out in this study because of Denmark's renowned continuous efforts towards a more digitised society (Danish Agency for Digital Government, 2022).

However, the outcomes of the study are not to be necessarily confined within Danish borders. In fact, although the thesis experiments with the Danish case, the study could, in the future, be opened up and applied to several different contexts since the themes and issues are becoming relatable to increasingly bigger audiences.

Framing the context

I began working on the atlas of algorithms during my internship at Tantlab, the techno-anthropology laboratory at Aalborg University in Copenhagen where computational methods, participatory design, and ethnography are combined to study science and technology in society. Here, I have been working together with Anders Kristian Munk and Mathieu Jacomy, following their research for the Algorithms, Data and Democracy (ADD) project, and helping on the creation of network visualisations, a map, that would subsequently be used to develop an atlas. The map is the visualisation of a network that represents terms used in research about algorithms, AI, and machine learning.

As I joined the project on its second year of work, when I started my internship a first version of the network visualisation had already been created and used as material in data-sprints[1] for different work packages in the ADD project.

My goal during the internship was to create a second, improved version of the map, designed to be readable and understandable by a broader audience, one that wouldn't necessarily have any skills regarding network analysis, or in other words, the so-called general public. This choice was moved by the will of making academic knowledge more accessible to the public combined with ADD's main effort to strengthen digital democracy, being the subject of our study such an important and present issue for citizens in today's society.

While advancing on the work, the target audience was narrowed down and identified within higher education programmes.

Once the second version of the map was developed (from now on I will refer to this version of the map as the 'Scopus map'), we used it as a base for the design process of an atlas of algorithms that could be used by teachers and students in high schools.

The main goal behind the creation of the atlas is to make an intervention that facilitates the understanding of what algorithms are and what they are developed for, turning the immense landscape of academic research about algorithms into a downscaled, explorable, and readable window on their functions and applications. The intervention aims to enhance dialogue between actors, opening up academic knowledge and

[1] Data-sprints can be described as intensive workshops ranging from a few days to a week, where a team collaboratively engages in a data-focused project. These workshops serve as a shared platform for social scientists and social actors to collaborate on a specific set of data and research inquiries. (Venturini et al., 2016)

making it accessible for young citizens' education and formation.

Algorithms, Data and Democracy project

The ADD project is an interdisciplinary research and outreach initiative that spans over ten years, from 2021 to 2031, striving to advance digital democracy. The project brings together researchers from six Danish universities (Roskilde University, Aalborg University, University of Copenhagen, Aarhus University, Copenhagen Business School, and University of Southern Denmark) across various departments including computer science, education, communication and arts, organisation, technology and innovation, and culture and learning.

The ADD project seeks to address the challenges and opportunities presented by algorithmic infrastructures that often appear to be incomprehensible to the majority of people. The project's primary focus is the examination of the socio-technical dynamics surrounding data usage, the development and applications of algorithmic infrastructures, and their implications, aiming to offer valuable insights and solutions to societal challenges, ultimately strengthening and supporting digital democracy, and promoting responsible usage of algorithms and data.

The multidisciplinary approach ensures a multifaceted exploration of the relationship between technology and society, focusing on key areas for Danish society like the role of traditional and new media, policy development, and the interaction between the public sector and the citizens. In a world increasingly moulded by algorithms and data, the project aspires for Denmark to emerge as a global leader in promoting enlightened digital citizenship and safeguarding democratic values and legitimacy within a decade.

Researchers within the ADD project are organised into three distinct work packages, each with its own specific objectives and areas of focus: theory development, methodological contributions, and empirical investigations. Furthermore, an outreach team takes part in the project to facilitate and foster dialogue between the academic institutions, government, the private sector, media, and the public.

This study will follow the evolution of a subproject that was developed by part of the theory development work package in

order to provide useful insights for other groups. The work package is led by researchers from Aalborg University and it aims to help the design of a common process for all empirical subprojects, starting by mapping the controversies associated with algorithms and data through data-sprints. These sprints help establish an overview of the relevant issues within each subproject, which will then use the gathered data to conduct workshops to explore algorithms and data as both technical and social phenomena. The insights gained from the workshops are then extended through a dialogue with international colleagues. Finally, the collective results are presented, highlighting the outcomes of the theoretical development.

Background

This section will analyse studies related to topics that are central to the thesis, providing background knowledge to better understand the reasoning of the study. Furthermore, the chapter will delineate the path that led to certain decisions for the atlas' design, in particular for the choices related to audience targeting and format design.

Algorithmic literacy

In the last years, machine learning algorithms have indeed been at the centre of countless debates, increasingly taking up space in our everyday life activities and, therefore, appearing more and more often in public debates and news media, becoming common objects of discussion for the general public as well as for researchers and scientists. Because of the many ways that algorithms work in the world and influence our lives, many scholars have called for better algorithmic literacy, and suggested that it should be incorporated into public education (Kitchin, 2016; Bakke, 2020; Gran et al., 2020). This chapter aims to represent what the academic response related to these issues is.

Algorithms in an algorithmic culture

The term 'algorithm' originally comes from the maths domain to generally indicate a set of rules that are followed in order to solve a particular problem. In recent times, however, the term is often used with a more specific take, for example to refer to the processes that drive the content displayed on our social media feeds, and is, in general, often used alone to specifically refer to machine learning algorithms, a subset of algorithms that enable computers to learn patterns from a given dataset to best predict the most successful (i.e. meaningful to the user) output to an input (O'Neil, 2016).

While machine learning may sound to many like a somewhat recent concept, its applications date back to the 1950s when Arthur Samuel, a computer scientist working at IBM, coined the term while designing a program that was able to play

checkers learning from its own experience. Over time, the applications of machine learning algorithms spread over a wide range of tasks and soon made their appearance in a substantial part of our lives. Because of this, following Galloway (2006), many scholars, among which Kushner (2013) and Striphas (2015) started talking about 'algorithmic culture' to explain the phenomenon of contemporary culture and society being affected by algorithms that shape our experiences and the way we see the world, and to describe the ways that computational procedures are being used to group, categorise, and organise individuals, communities, objects, and concepts, progressively taking more space into our daily life.

Despite the pervasive presence of algorithms across various facets of our lives, these are often treated as "*self-standing, autonomous and black-boxed entities whose properties and effects are independent from their design and application context*" (Glaser et al., 2021, p.5) conveying an idea of algorithms as an abstract and complicated concept for everyone but scientists, with their functionalities and operations veiled in incomprehensible mechanisms, and fueling the perception of these as tools that increasingly hold more power in our society (Lash, 2007, p.71).

The implementations of algorithmic solutions in different aspects of public life have, however, presented many issues over time. A collection of these is offered by an independent, public interest initiative called *AI, Algorithmic, and Automation Incidents and Controversies* (AIAAIC), founded in 2019. The AIAAIC database stores cases of controversies related to the use of AI starting from 2012. Each case is classified and labelled with an associated risk like privacy, discrimination, safety, surveillance, fairness, ethics, freedom of expression, disinformation, among others.

Yet, when discussing the socio-cultural effects of algorithmic solutions, it is important to acknowledge that these do not exclusively lie within the algorithms themselves. As Seaver (2019) points out, they are instead embedded within what he refers to as 'algorithmic systems', where code becomes only a part of what constitutes an algorithm in our understanding, turning into an "*intricate, dynamic arrangements of people and code*" (Seaver, 2019, p.419). These systems are characterised by their constant negotiation and evolution with the environment that makes use of them. Here, computational logic and contemporary culture influence and shape each other, configuring the possibilities of life itself (Kushner, 2013). In this perspective, where technical and

cultural details are equally important, trying to unpack the black box of algorithms becomes crucial. Understanding how algorithms operate in the real world, as well as the implications and our reactions to their implementations, is not solely the concern of scientists and academics, but also a matter of growing importance in the daily lives of every citizen (Seaver, 2017).

Because of the intricacies that algorithmic systems inevitably pose and the consequences they entail within an algorithmic culture, scholars (Dogruel et al., 2020; Gran et al., 2020; Swart, 2021) have already called for the need of better algorithmic literacy for present and future citizens.

Different ways of referring to algorithmic knowledge

Before exploring the study of algorithmic literacy and investigating how and why this education would play a crucial part in the formation of citizens, it is essential to define its limits and have a more precise idea of what this notion entails.

The umbrella term of 'media literacy' comprises users' skills and levels in accessing, utilising and producing information through various media (Livingstone, 2004, p.5). Within the realm of media literacy, in recent years, there has been a growing focus on algorithmic literacy. Despite the lack of a universally recognised definition of what algorithmic literacy entails, most conceptual approaches analyse the knowledge and abilities of users, but also involve the development of a critical thinking towards algorithms, letting them understand the 'why' beyond the 'how'.

Surely, delimiting the knowledge and skills that determine algorithm literacy has its challenges due to algorithms' complex, opaque and user-dependent nature (Swart, 2021, p.3) that makes the application of a fixed framework meaningless. However, several studies attempt to synthesise the user experience of algorithms as different levels of familiarity and capability with this technology can be observed.

The first level, the most basic one, is typically defined as algorithmic awareness. Hargittai et al. (2020) describe it as "*knowing that a dynamic system is in place that can personalise and customise the information that a user sees or hears*" (Hargittai et al., 2020, p.771), in other words, the basic awareness of the existence of algorithms around us and the fact that these have a certain level of agency. Studies (Cotter & Reisdorf, 2020; Gran et al., 2020) show that the lack of

algorithmic awareness can result in a digital divide and forms of inequality for some types of users, as it will be discussed later in this study.

A higher level of literacy may span from the ability of making informed decisions based on the knowledge and judgement that the user develops about the possibilities of algorithmic systems, to the faculty of evaluating how these technologies are developed and implemented, and possibly advocating for a responsible design and use. A practical definition of algorithmic literacy can be found in Dogruel et al. (2020) where it is explained as the users' ability "*to apply strategies that allow them to modify predefined settings in algorithmically curated environments, such as in their social media newsfeeds or search engines, to change algorithms' outputs, compare the results of different algorithmic decisions, and protect their privacy*" (Dogruel et al., 2020, p.118). The wide range of skills that algorithmic literacy is defined with, can be seen by comparing studies like Gezgin (2019) that analyses algorithmic literacy to discuss the need of it to upgrade critical citizenship education in an age of ubiquitous surveillance capitalism, and Klug et al. (2023) that studies it in connection to users adopting certain communication practices in order to overcome social media content restrictions.

Following the broad perspective that Shin et al. (2021) propose, in this study I will define algorithmic literacy as "*understanding what algorithms do and why, but also what they mean*" (Shin et al., 2021, p.1217). More specifically, algorithmic literacy is intended as implying a set of skills that allow for the management of the surrounding AI environment in terms of comprehension, control, and curation. This definition enables a critical reflection on algorithms, perceiving them as components of algorithmic systems situated in an algorithmic culture.

Algorithmic literacy for informed citizens

Algorithmic literacy plays a crucial role in empowering citizens in an age where algorithms enable crucial decision-making tools embedded in many aspects and situations of public life and democracy such as public administration services, politics, health, and, of course, the media (Gillespie, 2014; Gran et al., 2020). In their study, Gran et al. (2020) point out how much these algorithmic systems are embedded in our lives through different aspects, gaining a fundamental role in the democratic structure of our society. Thus, the need for a better understanding of the way these

technologies operate is urgent, even more considering that algorithms are already generally known for often having perpetuated structural inequalities and historical bias while erroneously being presented as neutral devices. Douglas-Jones et al. (2021) argue that algorithms are, in fact, often presented as neutral, objective, and unbiased, while, in reality, because they are created by humans, these reflect the values, assumptions, and interests of their creators. As such, algorithms can perpetuate and even amplify existing biases and inequalities.

Algorithmic literacy enables citizens to understand and interact with algorithmic systems, promote critical thinking and informed decision-making, strive for and protect democratic choices and values regarding data and technological development. Expressions of algorithmic literacy contribute to shaping users' exposure to and consumption of information, therefore influencing their ideas and behaviours in their personal and public life (Swart, 2021).

On the contrary, the lack of algorithmic literacy can result in various social issues regarding agency, democracy, and privacy among others. One significant factor that contributes to the development of these issues is the evolution of the digital divide between citizens that have a certain familiarity with algorithmic systems and the ones that don't.

The phenomenon of the digital divide has been documented as a fundamental aspect of social inequity in the information age, and has initially been measured through different parameters related to users' possibilities in accessing the internet (Muschert & Ragnedda, 2015). Overtime, the digital divide has evolved beyond a mere access issue and, at least in Western democratic societies, it has become a matter of skills and usage disparities, where the ability to consciously navigate the internet created a '*new and reinforced level of digital divide*' (Gran et al. 2020, p. 1791). The users' disparity is proved to be influenced by common factors like age, with younger users generally being more proficient in navigating the digital domain compared to their older counterparts, but, most importantly, digital knowledge gaps are becoming primarily related to socioeconomic advantage. Disparities can be observed on three levels: the first level of digital divide concerning the access to the internet and technological equipment, the second being about skills and usage, and the third about general benefits (Cotter & Reisdorf, 2020; Gran et al., 2020).

The division among users, in fact, is now more nuanced as the internet is increasingly accessible to people while, at the same time, its infrastructure is getting more intricate. As of July 2023, it is estimated that 64.5% of the world population had access to

the internet, with an annual growth rate of the data of 2.1% (data from Datareportal, 2023). The new digital divide tells us a story of education more than accessibility. Studies from Park and Humphry (2019) and Rainie and Anderson (2017) argue that traditional concerns of the digital divide shifted to new exclusionary practices with the introduction of big data and automation processes into service delivery systems of highly networked societies, making the new digital divide an issue of '*exclusion by design*' where citizens that lack this type of literacy may experience social disadvantages by ignoring important information that would not be prioritised to them. In this perspective, algorithmic literacy comes as a necessary condition to avoid social and economic exclusion stemming from this situation, and to empower individuals to effectively engage with the internet infrastructure, and promote a more enlightened and rewarding online life (Gran et al., 2020, p. 1791).

> "*Knowing more about the structural forces that shape the Web is not just an online navigational skill, but a necessary condition managing information as an informed citizen.*" (Gran et al., 2020, p.1791)

Algorithmic literacy is, in fact, closely connected to issues of data democracy and democracy at large. An algorithmic infrastructure that automatically perpetuates and amplifies existing patterns, poses the risk of reinforcing existing social disparities and democratic deficits. On this note, Gezgin (2019) discusses the importance of algorithmic literacy as a pivotal element to promote a more democratic and participatory approach to data governance in a data-driven society. By being aware of algorithms' functions and impacts, citizens can engage with platforms, services, and search engines consciously and critically. Algorithmic literacy enables individuals to question the biases and influences embedded in algorithms, thus contributing to a more informed public and democratic participation to the wider socio-political landscape that data creates and participates in.

Moreover, an important factor of algorithmic literacy is the fact that it enables citizens to actively shape their information environment, rather than passively accept governance options and decisions. Bakke (2020) poses this problem in her study investigating how "fake" news travels farther and faster than real news, with political, environmental, and educational consequences. The study attributes this phenomenon to the way that social media algorithms are designed and, above all, to the fact that citizens tend to not critically analyse what they come across in their news feed.

In another study, Brock and Shepherd (2016) call for awareness and critique of algorithmic procedural systems, analysing how these often interact with humans through persuasion, giving us the illusion that we are actively deciding on something when in reality we are just choosing from a set of constrained possibilities without noticing it. The authors argue that "*there can be no significant social or political change in how these systems influence activity if it is difficult or impossible to recognize those influences*" (Brock & Shepherd, 2016, p.19).

