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Inversions: The good and the bad of digitalization

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Inversions –

The Good and the Bad of Digitalization

Stefan Klein & Carsten Totz (editors)

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Abbreviations

AI	Artificial Intelligence
AM	Algorithmic Management
CF	Climate Footprint
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
DLP	Digital Labour Platform
EDMO	European Digital Media Observatory
EEAS	European External Action Service
EU	European Union
GEC	Global Engagement Center
GDPR	General Data Protection Regulation
GenAI	Generative Artificial Intelligence
GHG	Greenhouse Gases
GPS	Global Positioning System
HEI	Higher Education Institutions
HFCs	Hydrofluorocarbons
ICT	Information and Communication Technology
IM	Information Management
IS	Information Systems
IW	Information Warfare
N_2O	Nitrous oxide
NATO	North-Atlantic Treaty Organization
PC	Psychological Contracts
PFCs	Perfluorocarbons
PsyOps	Psychological Operations
PWD	Platform Work Directive
SF_6	Sulfur hexafluoride
StratCom	Strategic Communication
SuSe	Summer Semester
TAM	Technology Acceptance Model
WBCSD	World Business Council for Sustainable Development
WHO	World Health Organization
WiSe	Winter Semester
WLB	Work-Life Balance
WRI	World Resource Institute

Symbols

$E_{SuSe/WiSe}$	Emissions generated per module over the semester in kg CO_2e
h_i	Heating consumption per month in kWh
$_i$	Electricity consumption per month in kWh
t_o	Aggregated time of occupancy in the Leo 18.3
t_m	Time of occupancy per module m
E_e	Electricity emissions in kg CO_2e/kWh
C_e	Computer emissions kg CO_2e
P_c	Number of participants,
E_c	Emissions per computer in kg CO_2e
T_L	(Aggregated) lecture duration measured in hours
Y	Years of useful life of a computer
H_d	Daily hours of computer usage.
N_e	Network data transfer emissions
P_c	Number of participants
E_e	Electricity emissions measured in kg CO_2e
I	Internet energy intensity
Q_e	Emissions generated by search engine queries
Q	Number of queries
E_q	Emissions per query, measured in kg CO_2e
r_e	Research emissions per hour

Working Paper Sketch

Type: Research Report

Title: Inversions – The Good and the Bad of Digitalization

Editors: Stefan Klein, Carsten Totz

Authors: Maxime Paul Roger Delwaulle, Julian Granitza, Anirudh Ravi, Daria Luise Stumkat

Abstract

This working paper combines four student contributions whose themes highlight the pertinence of studying the inversion of digital technologies' outcomes:

- Disinformation as part of Russias Information Warfare
- The impact of algorithmic management on labour relations
- Implications of Chat GPT for students in higher education
- The contribution of blended teaching on the sustainability of institutions of higher education.

As such it encourages the reader to not only be attentive to the potential abuses of technologies that are meant to create value(s) for society but also to examine the mechanisms of inversion: how and when do positive impacts turn into negative ones? Doing so is a first steps to "own one's future": to overcome technology cynicism and explore ways of making our world a better place.

Keywords:

Digital transformation; disinformation; algorithmic management; Gen AI in education; environmental impact of HEI

Preface

Earlier this year, IEEE, the world's largest technical professional organization dedicated to advancing technology for humanity, celebrated 50 years of the Internet. The developers of the TCP could not imagine that this protocol would enable a global infrastructure for the digital world. However, the early idealism and hope for societal benefits, prominently equality and democratization, but also progress towards what we now call the UN development goals, has been overshadowed by the dark side of technology (use): surveillance, exploitation, large scale disinformation, and escalating power consumption. Every new technological breakthrough and innovation, generative AI as the most recent one, has been heralded by optimism, which soon after turned into negative effects more devastating and more difficult to mitigate than the previous ones. Against this backdrop, we have designed a Master's seminar entitled "Inversions - The Good and the Bad of Digitalization" as an invitation to students to analyze and critically reflect cases of inversion, where good intentions – eventually - turned into bad outcomes.

This working paper combines four student contributions that illustrate the range of topics we have been studying:

- Disinformation as part of Russias Information Warfare
- The impact of algorithmic management on labour relations
- Implications of Chat GPT for students in higher education
- The contribution of blended teaching on the sustainability of institutions of higher education.

We have used a quote by Orlikowski and Iacono as motto and teaser for our seminar: "Our future is becoming increasingly dependent on a multiplicity of pervasive and invasive technological artifacts. As IS researchers we have the opportunity and responsibility to influence what future is enacted with those technological artifacts**.** To do so, however, we must engage deeply and seriously with the artifacts that constitute a central component of that future. Otherwise, we will remain passive observers of the technosocial transformations occurring around us, and we will risk fulfilling our own worst prophecies of technological determinism." (2001, 133)[1] It nicely positions the topic into the information systems discourse but more importantly it sets the challenge we have set to our students: "We are looking for participants who are curious to examine the dark side of technology, to explore how it shapes us, society and the economy. The seminar topics are meant to provide a hook for you to think about, to do your own research and develop your own view about the present and a sense of direction for the future."

We made it abundantly clear, that this seminar is about the students' future: what is the future they are aiming for, how they would like technology to affect their lives, if and how it align with their values and what they need to do to make this future a reality?

Stefan Klein and Carsten Totz

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1 Orlikowski, W. J., & Iacono, C. S. (2001). Research Commentary: Desperately Seeking the "IT" in IT Research - A Call to Theorizing the IT Artefact. ISR, 12(2), 121–134, p. 133.