In conclusion, algorithmic literacy is essential for fostering critical citizenship education towards the digital realm. The ability to critically reflect on the information and choices that we get presented as citizens and users plays an increasingly crucial role in our society to ensure a more inclusive, informed, and democratic digital landscape.

How can algorithmic literacy be taught in schools?

Once the necessity for algorithmic literacy is ascertained, the following step to take is to understand what is the best way to provide it. Younger generations are documented to be the ones that can more easily acquire digital skills. However, while functional literacy is important, students need to be able to make informed decisions and develop a critical understanding of technology (Selber, 2004). It is important to develop and improve algorithmic literacy in schools so that the students will have the necessary skills to be conscious and critical citizens in today's and tomorrow's society.

Bakke (2020) presents an observational study where she analyses how to teach algorithmic literacy in schools, investigating the best ways that teachers can increase their students' algorithmic literacy. When providing algorithmic literacy in education, two main focuses seem to be crucial according to studies: develop algorithmic literacy as part of information literacy and develop a critical sense that will help make informed rhetorical decisions about technologies.

Students need to critically and reflectively evaluate information sources while also considering the role algorithms play in shaping the availability and visibility of those sources. By teaching students to be aware of algorithmic processes, educators can help them navigate the complexities of online information more effectively. As students' research stances are often influenced by non-scholarly sources such as social media, unpacking the socio-technical implications within these online

environments becomes highly significant for their experience. Teachers should acknowledge these influences and guide students in critically assessing the credibility and reliability of information encountered outside traditional academic channels. To achieve this, awareness of algorithms is necessary but not always enough. A deeper process of encouraging students to question biases and consider the validity of sources can enhance their algorithmic literacy.

Many studies show that children and young students learn best through hands-on experiences and interaction with their environment. Incorporating interactive activities, such as analysing data sets, creating simple algorithms, or participating in coding exercises, can enhance students' understanding of algorithmic processes. Experiential learning opportunities allow students to develop a deeper grasp of how algorithms function and impact their daily lives. Moreover, integrating real-world examples and case studies related to algorithmic biases and misinformation can facilitate deeper learning. In this regard, the study from Jeong et al. (2022) shows how employing game-based media education interventions and 'simulation-activities' based on tools, websites, and social media that the students are familiar with, is particularly effective in making them reflect about the role of algorithms within these channels. The researchers argue that these methods could become a starting point for critical algorithm literacy in schools and develop in reflections and discussions about algorithms' social role.

To conclude, teaching algorithmic literacy in schools is essential to equip students with the necessary skills to navigate the digital world effectively. Developing algorithmic literacy education programmes in schools contribute to making students become informed and judicious digital citizens in an increasingly algorithm-driven society where the answer cannot lie in avoiding algorithms but rather developing consciousness and skills around them, understanding functions, applications, acknowledging issues and solutions.

Digital education in Denmark

In recent years, Denmark has progressed significantly in the development and adoption of policies that would make the country a digital frontrunner, reflecting the growing importance of technology and digitalisation in education. In cooperation with municipalities and private actors, *Børne- og Undervisningsministeriet* (the Ministry of Children and Education) is responsible for developing high-quality and

reliable IT solutions for education, emphasising the integration of Information and Communication Technology (ICT) in teaching and learning, digital competencies for both students and teachers, and heightened awareness of cyber and information security.

The 2018 Action Plan for Technology in Education was a pivotal initiative aimed at enhancing digital competencies among students and teachers. This plan sought to equip educational institutions with the necessary resources and tools to incorporate technology effectively into their teaching methodologies (Undervisningsministeriet - Styrelsen for IT og Læring, 2018). In 2022, the government presented the National Strategy for Digitalisation which aimed to enhance students' and teachers' digital knowledge and skills. However, due to national elections, the full implementation of the 2022 strategy was postponed.

A notable effort that more closely relates to the teaching of algorithmic literacy was posed in 2018 with the experimentation of a new subject called *teknologiforståelse* in primary schools. The closest translation of the term would be 'technology understanding' but the subject also focuses on awareness and literacy, aiming at providing the tools for students to be able to relate critically to technology and shape it, rather than simply use it. In the proposal for the content of the test-subject to *Børne- og Undervisningsministeriet*, the experts committee drew a parallel between the lack of computational thinking and informatic skills, and the historical lack of reading and writing skills centuries ago (Caspersen et al., 2018). This comparison underscores the essential requirement for a broad comprehension of informatics today. The test-subject, with 46 participating schools, went through a three-year trial (2018-2021) that was then extended until 2023 (EMU - Danmarks læringsportal, 2022).

As of today, the 2022 Act on primary schools (LBK no. 1396) presents the introduction of technology-related subjects like *Natur/teknologi* (Nature/technology), *Teknologi og Kommunication* (Technology and Communication), and vocational workshops like *Teknologiværksted* (Technology workshop) at various education levels.

In conclusion, Denmark's digital education policies have been evolving to meet the challenges and opportunities presented by the digital age. The presented policies emphasise the integration of ICT in education, the development of digital competencies, and robust cyber and information security while institutions are striving to create new subjects that will be more aligned with the necessities of a digital society.

Problem formulation

This study presents the coming of age of the Atlas of algorithms as an intervention aimed at providing and enhancing algorithmic literacy in Danish high schools. Here, research and design processes are portrayed together, revolving around three main focus points: algorithmic literacy, knowledge translation, and format design. Starting from the provided analysis on the issue of algorithmic literacy and its grounding on a Danish context, this study aims to find answers to the following question:

How can algorithmic literacy be provided to Danish high school students by developing a tool that utilises data visualisations to effectively translate academic knowledge?

Research questions:

- What is the state of computational methods education in Danish high schools' programmes and how is algorithmic literacy provided to young citizens?

- Which stories within academic research on algorithms are relevant for educating on algorithmic literacy for the high school education system in Denmark?

- How to facilitate the translation of academic knowledge for young students through the design of an atlas?

Building the map

The last decade of research on AI, machine learning, and algorithms have been highly prolific due to the constantly increasing solutions that have been designed and developed based on these kinds of technologies.

As mentioned before, the network visualisation this study is based on was made as a tool to be used in data-sprints with different teams of researchers that are part of the ADD project. Initially, the network visualisation had the intent to provide a readable and accessible mapping of which academic domains are doing research on algorithms, how prominent these are compared to others, what they are focusing on and how they are connected. The visualisation was also developed into an interactive datascape that the researchers were able to navigate and filter through keywords, timeframes and other criteria. This was used by the different work packages as an explorative tool to have access to the academic world of algorithms to investigate issues of their interest, make connections, and find answers to questions in their research.

The techniques used to develop the map can be inscribed in what, in research, have come to be called *quali-quantitative methods*.

Although the naming could lead to thinking that the employment of these methods simply consist in the alternation of qualitative and quantitative research, quali-quantitative methods strive to work out new ways of investigating action networks other than by these two classic strategies that will inevitably have their limits (Venturini & Latour, 2010; Munk, 2019).

In the following section I will explain what the Scopus map represents and how we obtained it, from the first phases of data harvesting to the last ones where we annotated and curated the visual outcome, showing how we employed different strategies.

What am I looking at?

To build a visualisation that would capture the complexity of academic research, choosing the database in the

first place plays an important role. The decision to harvest data from Scopus has been informed by a study (Yao et al.,2021) that compares the contents of Thomson Reuters' Web of Science and Elsevier's Scopus, the two main databases used for scientometric analysis. According to the authors, Scopus encompasses a total of 39,758 scientific journals, whereas Web of Science only includes 13,610 journals, 99.11% of which can be found in Scopus as well.

Thus, we searched the Scopus database through the API for papers containing either algorithm*, "artificial intelligence", AI or "machine learning" in the title, abstract or author keyword, and were published in English language journals. The search was also filtered in order to get papers that were published between January 2011 and October 2021, that is when the data was retrieved, and resulted in a corpus of 1,004,003 articles from which abstracts and all bibliometric data have been extracted to form the dataset that has been used for the map.

Using the SpaCy library in Python, we performed part of speech tagging and named entity recognition on the abstract texts to get a list of nouns and a list of named entities for each article in the corpus that were combined with the list of author keywords and the list of scientific disciplines from the Scopus metadata. The four lists were combined to create a co-word network using the NetworkX library in Python, where each node is an n-gram and the edges represent co-occurrence of the n-grams in the same articles.

The first version of the network visualisation resulted in a big round cluster, a common issue for big co-word networks. To improve the visual outcome and create a more diversified map, the edges were ranked by pointwise mutual information (PMI), and the lower PMI edges were filtered out, resulting in a network of 7,562 nodes, 85,215 edges, and good topical clustering as can be seen in figure 2.

The map has been rendered neutrally to allow for a convenient annotation overlay but it still presents a hillshading effect that makes the clusters more easily identifiable and comprehensible.

Figure 2. Improved version of the network visualisation for our research. This visualisation has been used as base to create the Scopus map.

Working quali-quantitative

The annotation layer started with a process of cluster tagging. This was done through a quali-quantitative process that has been specifically designed for our case.

The entire dataset was stored within the ElasticSearch database in Kibana, a tool used for data visualisation and exploration, where it could be filtered through constructed queries that were determined by computing all the k-clique communities where k=7.

A clique refers to a group of nodes within a network where any two different nodes in the clique share a connecting edge. When the size of such a group is defined as k, it is called a k-clique. Essentially a k-clique consists of k nodes that are all interconnected. This filtering technique helps identifying highly interconnected node communities within a network. An example of a k-clique with k=7 is shown in figure 3, where the nodes forming the clique are highlighted by the red coloured edges.

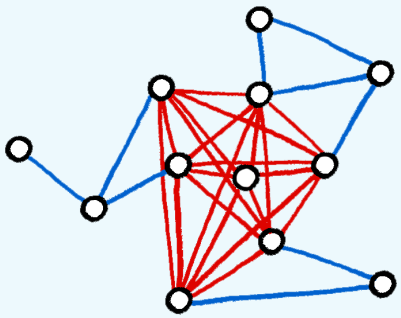


Figure 3. Example of a network visualisation with a k-clique where k=7

The network presented a total of 166 cliques to annotate. The queries were designed so they provided papers that generated a triad in a clique. The triads consisted in the most central node in the clique, its closest neighbour in the clique (i.e. the node with the highest PMI) and one of the other nodes in the clique, neighbour to the most central node. When this resulted in multiple queries, we kept the ones with less than 10% node overlap for a clique. This gave us 235 different queries to annotate.

Finally, through the obtained queries it was possible to access a relatively small (i.e. close readable), highly connected subset of documents, that could then be read, analysed and condensed in a short description. Thus, the landmarks that appear in the map are not just about the words that can be found in the nodes' label, but they come from a more specific and in-depth qualitative analysis of the data, a process of analysis of the articles that constitute the clique to understand how and for what purpose AI, algorithms and machine learning are involved and discussed. This step is of crucial importance in the

annotation of the map because it ensures a deeper process of translation, taking into account not only the nodes' labels or the visible topographical features, but forcing the researcher to go back to the data, digest and translate informations through qualitative choices about when and how to highlight which feature.

Once each of the 235 queries had been analysed and notes had been written down on a placeholder in a digitally shared version of the map (see figure 4) using Miro, a digital collaboration platform.

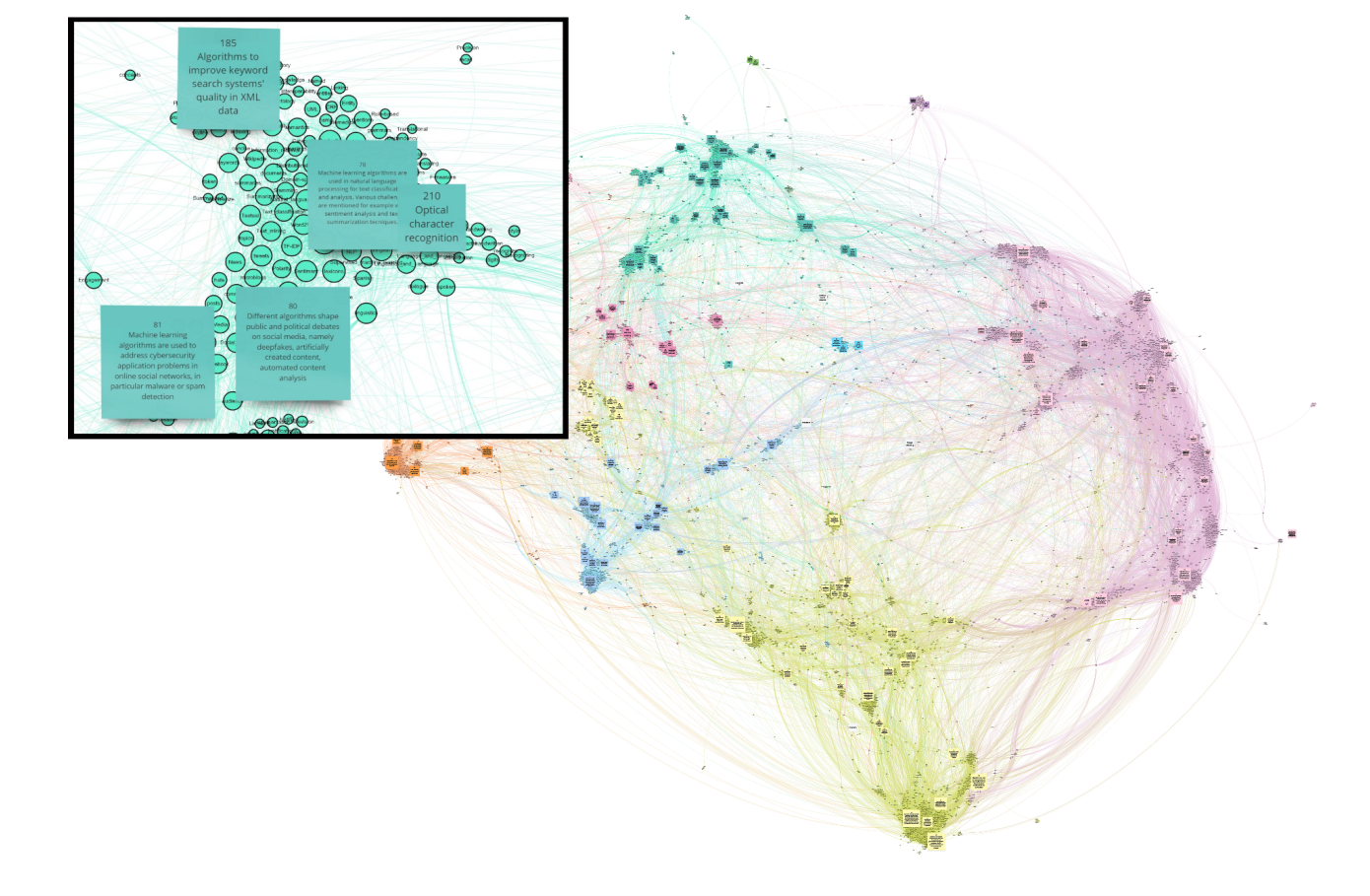


Figure 4. Screenshot of the Miro board where notes for future annotations were placed on the map. In the top left corner a section of the map is zoomed-in.

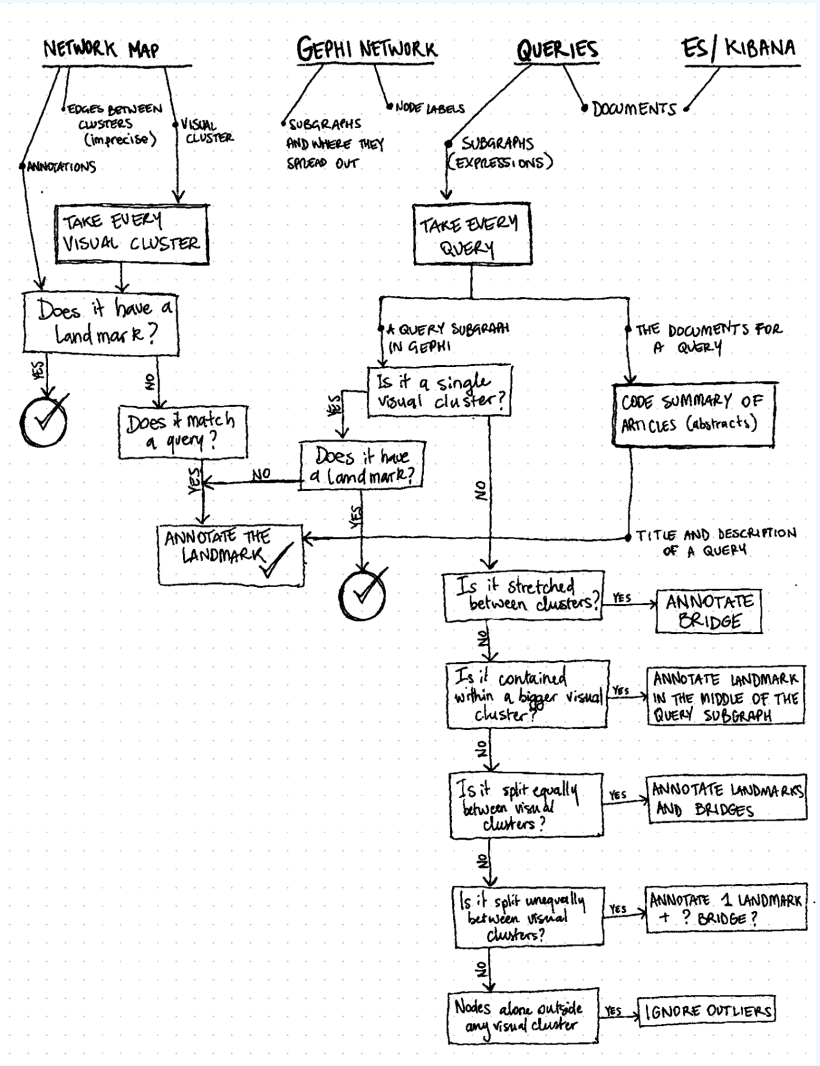


Figure 5. Visualisation of the protocol used to annotate the map.

We developed a protocol (see figure 5) that clarified the visual outcome for a wide range of encountered scenarios throughout the process. Once we started with the annotations, we made sure to employ the protocol diligently to ensure a transparent approach in the determination of our decisions and a consistent design in the visual outcome.

Regarding the annotations, the tracing of each word and symbol that was placed on the map came after an iterative process of visualising, filtering, labelling and collectively discussing each decision. A version of the map was printed out in an Ao format so that it would be possible to annotate it manually. Opting for this solution benefitted the collaborative procedure, encouraging discussions of translation and design choices since it required us to work together. The translation process is a key element in the development of the map because the aim was to design it so that it could be part of an atlas that is understandable by an audience which is not trained in network analysis. Essentially the goal was to simplify the language without compromising the accuracy and comprehensibility. To annotate the map we decided to draw on Kevin Lynch's *The image of the city* (1960) and use some of the terms that the author employs to categorise different parts of urban spaces. The negotiation of the terminology from

environmental planning studies enabled us to to create annotations that would indicate landmarks, bridges and areas. The landmarks were annotated consulting the placeholders that were previously positioned on the digital version of the map in Miro, whenever a query would match a visual cluster this would get annotated with a landmark (a few other minor cases could result in the annotation of a landmark, see the protocol in figure 5).

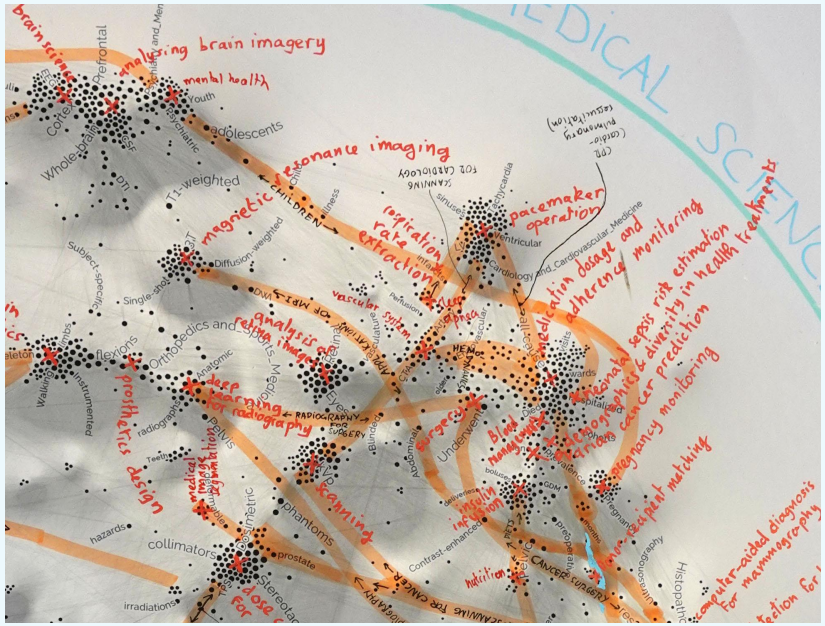


Figure 6. A section of the printed map that shows landmarks annotated in red and bridges in orange with a black label. The section is part of the health and medical science area, annotation that can partly be seen on the top right corner.

Picture of me and Mathieu manually annotating the network visualisation with coloured pens on a printed version of the map.

Figure 7. Visualisation of the bridge queries. The queries have been given different colours to visually differentiate them and facilitate the annotation process.

The method adopted to annotate the bridges was similar but, because of the impossibility for one placeholder to cover the whole area, or most of it, we opted for a supplementary visual representation of the bridge queries (see figure 7), that we analysed one by one and annotated on the printed map as an orange bridge with a label that would serve the same function as the landmarks.

It is worth noting that the bridges that have been marked down in orange do not represent the edges derived from the network but, instead, they are topographical bridges, meaning that each of them, exactly as the red landmarks, derive from the analysis of a specific query. However, in this case, the cluster in the network has been stretched out between two or more points, giving it an elongated look, spreading the nodes on the map.

On an analytical level, we can see how this case works in figure 8 where, on the left,

we are presented with a cluster that has nodes and landmarks like ‘words’, ‘sentences’, ‘text classification’, and, on the right, another cluster with ‘listening’, ‘speaker’, and ‘music genre recognition’. These two clusters become connected by a bridge labelled as ‘language’ because this comes from a query that comprehends nodes that have been spread in both clusters, hence the logical connection between the three elements.

Once the queries had all been analysed and reported, and the map was fully covered, a final digital version was created (see figure 10). This version of the map presents about 12 large areas, approximately corresponding to research fields: health and medical science; genetics; chemistry; remote sensing; materials; flight; fluids; electricity; signal processing; cryptography; computer science; economics; and social science.

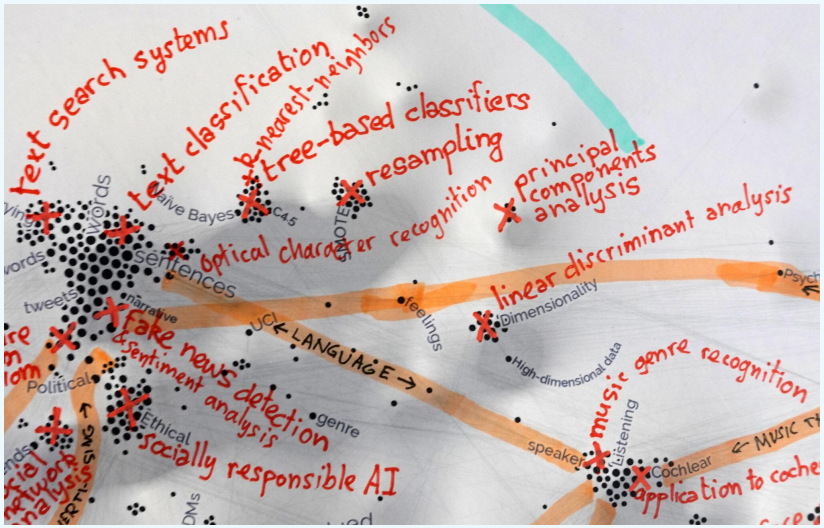


Figure 8. Example of a bridge in the hand-annotated version of the map. Bridges derive from the analysis of a query, just as landmarks, but appear stretched because of forces pulling their nodes in the network.

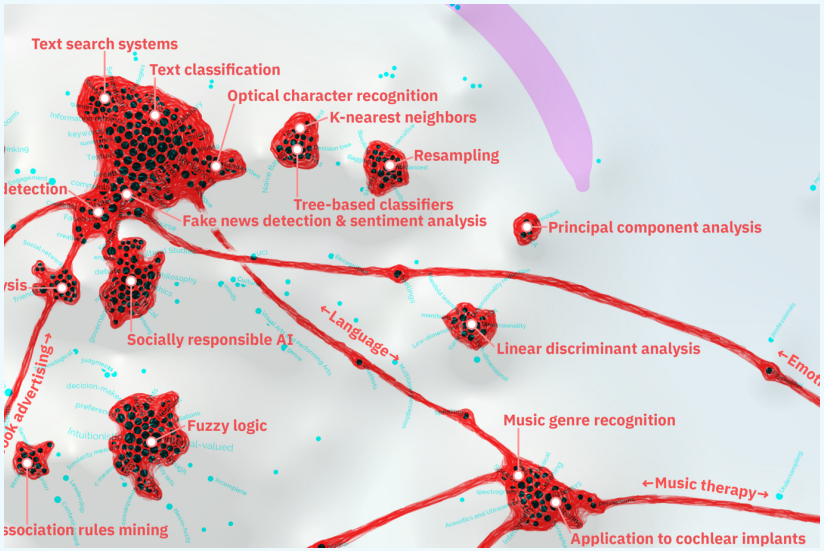


Figure 9. The same section of the map that is represented in fig. 8 is shown once rendered in its final digital version.

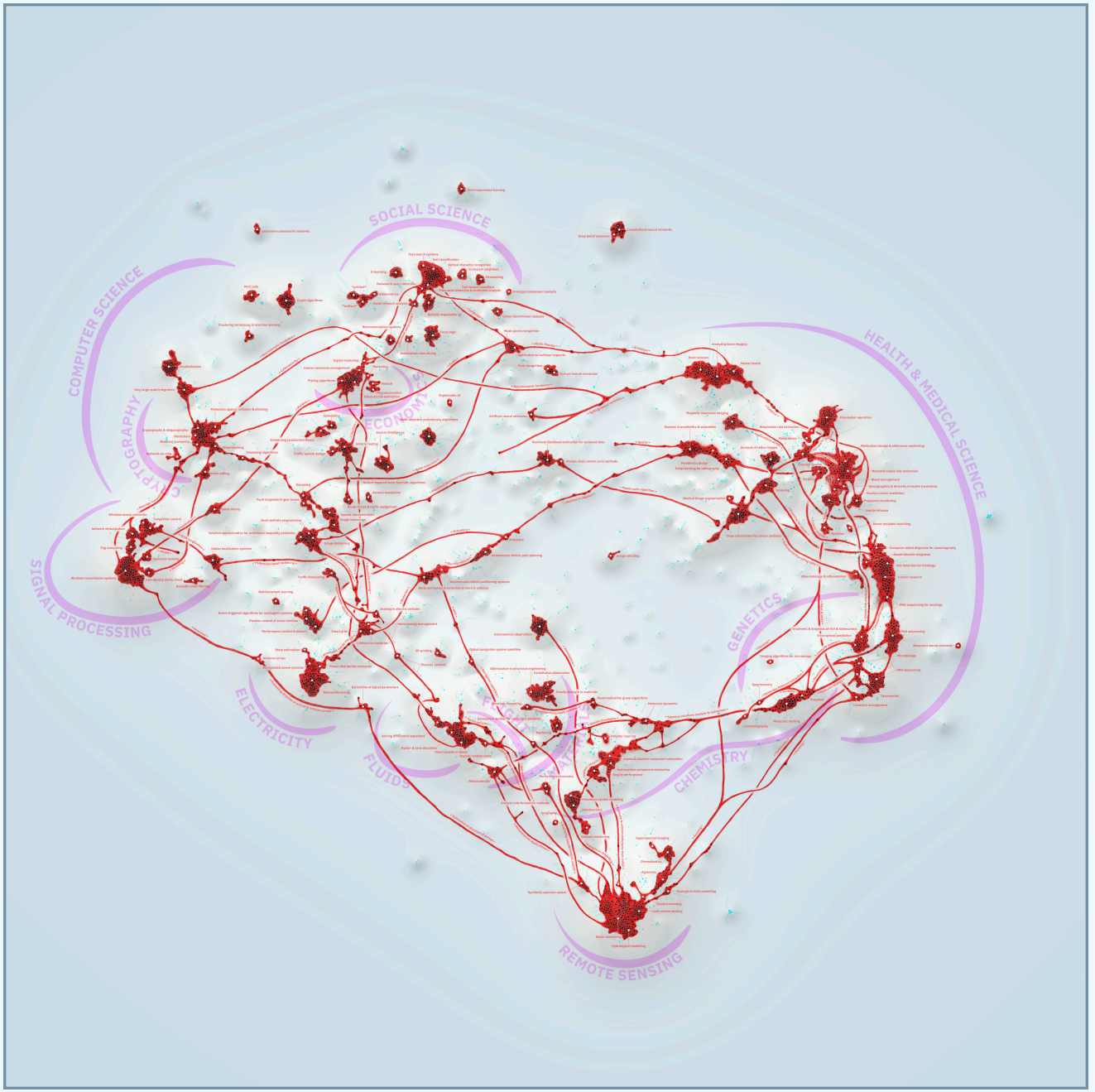


Figure 10. The final version of the Scopus map.

The areas are purposely only indicated with a vague limit, as it would be pointless, from our perspective, to strictly place such a border between nodes. Furthermore, the areas do not entirely cover the map, as some clusters do not necessarily fit within our partitions. The map has been rendered with red and cyan as main colours. In particular, the layer with cyan dots and labels provides information about the underlying data, representing the co-word network created from our dataset where the edges have been deleted to prevent visual clutter; in red, we see our qualitative annotations. It is crucial to note that, when overlapping, the red layer makes the cyan layer appear black.

This colour division has been planned so that when looking at the map through either red or blue coloured lenses, the observer would only see one of the two layers, as shown in figure 11. A similar effect can be obtained by looking at the map through 3d anaglyph glasses, closing one eye at a time. As the areas markings were meant to facilitate the understanding of the map without prevailing the rest of the annotations, they have been rendered in light purple, remaining fairly muted when looking at the map as a whole and only appearing with a light colour when looking through the blue lens.

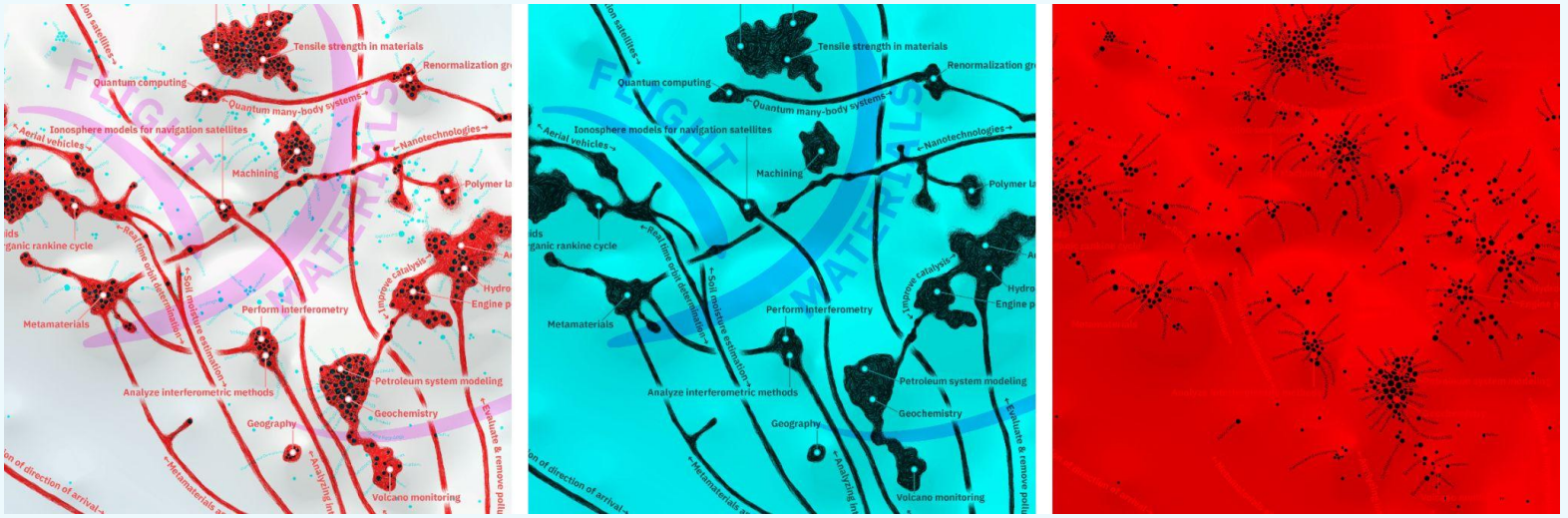


Figure 11: Three versions of the same section of the Scopus map. Filtering through different coloured lenses will emphasise certain details and mute others.

Thinking the atlas

At this stage of the study, the reader has an overview of the background work that equipped us with a product that would serve as base for the design of the atlas of algorithms, but also a tool to be used in the interviews that will inform the atlas' design process.

The following research chapters will introduce elements from our methodological choices and theoretical background, presenting the actors that were involved in the study and the methods used to ensure that the development of the project was based on co-creation practices.

The design chapters will immerse the reader in the coming of age of the design of the atlas, beginning from the Scopus map.

The first two design chapters (*Diagnosing the issue* and *Following the actors' voices*) are meant to show and analyse the material generated through the interviews, providing reflections on the state of the education programmes investigated through their curricula and the experiences of the teachers. These sections focus on the topics of algorithmic literacy and knowledge translation, concentrating on the challenges that teachers and students face when dealing with algorithmic literacy, the tools that are employed to do that, and the requirements for the design of a potential educational tool. Moreover, conversations with AI experts that are involved in the ADD project will provide an additional point of view on the relationship between publics and academia, giving points of reflection for stories that could be told through the atlas. Through their experience, in fact, the reader meets particular algorithms and sees what questions and curiosities the public have about them.

The last section (*Putting the pieces together*) will be centred on the reflections and ideas about the atlas' format that were discussed in Tantlab once the interviews were done and the analysis of these was ongoing. Here, the design process takes shape when the atlas' developers respond to the inputs from the interviews aiming to find elements and solutions that will help create a meaningful tool for its potential users, Danish highschool teachers.

Looking for the actors

To answer this study's research question about how to design and develop a tool to facilitate the teaching of algorithmic literacy to Danish high school students, an inquiry about the Danish high school system was necessary. In order to do this, semi-structured interviews were conducted with different teachers working in the Copenhagen area, where they were asked about their opinion towards challenges and needs regarding digital education and digital literacy, subjects and discussions they present to their students everyday, and if and how they could see our project be a helpful and meaningful integration in their classes.

The process of selection of the interviewees started from an outreach initiative of the ADD project: in November 2022, the outreach team organised a partner conference where people from several institutions associated with the ADD were invited to attend presentations and debates around the projects that the different work packages were working on. Our team presented, while still in a preliminary phase, the Scopus map, as a mapping of academic research on algorithms and AI that was being developed. Our goal for this event was to observe what the reaction from a diverse audience, stemming from different backgrounds, predominantly outside academia, would be to our research efforts and, from there, discuss how and for whom this material could be interesting and useful. Notably, at this stage, we generally thought about designing an atlas of algorithms tailored for a broad non-academic public without having a clear reference audience. During the ADD partners' conference, some of the participants that showed the most interest towards our project were people connected to education, which steered the decision to design an educational tool that would talk to students. In particular we established a connection with representatives from *Foreningen Af Lærere i Samfundsfag* (FALS) "association of teachers in social studies", and IT-vest, an ICT-focused educational and scientific network, formed by three Danish universities that seek to develop digital literacy and computational methods education in primary and middle schools, and higher education. Within these groups, several people that work around the Copenhagen area, for accessibility

reasons, and teach in higher education programmes were chosen and contacted asking for an interview in order to set off a process of co-creation.

Once the Scopus map was finalised, the following step was to understand how to create an atlas starting from it.
When undertaking a design process, identifying the target audience becomes crucial. This ensures that the tool that is being designed will be aligned with the needs and requirements of the potential future user. Involving the teachers at a stage where we don't have the atlas yet helps us understand which stories to select, curate, and develop. Involving them early in the process allows us to understand what kind of stories are relevant for them, and where their interest meets ours. This process brought us to mostly focus on social science discussions and public controversies.

As previously pointed out in this study, our project started from the ambition to facilitate accessibility to scientific research on algorithms, influenced by the societal necessity to keep pace with technological advancements, and to simplify access to stories and narratives around algorithms that can enrich the public discourse. Currently, the Danish government seems to agree with this necessity, at least regarding public education, as evidenced by the publishing of documents and guidelines in recent years to regulate the integration of digital education within school programmes (Børne- og Undervisningsministeriet, 2021).

Efforts to provide technological and digital education are present as early as primary school in the Danish educational system. However, because of the type of tool that is being developed, and its possible integration in certain domains, this study focuses on high school teachers and students as possible users. This choice also stems from the fact that high schools serve as a commonly utilised sample in similar studies and investigations, thus facilitating meaningful comparative analyses in line with the references cited in previous chapters. Admittedly, today citizens are exposed to the use of technology well before their high school years. In fact, it is more and more common for children to quickly gain familiarity with the use of technological tools. However, it is mostly during the secondary school phase that young citizens start to develop a critical understanding of certain technologies and their application and consequences in societal and personal life aspects.

Meet the actors

In the study, the interviewees from the teachers' group will be presented as T(1/2/3/4) for anonymisation purposes.

The first participant (T1) is a political science teacher in an stx gymnasium[1]. They were contacted to participate in the interviews because of the interest they showed during the partner conference towards our research presentation.

The other participants are all teachers that are part of a Special Interest Group (SIG) from IT-Vest for the relation of informatics to other subjects. The groups focus on how computational methods, as a new language, can renew teaching in different subjects and school levels. Seven different SIGs divided by field have been established. The teachers that have been involved in the interviews were higher education teachers belonging to the SIGs of language, humanities, and social studies and mercantile subjects. T2 is a Danish and drama teacher in a stx gymnasium; T3 is an informatics teacher in stx and hf gymnasium, and T4 teaches social science and history in stx and hf gymnasium.

Another type of interview was conducted with AI experts. At first, they were meant to be recorded and used as short video-portraits of specific algorithms, where the researchers would explain, in a moderately simple language, what kind of algorithms they work with and what type of research they do, where are the algorithms used and for what, and what are the connections with other research areas.

Picture from a teacher's interview. Discussions around the map.

[1] Danish upper secondary schools are differentiated by education programmes, namely stx, hhx, htx, hf. Every school, according to their curricula, has specific subjects on different levels (A,B,C).

The videos were intended to be integrated in the atlas as the first idea was to develop it as a public website. However, the purpose of these interviews changed along with the evolution of the atlas' design process. As our research proceeded, and as the interviews informed our choices, the ideas for the format of the atlas shifted from a website to a more tangible tool, making the integration of videos more difficult.

Nevertheless, the interviews with the experts became important to get their perspective on the public's interests regarding scientific research on algorithms. This will inform the stories' curation and the annotation process for the atlas.

The experts involved for the interviews were three researchers connected to the ADD project. A bigger list of names was compiled at first but as circumstances changed, the interviews were put on hold.

The experts that participated in the interviews are:

- Sine Nørholm Just, professor from the department of Communication and Arts at Roskilde University, and Principal Investigator of ADD;
- Helene Friis Ratner, associate professor from the Danish school of education at Aarhus University
- Ida Schrøder, postdoc researcher from the department of Education studies of University of Aarhus

Interviewing different groups

The interviews that shaped this study's fieldwork have been conducted with two different types of interviewees, namely high school teachers and AI experts, and had, therefore, different purposes, styles, and approaches to the analysis of the generated material.

As the aim of the project was to design the atlas of algorithms as an educational tool for schools, involving the potential users to participate in semi-structured interviews was a way to ensure a process of co-creation that would facilitate the atlas' format design but also the curation of the contents of it.

As a methodological reference to conduct the interviews I mainly used *Qualitative Interviewing* (2013) by Svend Brinkmann.

The interview guide was structured based on this study's research questions but these were never mentioned as they appear in the thesis. Instead, they were just providing the themes that would steer the dialogue in order to get a more nuanced vision around the issues and keep the conversation flowing.

The interviews would always start with an introduction about myself, the atlas project, and my position within it. Within the

teachers' group, I tried to keep the tone of the interviews quite informal since the participants did not know me nor the research group beforehand and I wanted to avoid discomfort or them feeling part of an evaluation inquiry about their teaching. Only one participant already had a certain level of familiarity with the Scopus map, as they personally participated in the ADD partners' conference where we presented it. The rest of the teachers were not aware of our project but participated in other initiatives from IT-Vest and ADD and quickly showed interest in our research.

A consistent part of the interviews with the teachers was of exploratory nature since, as an international student that has been living in Denmark only for a short time, I was not familiar with the Danish higher education system. From the study perspective, I tried to use this lack of knowledge as a factor that would guarantee me a favourable position, allowing me to ask simple yet fundamental introductory questions about how the classes are structured, what kind of assignments the students get, and how are the contents of a course selected. During the initial phase, the objective was to generate rich descriptions about the participants' experiences. Whenever any noteworthy keywords or events relevant to my research emerged from the teachers' responses, I tried to stay on topic with follow-up questions, to get deeper insights and give more value to their perspective on the matter.

After the exploratory phase, I introduced the Scopus map as a third actor in our conversations, both in material form so that it could be placed on the table in front of us, and digital so that it could be zoomed in and explored in detail. One of the principles that ANT revolves around is the fact that non-human actors are also viewed as agents participating in networks, and can play central roles in translation processes. Because of this, I wanted the teachers to be able to interact with and explore the map, use it as an elicitation tool in the interviews to get the interviewees' opinions, see what areas and keywords they would show interest for, and how our conversations would be shaped by the presence of the map in front of us. Semi-structured interviews resonate well with this way of pursuing elicitation as this interview approach allows for unexpected discoveries and creates space for stories, while also requiring a clear focus and predetermined purpose for the interview.

In this regard, it is worth noting that, because of some schedule difficulties, one of the interviews had to be conducted online meaning that the only way that I could show the map was by sharing my screen with the interviewee. On this occasion, the conversation never reached the same level of interest and

engagement that other interviews did, and I was not able to go beyond the first phase with my questions.

All the interviews were recorded and transcribed. Then, based on my research interests, algorithmic literacy, knowledge translation, and format design, I created five categories that resonated with these and that I have discussed with all the participants. The categories were 'tools', 'state of education', 'readiness', 'topics discussed in classes', and 'atlas requirements'. I selected, from the transcriptions, quotes that were connected to one of these and placed them all together on a digital board to have a full overview of the opinions and discussions. I colour-coded the posts depending on the interviewee so that I could easily go back to the full interview when needed (see figure 12).

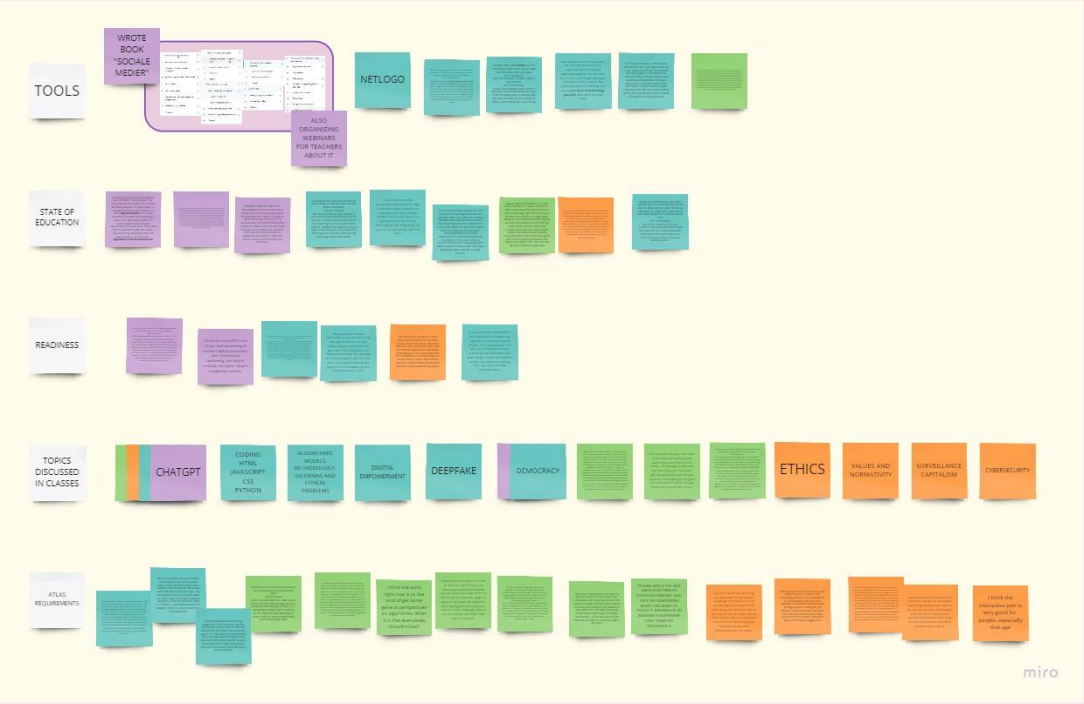


Figure 12. Screenshot of the Miro board where I collected and categorised parts of the interviews' transcriptions.

The interviews with the AI experts were framed differently. As mentioned before, these interviews were video recorded because their initial purpose was to be used as short video annotations for the atlas when this was still planned to be developed in a digital form. The videos portrayed the experts standing next to the Scopus map so that they could interact with it while talking. After a short introduction of themselves and their work, they were asked to locate the area of the map where their research would belong to. The rest of the interview would see them placing their research in the map, explaining different elements of it, talking about key events and challenges that concern algorithms, and where the public interest lies.

The co-creative effort in these interviews would have been achieved by giving voice to the actors, in this case the experts, and having them explain our Scopus map so that this could become an intervention that creates a space of communication between academia and the public. Having the experts participate and explain the map was, among other things, a necessity from our perspective. The Scopus map represents many different research domains, most of which are not of our competence. Our annotation process could only reach a certain level of coverage and explanation by reading the papers' abstract and trying to summarise them in a few words. In our opinion, the best way to get more nuanced and accurate annotations was to let the actors explain our findings and tailor their stories around our work. The Scopus map, in fact, does not come with conclusions but rather has the setting of an open-ended, explorative tool that was built to find stories.

However, as the atlas changed its format during the design process, the interviews with the experts acquired a different purpose. The parts of the interviews that will become central now are the experts' answers to the questions about the public reaction and interests. Their experience of what the public is interested in knowing will be crucial to shape the stories that will be curated for the atlas. This aspect of the design process will not be analysed as much as the teachers' counterpart in this study, as the collection of material for this study stopped at a stage where there was not a clear project for the employment of these last interviews. Nevertheless, a brief section in the following chapters will be dedicated to a more in-depth exploration of this element of the research.

Picture from an expert's interview. Looking for relevant keywords.

Diagnosing the issue

This first part of the chapter focuses on the analysis of the material generated from interviews that have been conducted during April and May 2023 with teachers from different high schools in Denmark.

Through our dialogues, I am investigating what is the current state of algorithmic literacy within Danish high school education and identifying requirements, needs, and different efforts that are made to educate the students on this topic. Reflections on this data will serve to structure fundamental reflections and build a diagnosis of the issue.

One of the focal points of the interviews revolved around the unravelling of the requirements connected to the teaching of algorithmic and digital literacy, to understand what the schools depict as necessary knowledge for young citizens, followed by more in-depth questions about how the teachers fulfil those requirements in their courses and how they discuss certain contents with the students.

As an answer to that, the teachers often referred to the *læreplaner* (i.e. the curriculum that describes academic goals, content, and principles for the different subjects in Danish upper secondary school programmes). The curricula present specific goals and contents for the different subjects and for every type of school. Danish high schools don't present a specific subject in their programmes about algorithmic nor digital literacy. Some schools have, in their programmes, subjects that to some extent relate to algorithmic literacy, namely *informatik* or *teknologi* (informatics or technology); albeit all the different subjects' curricula have a chapter titled 'Didactic principles' that presents a section about IT.

T2 is a teacher of Danish and drama in an stx programme school and during our interview, we consulted together their reference *læreplaner* (Børne- og Undervisningsministeriet, 2017), which in the aforementioned section states (my translation):

> "*The Danish subject contributes to the students' digital education by working with digital analysis objects and the internet as a knowledge resource and digital community in daily teaching. The receptive and productive work with texts in digital*

communities teaches students to relate critically-analytically, responsibly and reflectively to the digital media and their possibilities of use. Through the preparation of written, oral and multimodal productions with a focus partly on professional communication and partly as part of creative and innovative solutions, students learn to use IT in professional contexts. The students' work in developing and reflecting on their own digital identity promotes the opportunities for citizens to orientate themselves and act in a modern, democratic, digitised and globally oriented Danish society."

When consulting different curricula with the other interviewees, the IT sections looked similar in contents and proposed different applications based on the subject that this was referring to. Nevertheless, the emphasis seems to gravitate around keywords like digital identities, digital media, digital communities, and the ability to develop a critical and analytical perspective towards these elements to become citizens that can adapt in an increasingly digitised society.

Curiously, despite the recurring presence of these digital dimensions, there is no sign of the term 'algorithm' in the curricula. This omission was pointed out several times by the interviewees, underscoring a critical effect:

> "*We have this læreplaner which is like the overall view of the things we have to teach, in very broad terms, and algorithms aren't a part of it. Some teachers take it up, I do it very much myself, and others do, but it is not required to do that.*" (T1)

It is evident that while some educators might choose to propose the topic in their classes, there is no binding requirement to do so. The lack of a precise reference to algorithms, their applications, and consequences in the curricula results in the students only receiving this type of education as long as the teachers are interested in it and are capable of delivering it. Potentially, this can lead to a considerable imbalance in the quality and level of algorithmic literacy that is provided across different courses and education programmes. In certain cases, this variable could mean that the students might even not get exposed to this domain at all, as the reflection from one interviewee points out:

> "*I think it* [algorithmic literacy, ed.] *should be part of the curriculum. You should know about that. And a lot of our students who will finish this*

summer won't have a clue. Some do, but a lot haven't had any teaching about it." (T4)

Underpinning this situation, is the concept of '*digital dannelse*', the Danish term that is used to set the boundaries of the IT didactic principles section in the curricula and whose translation sits between 'digital education' and 'digital literacy'. What this knowledge comprises can vary based on which subject it is applied to. For example, referring to this issue, one of the teachers states:

> *"I'm supposed to teach digital literacy, but it's called digital dannelse, it's not completely the same. And what does it mean for me in the high school system? I'm meant to teach documentaries, films, and social media [...] Algorithms are not mentioned at all."* (T2)

In the curricula we see that the requirements for the subject themes are kept quite open and vague, the main focus seems to be on the fact that the contents that are taught should contribute to the formation of citizens that can live in and respond critically and analytically to a society that gives a determining role to its digitisation process. The openness of the requirements gives teachers both more responsibility and control, presenting them with the possibility to determine whether or not algorithmic literacy will be part of their students' knowledge.

Essentially, the absence of explicit references to algorithms within the curricular framework, in addition to the potential vagueness of the concept of *digital dannelse*, culminates in a scenario where, despite the acknowledged increasing importance of this type of knowledge and skills, it is up to educators to determine if the teaching of algorithmic literacy is integrated into their subjects, as well as the modalities of it.

When addressing this situation, my interviews with the teachers were naturally steered towards questions about methods and tools. As our intent is to design a tool to help provide algorithmic literacy, it is necessary to get a more clear idea of what kind of tools the teachers already have, how they have access to them, and how these are used by them and the students during classes.

The lack of material, especially textbooks, that could address themes surrounding algorithmic literacy has been pointed out several times during the interviews. This situation brings the teachers to have to look for teaching materials themselves, which often appears to be challenging.

> *"And then we have some books, but not a lot addressing these issues so there's a lack of teaching books for my courses. So you have to find things yourself, and that's not that easy."* (T4)

To solve this problem, some of the teachers decided to create their own tools and write books themselves so they could use them in their classes, following the needs of their specific curricula and programmes.

> *"I've written a book for teaching about technology and society and the connections there. Now I teach at the stx, the broad gymnasium, and previously I was at Sukkertoppen Gymnasium which was a technical gymnasium* [i.e. htx, ed.]. *There the political science part had to, someway, deal with the connection between technology and society. So that is why I wrote a book about that."* (T1)

> "*I've just written a book, not on algorithms, but that's a part of it. For teaching also how to deal with all the unknown matters of what's happening to you whenever you act on the Internet, [...] especially on social media.*" (T2)

In this situation, where educational demands are not adequately met by the provided materials, teachers find themselves in the position of having to address this deficiency. Thus, teachers have the possibility to create their own tools, but two elements become of crucial importance in this scenario: expertise in the field and the willingness to do so.

Other solutions employed by teachers involve the use of recorded lectures or talks by experts, particularly to address the more theoretical aspects of what an algorithm is and how it functions.

Regarding the technical aspect, not many consider it necessary, but those who do often utilise software and websites that teach certain types of algorithms through gamification. Many teachers seem to agree that the elements of gamification and hands-on experience are crucial, emphasising that interactivity is a feature they seek in the tools they use, as, they argue, it constitutes a more effective method of learning.

On the other hand, the use of "external" tools that are not originally designed with high school students and teachers as target audience highlights the significance of format design in addressing these issues. A tool designed with a different target audience in mind runs the risk of being highly ineffective, especially in the field of education, sometimes presenting

problems such as overcomplication or oversimplification of certain elements or tasks and ultimately failing to engage the students' interest.

Another issue stemming from the curricula seemed to be that this type of knowledge and related skills are not part of what the teachers are requested to test the students for. Some argue that this sometimes leads to teachers opting to not cover algorithmic literacy in their courses or to do it just partially.

> "*What is it that you are asked to teach?"*
>
> T4: *"It's very fluffy, actually. They use a term called* 'digital dannelse' *and everyone has to address it in their teaching, but it's not a part of the exams. [...] None of the digital skills are at play during the exams. So, in reality, they don't play a very big part in the teaching every day*"

What we have seen by now is that the challenges that first arise when investigating the state of digital education seem to reside in unclear indications regarding contents and, moreover, in the fact that this type of knowledge is never a part of the exams, which makes some of the teachers undervalue the importance of an education on certain topics. Therefore, surely a solution to these issues would have to be found in potential updates of the curricula. Admittedly, the Danish education system seems to be already moving in that direction if we observe efforts like the experimentation of the test subject *teknologiforståelse*, carried out in primary schools by *Børne- og Undervisningsministeriet* (the Ministry of Children and Education) from 2019-2021. The evaluation report from the experiment does not provide a definitive answer on whether *teknologiforståelse* will be implemented as a subject in the Danish school curriculum. However, the report states that the experiment serves as a basis for a political decision on whether and how technology understanding can be strengthened as part of compulsory education in Denmark.

To possibly create a potential different curricula with elements and notions that would contribute to the provision of algorithmic literacy to students, however, one of the preliminary conditions would be for teachers to have the necessary knowledge and to be prepared to implement it into their subjects, a factor that the experiment's participants as well have indicated as challenging.

We have seen that the presence of elements of digital education in the curriculum of each subject necessitates a certain level of preparation by all teachers, which seems it might not always be encountered. According to the interviewees' opinions, overall, the level of preparedness that would be

necessary to support the integration of an education that focuses more on algorithmic literacy is lacking.

Discussing their experiences with the teaching staff and their perceived level of preparedness among colleagues to integrate this education into their subjects, the received responses uniformly showed pessimistic viewpoints.

> "*Do you think teachers would be ready to provide this education?"*
>
> T4: *"No, in general, no. That's the short answer. The longer is that at school there are some informatics teachers that are quite prepared to take these talks and to develop a course with other teachers, but in general no. We don't have enough knowledge to talk about algorithmic understanding, coding, looking at code and discussing what is the intent in it, and what is dangerous or could be dangerous. And I think that is a big loss in education right now. We don't have the abilities to do that [...] I think we're trying to take the debate and the general talks, but we do not understand what's going on behind it, we need more knowledge."*

It is important to remember that the interviewees are not strictly informatics or computer science teachers, instead, they all work in different schools and teach different subjects but, together, are part of a group whose efforts are aimed to find solutions to implement computational methods as a new language to renew school subjects.

> *"About artificial intelligence, I think there's a lot of teachers in social science, or political science, a lot of them don't have the expertise to understand what's going on. So it's very difficult for them to have the discussion or take it in as part of their classes. How can they really discuss how it affects democracy if they don't really know what's going on?"* (T1)

The lack of expertise and knowledge raises doubts about the quality of the teaching when it comes to implementing discussions about algorithmic literacy. It is evident that without a foundational understanding, that is an algorithmic literacy that the educators need to have in the first place, establishing interdisciplinary connections between specific elements of the digital realm and discussions derived from their subjects becomes a challenge.

To conclude, if the aim of the education system is to move towards increased societal digitisation, this will need to make an effort in that direction creating curricula that address issues, tools, and applications in the field of digitalisation and algorithms more clearly, and take action in providing appropriate algorithmic literacy. The creation of a tool that can be implemented in the programme by different schools to provide algorithmic literacy is certainly a step that can facilitate the evolution of this teaching, especially when designed through a process of co-creation with the teachers.

Actor-network theory and controversy mapping

This chapter provides a brief overview on the theories and studies that set the framework for this research. In particular, a zoom into two key elements for this study will be provided: the concept of boundary object and the concept of translation, introducing how these have been shaped and how they became central in science and technology studies (STS) and, more specifically in the domain of Actor-Network Theory (ANT) and controversy mapping. This will help understand how and why this study has its bases on those concepts and how these connections necessarily move certain decisions and actions.

In the landscape of STS, ANT stands as a prominent methodological tradition, founded in the 1980s by Michel Callon, Bruno Latour, John Law and others.

ANT fundamentally rejects rigid theoretical frameworks and calls for a suspension of a priori judgements in investigations. This way, it encourages us, as researchers, to remain impartial and resist both realist and relativist notions of truth and power (Venturini & Munk, 2022).

Despite the labelling, ANT's founders often denied it even being a theory. In the book *Actor Network Theory and After* (Law & Hassard, 1999) Latour argues:

> *"Far from being a theory of the social... it always was, and this from its very inception, a very crude method to learn from the actors without imposing on them an a priori definition of their world-building capacities."* (p.20)

ANT emphasises the impartiality of the observer, advocating for the scholar to learn from social actors more than from handbooks, refraining from censoring them when they express their views or discuss the social environment.

"No point of view is privileged and no interpretation is censored." (Callon, 1984, p.200)

As a reaction to the increased digitalisation of public debate, within this methodological tradition, digital methods became crucial and served as a pivotal tool for operationalizing the discipline of controversy mapping. This research approach enables social scientists to navigate the complex terrain of socio-technical controversies, merging qualitative and quantitative aspects of research.

The quali-quantitative approach aligns with the essence of controversy mapping, making it an apt technique for capturing the dynamics of sociotechnical disputes. As science and technology increasingly shape political discourse, controversies surrounding technical infrastructures and expert knowledge have gained prominence. To unravel public debates, accommodate diverse viewpoints, and enhance our understanding of collective disputes, controversy mapping emerges as a form of mapmaking. While it may not be geographical or graphical in the traditional sense, it strives to provide a comprehensive and nuanced representation of sociotechnical landscapes (Venturini & Munk, 2022).

This interdisciplinary approach allows researchers to grapple with the digitisation of public discourse and bridge the divide between qualitative and quantitative research methodologies.

In line with ANT principles, it is essential, in controversy mapping, to view controversies not as problems that need fixing but as 'generative events' (Whatmore, 2009) that shed light on the transformation of the social fabric, highlighting the intricacies and tensions within public debate rather than simplifying or dismissing the actors' voices.

Venturini and Munk (2022) explain that one of the reason to map controversies is, in fact, "*to help their publics to take sides, not by proposing simple solutions, but patiently unfolding the multitude of issues and voices that articulate them*" (Venturini & Munk, 2022, p.43).

In our case, making the map and the atlas available to the public, and specifically designed for educational purposes, empowers the involved actors to engage with and interrogate the maps, fostering a more equitable and participatory approach to sociotechnical debates.

To get a deeper insight into the study and the project, two conceptual tools will be introduced and employed: the notion of translation and the concept of boundary objects.

Mapping as translation - Maps as boundary objects

Originally discussed in anthropology and ethnography studies, and later used by STS in a more socio-technical key, the concept of translation quickly became one of the most important to ANT, which was also known, at the beginning of its development, as 'sociology of translation'.

The process of translation can be found at the base of many aspects of human communication and interaction. For anthropology scholars, translation has always had a central role in studying issues of encounters and communication dynamics between cultures, facilitating an understanding of how different social practices can mutually influence and shape one another (Geertz, 1973; Clifford & Marcus, 1986; Ingold, 1994). Over time, the concept of translation gained complexity and started indicating not only the transfer of information but, more broadly, all the practices around the negotiation of meaning and knowledge creation.

This specific take on the concept is what ANT scholars have used to study the role of this process within the development and spread of scientific and technological knowledge through networks and social actors. Using Callon's (1986, p.18) words: "*Translation is the mechanism by which the social and natural worlds progressively take form*". This includes the impact of translating scientific texts and technical language on the development of new ideas and theories. It also addresses how the process of translation can affect the sharing of scientific knowledge across diverse cultures and communities, shaped by cultural and social dynamics (Callon, 1984; Latour, 1988; Star & Griesemer, 1989). Latour's perspective suggests that scientific knowledge is always created and shared through a process of translation that involves the collaboration of various actors like scientists, policymakers, journalists, and the general public, that work together to obtain a shared understanding of a matter starting from divergent positions:

> "*First, translation means drift, betrayal, ambiguity. It thus means that we are starting from inequivalence between interests or language games and that the aim of the translation is to render two propositions equivalent*." (Latour, 1988, p.253)

Various aspects on different levels of this study can be reconnected to and labelled as translation processes.

The discipline of controversy mapping can be seen, in this light, as a broad process of knowledge translation. Venturini and Munk (2022, p.43) explain, in fact, that one of the reasons to map controversies is "*to help their publics to take sides, not by proposing simple solutions, but patiently unfolding the multitude of issues and voices that articulate them*". This appears to be particularly important in an era of social media and fake news where translating otherwise prohibitive debates and controversies in a way that these become understandable by the masses, can democratise knowledge dissemination.

The translation concept takes on a different but equally crucial form when dealing with algorithms. Algorithms themselves can be seen as translation processes, albeit black boxed ones. To unveil their inner workings, we must translate the translation itself. In the computational perspective, these translation processes are often considered "*strictly rational concerns, marrying the certainties of mathematics with the objectivity of technology*" (Seaver, 2019, p. 412). This perspective, if not challenged by a broader view, can obscure the more intricate aspects that underlie algorithmic dynamics, production, and usage (Gillespie, 2014).

Lastly, the concept of translation can here be investigated in relation to the act of map making. Cartography historians Brian Harley and David Woodward in the introduction of their *History of Cartography* (1987, p.xvi) define maps as '*graphic representations that facilitate a spatial understanding of things, concepts, conditions, processes, or events in the human world*' detaching the notion of a map from the mere objective reproduction of territories but presenting it as a representation that needs to take different implications into account. Drawing from this, Italiano (2021) explains how the semiotic structure of a map expands between the space of the map itself and outside of that space, becoming translational devices that transfer meanings across different media, locations, and time.

Because of this interpretation of maps as tools for translation, in this study I use the concept of boundary object and associate it to the Scopus map. This concept, developed by Star and Griesemer (1989), originates from the grounded theory framework as it arises and is developed as a component of theorization for authors and researchers when engaging with their field materials.

A boundary object can be understood as a scientific object, an artefact, involved in the management and translation of knowledge. A boundary object can be employed at the intersections of different social contexts, serving the

informational needs of each of them. Their meaning can change across different social worlds, yet, their structure is common enough to more than one world to make them means of translation, facilitating communication and understanding among them (Star & Griesemer, 1989). A boundary object is produced by an iterative process, subject to continuous reflections and adjustments in order to meet different actors' needs. Maps have already often been intended and used as boundary objects in numerous applications, because of their efficacy at communicating and integrating distinct interests and knowledge from multiple stakeholders (Bishop et al., 2021).

As mentioned before, these reflections and studies about maps can be applied to geographical maps but not only. In fact, ANT and controversy mapping have, over time, established a solid tradition of data mapping and network visualisation, starting from the development of sociograms from Jacob Levy Moreno, proceeding to Pierre Bourdieu's studies on French society's culture and taste (Bordieu, 1984), up until today's STS scholars employing digital methods to build network visualisations of everyday's controversies from online scraped data.

In conclusion, since knowledge translation is one of the main purposes of a boundary object, this conceptual tool becomes easily applicable in an ANT context where the investigated object is positioned in a network as a non-human actor and serves a translational purpose. The employment of boundary objects as conceptual tools, helps us, in this study, understand and justify the use of the Scopus map as a base for our design process. In fact, this is introduced here as a self-standing product of a research effort, that can be read as is and provides a certain type of knowledge based on data-driven narratives, but, in the context of this study, it should also be seen as a non-human actor that facilitates knowledge translation processes between experts, non-experts, and mediators.

Following the actors' voices

This section aims to analyse how the knowledge translation process needs to be curated, determining which kind of stories the atlas need to present and how these can be best told.

This will be done by portraying perspectives from three different groups of actors connected to the atlas: the teachers, the AI experts, and the atlas designers. Following their voices and ideas, the translation process starts by looking at what kind of discussions the teachers usually bring to the classrooms, understanding what resonates with their teachings and what they find necessary and helpful, keeping in mind what was previously discussed about the curricula and the school programmes requirements. Afterwards, these conversations are compared with observations that emerged during the design process and discussions with the AI experts reflecting on their research while commenting on the Scopus map, so that meaningful connections can be drawn to build a base for the stories that the atlas will tell.

As the range of discussions during the classes can be quite open due to the adaptable curricula, the interviews mainly served an explorative purpose, to understand what kind of themes the teachers were already discussing and what others they thought could be integrated in the future.

> *"I think the work right now is to get some general perspectives on algorithms. What is it that everybody should know? Because this map shows the impact, a huge impact, and importance in every kind of sector."* (T3)

The challenges in addressing algorithms within other subjects seems to come from the vastness of the topic. The vast array of applications and approaches to development makes it complicated for teachers that are not specifically trained on the subject to have a propaedeutic approach to algorithms, starting from basic notions and building connections to other issues. Instead, algorithms are often mentioned as insights for broader themes that are discussed.

> *"It is pretty widespread, an algorithm. I do use the word now and then, like when we're doing an*

accounting system for an app, to get it to calculate prices or, very basic things, to do discounts, or something like that. But it's not a very important part for me to explain. It's so basic and so interwoven with all of the other things that they do. It would be more specific to talk about a certain kind of algorithm, or ways to do things with them, rather than using the algorithm word because it's so vague and I'm not really sure what I would teach the student." (T3)

One of the issues in tackling the topic of algorithms from their basic notions, for T3, lies in their wideness. It seems that the preferred way of providing basic knowledge on algorithms is to explain different applications of them, rather than actually start from what an algorithm is and how it works.

Connected to what was previously addressed, when asked about how they present the topic in classes and what they teach about algorithms, the most common replies presented contents that to some extent mirrored current news media such as AI related controversies, issues of democracy in a data-driven society namely surveillance, privacy, bias, fake news and deepfakes.

"The question is what do they [the students, ed.] *get? We are not making professionals* [in AI, ed.]. *We're making stuff that they should know, whether they are going to be teachers or doctors or whatever. [...] Like bias, that's kind of central because whether you are a doctor, you are a teacher, or you are going to work at the local society, you're going to use some kind of machine model and you have to know that there is something called bias, and you have to think about that when you are using these kind of tools. [...] They need a general understanding, general problems and possibilities."* (T3)

It appears that the difficulty in talking about what an algorithm is might arise from the fact that, not having prior education in the subject, and often being part of a population group that is more prone to some effects of the digital divide, the teachers may have difficulties in explaining what an algorithm is without employing dramatic language and events, drawing almost exclusively from news media content. When this is the only narrative that the students are exposed to, the risk is to relegate algorithms to mere threatening tools whose usage should be minimised because they are perceived as the harmful faulty component of problematic processes and problems.

In addition, a minimal space in the programmes is sometimes left for a more technical study of the topic, which usually concerns algorithmic models and different programming languages, and it seems to interest only certain types of education and subjects. As seen before, in fact, there is no demand, in Danish high schools' curricula, for an introduction to algorithms from a technical perspective, and neither the teachers find it very helpful for their courses to cover that part, given the structure of the education system as it is now.

During each interview there has been a moment when, without it being mentioned before, the interviewees would start talking about ChatGPT, the language model-based chatbot developed by OpenAI that has been launched in November 2022 and has, since then, been at the centre of the media attention.

This is not surprising considering the debate that has been carried out by schools and institutions on how to limit and regulate the use of this technology, and how the school examination system might need to change on account of these types of tools being increasingly available for everyone (Roose, 2023; Stock, 2023). Thus, naturally ChatGPT appears to be a predominant matter of discussion within classes, and it is often used to open up debates about the aforementioned topics.

The way that the classes are structured consists in different themes that are addressed through lectures, hand-on activities, and group or individual assignments. The themes change based on the subject and depend

It is interesting to note how the teachers think that this tool will necessarily bring changes in schools as it gains momentum. Because of this, many have come to the conclusion that the first essential step is to focus on creating awareness and educate themselves about it to be able to make informed decisions on how to proceed regarding its usage.

> *"Yes, there's a new awareness. [...] So yes, some say "we have to forbid this, you know, use pen and paper and get it out", and then there is a huge part that says "We have to reinvent exams" and so forth. And if you have to do that you have to be more aware. So yes, it's a new reality, I think."* (T4)

In the same way, while reflecting on ChatGPT, T2 addressed it as a 'necessary awakening' for teachers

> *"I think that ChatGPT is sort of the hard awakening of teachers within humanities also. A necessary awakening, but they're certainly not aware* [about algorithms, ed.*], they're completely clueless."* (T2)

The conversations around ChatGPT can be seen as a sort of brief investigation on the perception that teachers have of algorithmic solutions. The reflections gravitating around our discussions on ChatGPT seemed to generally reflect the discourse on algorithms portrayed by the news media, which means mostly referring to them as tools that can turn out to be highly dangerous and that commonly present issues related to bias, privacy, and fairness. Thus, perpetrating the same apprehensive view and generating the same reflections, ChatGPT appears as a showcase of the general perception towards algorithms and algorithmic solutions.

On a larger scale, this shows that, because of the popularity of the tool and the huge echo that news about it have recently received, it is easy for the general public to just enlarge and portray a specific tool's narrative into a clearly broader category such as algorithmic applications, perpetuating a limited and generally sceptical idea towards it. It is arguable that this could mainly be connected to a scarce education on the matter, which seemed to peek from some of the teachers' interviews:

> "*In my experience, ChatGPT has made teachers aware that algorithms are not only in social science. They are in mathematics and others. They are also very important in social science due to deep fakes and other things. I think that teachers as well are getting their eyes open on how important this is"* (T4)

This sentence from T4 might sound unclear when stating that teachers are just now understanding that algorithms belong to the maths domain. Of course, T4 knows that algorithms are a mathematical concept but they seem to forget it when the discussion gravitates around ChatGPT and we employ the 'social science understanding' of the concept.

One of the aims of the map is exactly to deal with circumstances like this, opening up the discussions about algorithms, showing various applications, and highlighting connections. It is, in fact, easy to get stuck in a simplistic view when approaching a complex matter we are not familiar with, and reduce it all to the few pieces of information that we are able to reach and understand. In this regard, the interviews with the AI experts are useful as a response to this type of situation: through their stories and their way of interpreting the data and the map, different areas are highlighted and explored, relevant connections between disciplines are pointed out, and we see how different algorithm coexist within fields and support various solutions.

The fact that all the participants started a conversation about and showed curiosity in ChatGPT is relevant to us as mediators and atlas' designers because it shows an interest that was not mentioned when they were asked about topics but that they talk about during classes, but that should inform part of the stories' curation in the design process.

Overall, the discussions about topics helped to get an explorative insight to understand what the key focus of the atlas should be, and, as a result, what the annotations and stories should tell. Following a co-creative method for the design process of this intervention means that the voices of the potential users are of crucial importance to make sure that it meets their needs and interests.

It is worth noting that, when conducting a literature review about education on algorithmic literacy, the discussed issues are not distant from what was brought up by the interviewed teachers. Generally, algorithmic literacy is considered a necessary knowledge to be informed and develop a critique on data democracy, risks of discrimination and disinformation, and, in general, socio-technical implications related to the use of certain technologies. The contribution that our intervention brings is to facilitate an easier way into a wider understanding of algorithms, starting from the creation of a broad landscape of research on algorithms made accessible to non-experts.

Through our interviews with educators and experts, it became evident that while the general public is roughly aware about the critical aspects of algorithms, they often lack knowledge about the fundamentals, such as what an algorithm is, its various applications, and its broader implications. Our intervention aims to bridge this knowledge gap, fostering a more informed and comprehensive discourse on topics that can already be found in classrooms.

While discussions surrounding the use of algorithms and AI in society are undeniably relevant, it is crucial to recognize that the technology itself is not inherently problematic. Nevertheless, this is far from arguing that algorithms are neutral devices. Instead, the atlas will highlight the factors that render algorithms non-neutral and will address and investigate the origins of these issues. When conceiving the map, our primary objective was to offer a more extensive understanding of what it means to do research on algorithms, how we develop them, where we use them, and for what purpose.

It is notably common for AI and algorithms to be portrayed in the mainstream media discourse either optimistically as an uncritical solution or pessimistically as the prelude of a

dystopian future. In contrast, our map's narrative goes beyond these binary portrayals, refraining from judgement or imposing particular viewpoints on these technologies. Instead, drawing from the generated data, it aims to compose a mosaic of research and proposed solutions to problems from different areas, giving voice to the studies and experiences of experts in their respective domains.

While the dataset does contain reflections on controversial aspects and societal implications, these elements do not serve as the central focus of the Scopus map nor the atlas, but just contribute, as much as other elements, to the formation of stories around algorithms in academia.

Picture from and expert's interview. Sine explains her research.

Perspectives from the experts

As previously mentioned, part of the fieldwork for this study consisted in interviews with researchers that study algorithms in different academic fields.

The vastness of the Scopus map and the fact that it comprehends so many different research areas, made it necessary for us, as mediators, to seek for the voices and the knowledge of external actors in order to get more detailed observations about our annotations and our data. To do this, I firstly used our connection with the ADD project, and had some trial interviews with researchers involved in studies concerning algorithms and AI.

Since the plan for the format of the atlas has changed in the meantime, the interviews that have been taken will need to be repurposed for the new setting.

A significant contribution that these interviews provided to this study is about the experts' experience with the public and its interest towards this type of research.

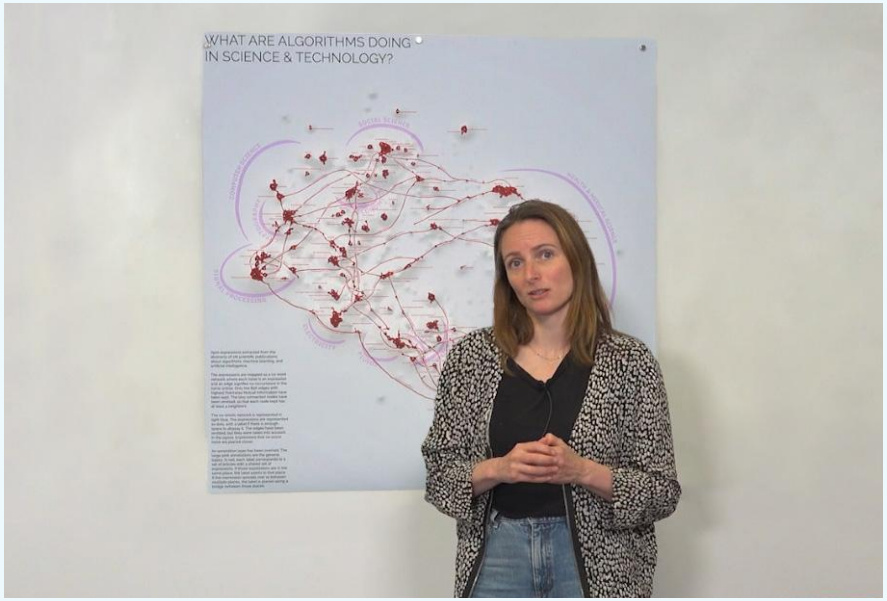
As mentioned before, the atlas is rooted in the Scopus map. With the latter being designed as an open-ended tool to

look for interesting stories, it is highly significant for us to listen to what questions the researchers get from the public and how they answer doubts and concerns.

Sine focuses her research on the socio-technical relationships between algorithmic development and the public investigating how the public debate is shaped and influenced around these, and how, as citizens, we meet algorithmic applications in our lives. While explaining her research pointing at keywords such as 'socially responsible AI', 'ethics', 'normative', Sine proceeded to point out:

> *"One question that has been raised here is "*can AI even be ethical?*" And I think the short answer is no. Just as people, actually, can't be ethical. It's not something that we are inherently, but it's very much a relationship, a stance that we cultivate in relation to other actors, be they human or non-human."* (Sine)

Helene's research explores how new digital and data-based technologies change the relationship between the welfare state and citizens, specifically focusing on education and predictive algorithms.



Picture from an expert's interview. Helene explains her research.

"*When I talk to people about my research there's a sort of duality between fascination...* "What can we do with these new technologies? What new possibilities that we don't even imagine exist?" *on one side, and fear on the other, fear of giving away autonomy and power to algorithms that are black-boxed and difficult to understand.*" (Helene)

"People are concerned about dehumanisation. What happens if you can no longer meet a human in the public administration but you only interact with self-service websites? [...] Some of this fear might come from previous experiences, a lot of people have an experience of digital exclusion and that, of course, adds to the experience of dehumanisation. Another explanation might be that we are more likely to have trust in humans, so when we encounter a human we have a greater degree of trust in them than in an automated decision system. So, social factors of trust are also playing a role here." (Helene)

Ida is doing research on a case study on how public administrations are trying to develop and use predictive algorithms to develop and innovate social services. In particular, she's looking into how algorithms are developed to support decision making in the area of child protection and counselling.

"*Either people say* "It's such a great idea to start using more objective tools and make it much easier to react upon it!". *The other part, which is more common, is people that think it's crazy and scary to think about predictive algorithms being part of counselling in the public administrations or NGOs. Usually it's one or the other. Sometimes people just say* "I'm sorry, I don't know what an algorithm is!"" (Ida)

As we can see, the responses from the public that the experts encounter are approximately aligned with the themes that the teachers care for. In addition, however, the experts' view on these reactions allow us to tie certain debates and concerns to specific responses from academia. This way, our task is to put together questions and answers listening to both parts, facilitating knowledge translation.

Picture from an expert's interview. Ida explains her research.

Furthermore, to explain their work, the experts were asked to place themselves in the area of the Scopus map that resonates with their research the most and, from there, indicate connections and paths that they encountered during their investigations.

Our design will follow requirements and suggestions from both the users and the experts to enhance interdisciplinarity and have meaningful outcomes for the future users.

Putting the pieces together

Given these different opinions and perspectives on what is needed and what is of interest for the educators and their classes, in the last section of the analysis chapter I will focus more on reflections that were discussed internally in Tantlab, where we developed the map and strove to design an atlas in the form of an educational tool for high schools.

The last part of the interviews with the teachers was dedicated to understanding if and how they could see an educational tool stem from the Scopus map they have been presented with. Given that the design of the atlas originated from the product of a different project and then evolved in an unsolicited effort to build a tool to be used in schools, fair reflections have been made around the necessity of this solution and how to actually make it into a helpful solution to be implemented in educations for teachers and students.

Generally, the teachers were positive about the idea of having a tool like this available for their classes, therefore, in order to steer the design process to their needs, during the interviews we explored different ways that they could see it being used in their courses.

Once the interviews were done, excerpts from the transcription were gathered and presented in a meeting with the atlas developers. This is the last meeting that has been included in the generated data for this study. Here, the different suggestions were talked through in order to find a meeting point in our visions.

First, I will report the teacher's proposals and then analyse them in relation to our knowledge and understanding of the existing map and the upcoming atlas.

Designing the atlas

From the teachers' perspectives, possible solutions for the atlas as an educational tool seem to be reflected through three different purposes: exploratory, confirmatory, or assistive. The first proposal sees the atlas as a tool that mainly aims to spark curiosity in the students. In this scenario, the teachers would make use of the atlas as an instrument to open up

different discussions about algorithms. It would be presented to the class at the beginning of a theme dedicated to algorithms and related issues, depending on the structure of the class and topics that need to be addressed.

> *"I could actually see it used for an explorative start, having a long term theme of algorithms and democracy. Like the very first class with that, you can use it more exploratively and you can just click around and see what you find. Because it's kind of intriguing, just the possibility. Click around and see what you find to awaken some curiosity."* (T1)

The atlas becomes then a first point of reference that facilitates the introduction to certain discussions.

The second case sees the atlas developed as a device to be used during exams. Here, the main purpose is to employ it as a confirmation tool during the exams. The atlas would then be provided to the students either as a base for their presentations, or purely as an examination device that the teacher would use as a sort of sandbox environment where the students will have to search for answers and navigate information.

> *"Or I can see it being used at the last part of the whole scenario. So, once you have all the theories and artificial intelligence literacy, use it for examinations. Once you're equipped to go, go out and search for this and that. [...] Now you've had a lot* [of teaching] *about this, and here's some quite specific tests that you have to go out and seek answers to based on what you've heard."*

Supposedly, in this situation, the students should already have an expectation of what the atlas looks like before having seen it. For this reason, this idea appears to be the most challenging one, as well as the one that seems to be more far from a tool that serves a knowledge translation purpose. Most importantly, if developed and used this way, the atlas would not have the function of a space for further research on things that appear curious or unusual anymore.

Moreover, when developing a tool that would potentially be implemented in different types of high school, a thing to that needs to be taken into account is the fact that the majority of students would not be familiar with data visualisations and could encounter difficulties in reading and interpreting a network map if they are not given an introduction to the discipline before.

A noticeable discrepancy between the way teachers perceive the map and our own interpretation of it appeared during the

interviews. When the educators engaged with the map, they approached it as a representation of society as is and sought insights about what they already knew about algorithms and AI. As developers, we possess a deeper understanding of the map's limitations and objectives, and our primary goal throughout the design process is to present it as clearly as possible to its users. The map does not serve as a direct reflection of society; rather, it can be viewed as a window into a defined segment of academic discourse on algorithms, whose creation required the establishment of specific boundaries and choices. The apparent intuitiveness of the map can then become deceiving. Without a thorough, or at least guided, exploration, everything appears to be neatly in its place, just as we would expect, and the geographical layout fosters a sense of familiarity, giving the impression that we would instinctively be able to navigate around.

The last discussed possibility is to develop the atlas as an assistive tool that would be provided to the students to work on their assignments. For their courses, the students need to work on individual or group projects that they need to present at the end of the program. This way, the atlas would be used by students to find their topic of choice, study it through text, videos, illustrations, and explore connections and applications. This solution shares some similarities with the first one, having again a particular focus on the explorative nature of the atlas, but unlike that, when designed as an assistive tool, the atlas main function will be to provide background material and reliable sources for the research that the students will conduct. During our interviews, teachers consistently emphasised the scarcity of appropriate educational materials, literature, and reliable sources that they had access to. While we built the Scopus map on a huge amount of resources, they predominantly consist of academic articles, making them unsuitable for high school students as they are. A transformative translation process is therefore necessary.

The question that arises is: How can we effectively overlay a qualitative dimension onto the map? One potential approach involves emulating the teaching methods employed by some educators during their classes. This approach consists of starting from familiar cases or events that students are likely accustomed with, linking these to the map data, and constructing the atlas' qualitative annotations with narratives that facilitate comprehension and context.

One of the main intent of the atlas is to challenge the a priori knowledge that the users have of algorithms. Thus, we plan to curate a series of ten stories, starting from universally known

cases, that students can follow and explore. The stories' layouts should incorporate elements like bridges and proximity as distinctive elements, and will have to have a significant transformative effect on the Scopus map. This could be done by crafting stereoscopic views with overlay layers, where the map will serve as the foundation and each layer explores a different dilemma. Each scenario will incorporate pertinent keywords, literature, explorable material, and curated annotations as part of the overlay. In order to do this, a tangible format for the atlas would give the best results. The atlas could be composed by the Scopus map and the extra layers that can be added on top. This format will allow us to reveal specific areas, mask others, and implement tailored annotations that will contribute to the story that the students will be able to explore. Employing elements of gamification in educational solutions has been reported, both by researched literature and the interviews' material, to be highly effective within young students. Because of this, the atlas could be developed as a board game with different explorable scenarios where the players will face different quests that will have them navigate the atlas' landscape and its stories.

In conclusion, considering the different elements that are crucial for educators and the ones that are necessary for an effective usage of the material the atlas is based on, as mediators we think that the atlas could work better as an explorative tool that the students will have the possibility to spend time navigating through a game-based setting, starting from issues that they are familiar with and extending their knowledge through the annotations that the atlas will provide on those subjects.

Conclusion

This study has been a dynamic journey of experimentation and ideation, centred around the creation of an atlas of algorithms. It underscores the process of zooming in and out of research and starting data, highlighting the intricate details that demand consideration during the design process. Throughout the chapters, we have delved into various factors to gain a panoramic understanding of the elements encountered and considered throughout this research. The Scopus map served in this research as a boundary object, fostering dialogue among various actors and making their knowledge, doubts, and interests more visible.

The ultimate step in this process has been assembling the pieces of the puzzle. The selection of specific elements in different phases has led to the shaping of various aspects of the atlas. First of all, its purpose: considered in a broad perspective, the overarching purpose of the atlas is to enhance algorithmic literacy among the public. This research responds to the call, echoed by many scholars, for improved algorithmic literacy to enhance public experience and engagement with AI. The results can be seen as a contribution to Kitchin's (2016) proposed strategies for understanding algorithms. This research effectively falls between approach 5, which involves unpacking the complete socio-technical assemblage of algorithms, and approach 6, which centres on examining how algorithms function in the real world. It not only contributes to these methodological approaches but also introduces new perspectives and insights to address the limitations in the public discourse surrounding AI. A deeper insight on this aspect of the research has been developed by the research team (Munk et al., forthcoming) in a paper that will be published in the future.

To underscore this need, this study opens with a comprehensive literature review on algorithmic literacy's importance and how it should be taught. This need was then transferred within the specific case of the Danish higher education system with the teachers' interviews. An analysis of the *læreplaner*, followed by the teachers' reflections during the interviews, confirmed the need, both validating the requirement

for a tool like the atlas and, at the same time, contributing to its formation through a co-creating process.

The heart of the atlas, its stories, is probably the aspect that had the most inputs to draw from. The stories' design stemmed from the data-driven narratives presented by the Scopus map. Conversations with teachers and researchers guided us beyond the confines of the datascape, providing valuable perspectives. These interviews helped us unravel the concerns, curiosity, and expertise that these different stakeholders brought to the table.

In terms of design, the feedback from teachers informed the process with the need for the tool to be engaging for young users, with gamification emerging as a potential approach. From the Scopus map, we drew the "see-through" style, originally used to access different types of information through varying lenses. This approach will be repurposed for the atlas, which will be conceived as a board game, to craft different landscapes for stories and allow players to explore specific areas with related annotations. This will allow the design of different stories, depending on the users' needs, as independent landscapes of the atlas that can be played on top of a base map. In light of teachers' concerns about undefined curricula boundaries and the increasing prominence of algorithms in public life, the atlas of algorithms appears as a timely educational tool for algorithmic literacy. It draws its content from academic sources, tailoring its stories to align with user interests, ultimately providing educators with the tools to support the teaching of their arguments of interest and, at the same time, demystify algorithms in the classroom.

While this research has been grounded in Denmark, more specifically in the Copenhagen area, its relevance extends to other places due to the growing integration of algorithmic systems into everyday life. The decision to work within a Danish context has been made because of the many elements of the project that connected it to Denmark but this doesn't confine the outcomes of this study in terms of potential applications in other contexts.

The application of algorithmic systems in our lives is going to stay, and progressively become more common. In order to foster a conscious usage among citizens and an ethical development of algorithmic solutions, we need to teach how to be critical about the applications, and how to understand consequences and implications. The technical know-how is something that changes at such a fast pace in the time being that we cannot base our critical thinking on the understanding

of it. Rather, we need society-centred reflections to be accessible to everyone.

The subject of this study can be described as a techno-anthropological intervention because of its co-creative effort in the design process of a tool that is meant to translate knowledge and open up the public debate, making broader perspectives available and understandable to audiences that are often excluded from certain arguments. The collaborative nature of this project has been instrumental in shaping the atlas and responding to the evolving landscape of AI in society. A techno-anthropological viewpoint and understanding of the digital world seems to be increasingly needed. Just recently, UNESCO published a "living toolkit" within their *Digital Anthropology Project*, where ideas and perspectives from experts all over the world are stored and shared in a repository of knowledge, to create an accessible collection of methods and resources to better define what it means to be a human in the digital era (UNESCO, 2023). Our project shares the ambition for a deeper understanding of this dynamic landscape and comes as an intervention in response to two of UNESCO's key workstreams: advancing education and building awareness.

In summary, this study represents a multifaceted journey of research, ideation, and co-creation of an atlas of algorithms, a tool to translate academic knowledge, enhance algorithmic literacy, and foster a critical understanding of AI in the public sphere.

Limitations

Necessary acknowledgements in this study are related to limitations, with a particular attention to the ones presented by the Scopus map. These limitations need to be clear to the reader and, even more importantly, to the atlas' users before approaching it so that a truthful representation can be achieved. The atlas is not going to be presented as a device that provides evidence, rather, a landscape where different stories take shape through the voices of different actors and create a fertile ground for discussion and knowledge sharing.

The process of development and design of both the Scopus map and the atlas presented different limits over the course of time.

The first limit comes from the map. This is situated, in the sense that it presents certain boundaries in space and time, and comes with no conclusions itself.

Regarding the space, the database that the dataset has been retrieved from, constitutes the first limit. As pointed out before, Scopus is the biggest database used for scientometric analysis, yet, journals in research areas like social sciences and humanities appear to be underrepresented compared to the ones that belong to medical and life sciences.

Additionally, the parameters that have been used to retrieve the data also set limits and boundaries to the final representation. A recurrent remark that has been made by researchers when confronted with the map is that this can not be considered a comprehensive showcase of research on algorithms since, as they point out, some more in-depth and niche study might not even use the terms 'algorithms', 'AI', or 'machine learning' and use more precise and specific terms instead that, therefore, would not appear in our representation. The query that has been used to choose what kind of article gets included in the dataset can then be considered a translation choice, moved by different reasons. First, over time algorithms have become a shorthand for things that somehow concern AI and machine learning. Mapping different ways in which the term is used in academia can help the promotion of a more thorough understanding of the role of algorithms in our world. Moreover, before designing the query, we were aware of the fact

that authors might use different and more precise technical terms in their studies, and reflecting on our knowledge about some of these made us decide upon not using them. Because of our limited knowledge about algorithmic techniques in certain fields, trying to include any more specific names or acronyms like GAN (Generative Adversarial Network) or KNN (K-Nearest Neighbours) would have produced a heavily biassed corpus that was most likely leaning toward the research domains that we were familiar with, and underrepresented some others that were not within our competences. The choice of using algorithm* as a search term reflects our explorative aim, keeping the search open to different fields and not influencing it towards specific types or fields of application. As stated before, the dataset that the Scopus map builds upon covers research on algorithms within the ten years prior to when the project started. Certainly, time poses a further limit. The choice of considering the last ten years was driven by the heavy development that AI and algorithmic applications have had in this period. However, events like the advent of ChatGPT and generative AI becoming extremely popular show us how quickly a tool like this can become obsolete in certain aspects, making it clear that a tool that aims to facilitate education in such a fast-paced growing field will always need to be constantly updated.

Surely, these elements need to be taken into account in the atlas' design process and clearly stated when this will be presented, since its data, design, and stories are going to be informed by the Scopus map.

This study sets the parameters and the baseline for the design of an atlas that will be developed in the next months. Depending on the kind of stories that this tool will be used to tell, a different version could be prepared with a different map that our research group has been working on. In fact, the same process has been followed to build a network map of terms harvested from news media articles about AI, algorithms, and machine learning. The data has been retrieved from Infomedia, the largest media archive in the Nordic countries. Working with this dataset would pose some different limits, first of all one of language, since the data comes from news articles written in Danish.

Ultimately, this study has covered some of the first steps in the design of an atlas of algorithms, where the attention is mostly given to the pedagogical necessities and the user is only presented through the role of the teacher. Future developments are anyway expected in the near future. Indeed, in order to efficiently design the solution that this study proposes while still following co-design principles, a necessary step will be the

collaboration with students from different high schools and classes, to implement their perspective and design a solution that meets their necessities as users.

Bibliography

Bakke, A. (2020). Everyday Googling: Results of an Observational Study and Applications for Teaching Algorithmic Literacy. *Computers and Composition*, *57*, 102577. https://doi.org/10.1016/j.compcom.2020.102577

Bishop, B., Oliver, E. C. J., & Aporta, C. (2021). Co-producing maps as boundary objects: Bridging Labrador Inuit knowledge and oceanographic research. *Journal of Cultural Geography*, *39*(1), 55–89. https://doi.org/10.1080/08873631.2021.1998992

Børne- og Undervisningsministeriet. (2017). *Stx læreplaner - Dansk A - stx, august 2017*.

Børne- og Undervisningsministeriet. (2021). *Forsøg med teknologiforståelse i folkeskolens obligatoriske undervisning: Slutevaluering*.

Børne- og Undervisningsministeriet. (2022). Bekendtgørelse af lov om folkeskolen.

Bourdieu, P. (1984). *Distinction: A Social Critique of the Judgement of Taste*. Routledge, Taylor & Francis Group.

Brinkmann, S. (2013). *Qualitative interviewing: Understanding qualitative research*. Oxford University Press.

Brock, K., & Shepherd, D. (2016). Understanding How Algorithms Work Persuasively Through the Procedural Enthymeme. *Computers and Composition*, *42*, 17–27. https://doi.org/10.1016/j.compcom.2016.08.007

Callon, M. (1984). Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay. *The Sociological Review*, *32*(1_suppl), 196–233. https://doi.org/10.1111/j.1467-954x.1984.tb00113.x

Caspersen, M., Sejer, O., Mogens, I., Arthur, N., Line, H., & Musaeus, H. (2018). Computational Thinking - hvorfor, hvad og hvordan?

Clifford, J., & Marcus, G. E. (1986). *Writing culture: the poetics and politics of ethnography* . University Of California Press.

Cotter, K., & Reisdorf, B. (2020). Algorithmic Knowledge Gaps: A New Dimension of (Digital) Inequality. *International Journal of Communication*, *14*, 745–765.

Danish Agency for Digital Government. (2022). *National Strategy for Digitalisation: Together in the digital development*. Ministry of Finance - Danish Government.

Dogruel, L., Facciorusso, D., & Stark, B. (2020). "I'm still the master of the machine." Internet users' awareness of algorithmic decision-making and their perception of its effect on their autonomy. *Information, Communication & Society*, *25*(9), 1–22. https://doi.org/10.1080/1369118x.2020.1863999

Douglas‐Jones, R., Walford, A., & Seaver, N. (2021). Introduction: Towards an anthropology of data. *Journal of the Royal Anthropological Institute*, *27*(S1), 9–25. https://doi.org/10.1111/1467-9655.13477

Galloway, A. R. (2006). *Gaming: Essays on Algorithmic Culture*. University of Minnesota Press.

Geertz, C. (1973). *The interpretation of cultures*. Basic Books.

Gezgin, U. B. (2019). Data Activism: Reviving, Extending and Upgrading Critical Citizenship Education and Consumer Rights Movements. *Connectist: Istanbul University Journal of Communication Sciences*, *56*, 67–86. https://doi.org/10.26650/connectist2018-0042

Gillespie, T. (2014). The Relevance of Algorithms. In T. Gillespie, P. J. Boczkowski, & K. A. Foot (Eds.), *Media Technologies: Essays on Communication, Materiality, and Society*. The MIT Press.

Glaser, V. L., Pollock, N., & D'Adderio, L. (2021). The Biography of an Algorithm: Performing algorithmic technologies in organizations. *Organization Theory*, *2*(2), 263178772110046. https://doi.org/10.1177/26317877211004609

Gran, A.-B., Booth, P., & Bucher, T. (2020). To be or not to be algorithm aware: a question of a new digital divide? *Information, Communication & Society*, *24*(12),

1779–1796. https://doi.org/10.1080/1369118x.2020.1736124

Gruber, J., & Hargittai, E. (2023). The importance of algorithm skills for informed Internet use. *Big Data & Society*, *10*(1), 205395172311681. https://doi.org/10.1177/20539517231168100

Hao, K. (2019). *Play this bingo game with your kids to teach them about AI*. MIT Technology Review. https://www.technologyreview.com/2019/12/27/131071/ai-mit-bingo-game-to-teach-about-kids-ai/

Hargittai, E., Gruber, J., Djukaric, T., Fuchs, J., & Brombach, L. (2020). Black box measures? How to study people's algorithm skills. *Information, Communication & Society*, *23*(5), 764–775. https://doi.org/10.1080/1369118x.2020.1713846

Harley, J. B. (1988). Silences and secrecy: The hidden agenda of cartography in early modern Europe. *Imago Mundi*, *40*(1), 57–76. https://doi.org/10.1080/03085698808592639

Ingold, T. (1994). The art of translation in a continuous world. In *Beyond Boundaries*. Routledge.

Italiano, F. (2021). Cartography and translation. In T. K. Lee (Ed.), *The Routledge Handbook of Translation and the City* (pp. 45–58). Routledge.

Jeong, H.-S., Oh, Y. J., & Kim, A. (2022). Critical algorithm literacy education in the age of digital platforms. In L. Pangrazio & J. Sefton-Green (Eds.), *Learning to Live with Datafication: Educational Case Studies and Initiatives from Across the World*. Routledge.

Kitchin, R. (2016). Thinking critically about and researching algorithms. *Information, Communication & Society*, *20*(1), 14–29. https://doi.org/10.1080/1369118x.2016.1154087

Klug, D., Steen, E., & Yurechko, K. (2023). How Algorithm Awareness Impacts Algospeak Use on TikTok. *Companion Proceedings of the ACM Web Conference 2023 (WWW '23 Companion)*. https://doi.org/10.1145/3543873.3587355

Kushner, S. (2013). The freelance translation machine: Algorithmic culture and the invisible industry. *New Media & Society*, *15*(8), 1241–1258. https://doi.org/10.1177/1461444812469597

Lash, S. (2007). Power after Hegemony. *Theory, Culture & Society*, *24*(3), 55–78. https://doi.org/10.1177/0263276407075956

Latour, B. (1987). *Science in Action : How to Follow Scientists and Engineers through Society*. Harvard University Press.

Latour, B. (1988). *The pasteurization of France*. Harvard University Press.

Law, J., & Hassard, J. (2007). *Actor network theory and after*. Blackwell.

Livingstone, S. (2004). Media Literacy and the Challenge of New Information and Communication Technologies. *The Communication Review*, *7*(1), 3–14. https://doi.org/10.1080/10714420490280152

Lynch, K. (1960). *The image of the city*. The MIT Press.

Ma, R., Temitayo Sanusi, I., Mahipal, V., Gonzales, J. E., & Martin, F. (2023). Developing Machine Learning Algorithm Literacy with Novel Plugged and Unplugged Approaches. *Proceedings of the 54th ACM Technical Symposium on Computer Science Education v. 1 (SIGCSE 2023)*, 298–304. https://doi.org/10.1145/3545945.3569772

Maraini, F. (1994). *Gnòsi delle Fànfole*. Dalai Editore.

Munk, A. K. (2019). Four Styles of Quali-Quantitative Analysis. *Nordicom Review*, *40*(s1), 159–176. https://doi.org/10.2478/nor-2019-0020

Munk, A. K., Jacomy, M., Ficozzi, M., Jensen, T. E., (forthcoming) *AI is not the issue, Is it the political situation?* [Manuscript submitted for publication]

Muschert, G. W., & Ragnedda, M. (2015). *The Digital Divide : the internet and social inequality in international perspective*. Routledge.

O'Neil, C. (2016). *Weapons of Math Destruction : how big data increases inequality and threatens democracy.* Broadway Books.

Oeldorf-Hirsch, A., & Neubaum, G. (2023). *What Do We Know about Algorithmic Literacy? The Status Quo and a Research Agenda for a Growing Field (preprint)*. Department of Communication, University of Connecticut, Department of Computer Science and Applied Cognitive Science, Universität Duisburg-Essen.

Park, S., & Humphry, J. (2019). Exclusion by design: intersections of social, digital and data exclusion.

Information, Communication & Society, *22*(7), 934–953. https://doi.org/10.1080/1369118x.2019.1606266

Rainie, L., & Anderson, J. (2017). *Code-Dependent: Pros and Cons of the Algorithm Age*. Pew Research Center: Internet, Science & Tech. https://www.pewresearch.org/internet/2017/02/08/code-dependent-pros-and-cons-of-the-algorithm-age/

Roose, K. (2023). Don't Ban ChatGPT in Schools. Teach With It. *The New York Times*. https://www.nytimes.com/2023/01/12/technology/chatgpt-schools-teachers.html

Seaver, N. (2017). Algorithms as culture: Some tactics for the ethnography of algorithmic systems. *Big Data & Society*, *4*(2), 1–12. https://doi.org/10.1177/2053951717738104

Seaver, N. (2019). Knowing Algorithms. In J. Vertesi & D. Ribes (Eds.), *DigitalSTS: A Field Guide for Science & Technology Studies* (pp. 412–422). Princeton University Press.

Selber, S. A. (2004). *Multiliteracies for a digital age*. Southern Illinois University Press.

Shin, D., Rasul, A., & Fotiadis, A. (2021). Why am I seeing this? Deconstructing algorithm literacy through the lens of users. *Internet Research*, *32*(4), 1214–1234. https://doi.org/10.1108/intr-02-2021-0087

Star, S. L., & Griesemer, J. R. (1989). Institutional Ecology, "Translations" and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science*, *19*(3), 387–420. https://www.jstor.org/stable/285080

Stock, L. (2023). ChatGPT is changing education, AI experts say — but how? *Deutsche Welle (DW)*. https://www.dw.com/en/chatgpt-is-changing-education-ai-experts-say-but-how/a-64454752

Striphas, T. (2015). Algorithmic culture. *European Journal of Cultural Studies*, *18*(4-5), 395–412.

Swart, J. (2021). Experiencing Algorithms: How Young People Understand, Feel About, and Engage With Algorithmic News Selection on Social Media. *Social Media + Society*, *7*(2), 1–11. https://doi.org/10.1177/20563051211008828

The Danish Ministry of Finance. (2022). National Strategy for Digitalisation: Together in the digital development.

Undervisningsministeriet - Styrelsen for IT og Læring. (2018). *Handlingsplan for teknologi i undervisningen*.

Venturini, T., & Latour , B. (2010). *The Social Fabric: Digital Traces and Quali-quantitative Methods* (pp. 87–101). Editions Future en Seine.

Venturini, T., & Munk, A. (2022). *Controversy mapping : a field guide*. Polity.

Venturini, T., Munk, A., & Meunier, A. (2016). Data-sprinting. *Routledge Handbook of Interdisciplinary Research Methods*, 158–163. https://doi.org/10.4324/9781315714523-24

Whatmore, S. J. (2009). Mapping knowledge controversies: science, democracy and the redistribution of expertise. *Progress in Human Geography*, *33*(5), 587–598. https://doi.org/10.1177/0309132509339841

Other cited sources

Algorithms, Data & Democracy (2023). *Research project*, (last access date 13/10/2023) https://algorithms.dk/research-project/

Datareportal (2023). *Digital 2023: Global overview report*, (last access date 13/10/2023) https://datareportal.com/reports/digital-2023-global-overview-report

EMU - Danmarks læringsportal. (2022). Om forsøget | emu danmarks læringsportal. www.emu.dk. (last access date 13/10/2023) https://www.emu.dk/grundskole/teknologiforstaaelse/om-forsoeget?b=t5-t34

UNESCO (2023). *The Digital Anthropology Project*, (last access date 13/10/2023) https://www.unesco.org/en/digital-anthropology#digital-anthropology-a-living-toolkit

Appendix A - Teachers' interview guide

INTRODUCTION

- Introduce myself, the project and my connections to it
    - What has been done by now and what we want to achieve with this project
    - Explain why I called them and what their contribution would be
- Introduce them
    - Their role in education, where do they work
    - Their connection to the project (IT-vest or FALS) and how their work is organised/ what they do
    - Are you familiar with ADD? If so, what are the connections and how does that relate to your work?

STATE OF EDUCATION

- Algorithmic literacy and awareness:
    - Are these topics discussed in class? Is it part of the curriculum?
    - How do you present the topic? What are the discussions about? What do you teach about it?
    - How do you structure your classes?
    - Do you use any tools/text? To do what?
    - What is the response from the students?
    - Are teachers generally prepared to teach about algorithms?
    - Any particular challenge about this education?

MAP AND ATLAS

- Show the map. Explain the dataset and annotations.
    - Have them explore the map. What do they look at? Which keywords/connections/areas do they talk about?
- Does it sound like an interesting base for a tool for schools?
    - What would you use it for? To talk about what?
    - What discussions would you like it to cover?
- Data literacy: do the students get any education about it? Would they be able to read and navigate a network map?
    - What would it need to speak to that audience?
- Does anything catch your attention? Anything that seems unusual or curious?

Appendix B - Experts' interview guide

INTRODUCTION

- Introduce myself, the project and my connections to it
    - What has been done by now and what we want to achieve with this project
    - Explain why I called them and what their contribution would be
- Introduce them
    - Who are you? Where do you work? What do you do research on? How is your research related to algorithms?

MAP - RESEARCH

- Ask to locate their research in the map (limit the area of interest so we know where to place the annotations. Placing can still be approximate)
    - What do algorithms do in that area?
    - What are key events, typical issues, challenges within that area that concern algorithms?
    - Pick three interesting words in the area and explain them
    - What connections do you think matter particularly?
- Is there something that surprises you about the map? Something you didn't expect to be there or something you expected but is not there?
- Is there a question people ask you frequently? Are they interested in anything specific?
    - What is the public response to your work?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