Dedication

We dedicate this working paper to Professor Howard Williams who inspired and started this seminar thesis and to all our students who courageous engaged with us on this intellectual journey, which at times has been disconcerting, eye opening, and inspiring: it is your future, make the best of it.

Chapter 1

Resilience in the Face of Disinformation: How can European States counter Russian Information Warfare?

Maxime Paul Roger Delwaulle

Don't expect to counter the firehose of falsehood with the squirt gun of truth.

(Paul & Matthews, 2016)

In the digital era, the phenomenon of disinformation has emerged as a significant threat to the stability and integrity of democratic societies (Bennett & Livingston, 2018). While social media can support democratic movements and communication – such as during the Arab Spring (Eltantawy & Wiest, 2011; Howard et al., 2011) – it can also be weaponized. Originating from a variety of state and non-state actors, disinformation campaigns are designed to manipulate public opinion, sow discord, and undermine trust in democratic institutions (Pomerantsev, 2015). These efforts exploit the rapid dissemination capabilities of social media and the internet, magnifying the potential impact of false or misleading information.

In 2018, the European Commission declared that "disinformation by the Russian Federation poses the greatest threat to the EU" (Action Plan against Disinformation, 2018, p. 4). This still holds true today (European Union External Action [EEAS], 2024)[2]. Russia's strategic use of disinformation reflects a sophisticated understanding of its power to influence geopolitical dynamics, necessitating a nuanced response that goes beyond traditional information security measures (Schiffrin, 2017; Snyder, 2018). Therefore, while being cognizant of Chinese and Iranian disinformation (Lucas et al., 2021, pp. 41–58; Wong, 2022), this study focuses on Russia.

The evolution of disinformation tactics, from historical propaganda to the current digital era, underscores the growing complexity of these campaigns (Jowett & O'Donnell, 2018). Social media platforms, pivotal in amplifying disinformation, highlight the dual challenge of countering these campaigns while protecting free speech (Singer &

2 Comparing the mentions of "Russia" versus "China", for example.

Brooking, 2018). This dilemma defines the asymmetric nature of information warfare. Democracies, with their open societies, are particularly vulnerable to disinformation campaigns that exploit these freedoms to undermine them from within (Giles, 2016).[3]

Impacts from disinformation on elections and societal discourse emphasize the urgency of developing effective countermeasures (Pomerantsev, 2019). International responses, including efforts by the European Union and NATO, further underscore the global nature of the challenge and the importance of collaborative strategies in combating disinformation (Action Plan against Disinformation, 2018; Gadkari, 2023).

Understanding the background and context of disinformation is crucial for developing effective strategies to counter its pervasive effects and protect the foundational principles of democratic governance (Paul & Matthews, 2016).

The overall aim of this study is to explore how Russian disinformation can be countered. Hence, two crucial research questions guide our analysis:

RQ1: "What patterns can be recognized in Russian foreign disinformation campaigns?"

Before countermeasures and responses can be developed and discussed, the phenomenon of disinformation needs to be fully understood. With Russia at the center of this study, its specific interference characteristics, tactics, and strategies are the critical foundation for the second part of this chapter.

RQ2: "How can European states effectively counter Russia's destabilizing disinformation campaigns?"

This research question aims to examine the strategies that can fortify democratic societies against the destabilizing effects of disinformation. Strategic responses such as resilience will be discussed. As a complete consideration of all stakeholders to Russian disinformation is out of scope, this study is limited to a policy perspective. To maintain focus, it is further limited to European states, current operations in Africa notwithstanding (Siegle, 2021).

Significance of the Study

The significance of this study lies in its timely investigation into the evolving phenomenon of Russian disinformation campaigns – again, "the greatest threat to the EU" (Action Plan against Disinformation, 2018, p. 4). In an era where social media and other internet technologies advance rapidly, these campaigns have become increasingly sophisticated, necessitating continuous academic analysis to identify new tactics and

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3 For further discussion of how democracies can fall prey to their own openness and tolerance, I recommend the book "How Democracies Die" by Levitsky and Ziblatt (2018).

develop effective countermeasures. Up-to-date analysis and recommendations from academia can support the iterative development of state policies to counter disinformation. In the end, this ongoing scholarly engagement contributes to the strengthening of resilience of democratic societies against the incessant emergence of new vulnerabilities (Paul & Matthews, 2016).

By enhancing the understanding of how nation-states can combat disinformation, this study aims to contribute to the broader discourse on the maintenance of societal trust and the integrity of democratic processes. This study's significance is further amplified by the pressing need for European collaboration in developing a cohesive response to a challenge transcending national borders.

Disinformation is not “just” an issue pertaining to international relations and social science. It can also be understood as a cyber risk to business. Its impacts on healthcare, media, and financial markets, underscore the need for comprehensive strategies to safeguard not only political systems but also the infrastructures underpinning our economies and democratic institutions (Petratos, 2021; Wachtel et al., 2022). Consequently, the findings of this research are also intended to equip future business leaders with an essential, robust geopolitical understanding, enabling them to navigate and counter the complexities of disinformation in the contemporary landscape (Belhoste & Dimitrova, 2023).

This chapter embarks on a comprehensive examination of Russian disinformation campaigns, situating these efforts within the broader canvas of information warfare and exploring the efficacy of resilience-based countermeasures. After this introductory chapter outlining the background, significance, and research questions, the methodology section delineates the qualitative approach adopted for this study. To ensure a robust analytical foundation, the rationale for the selected theoretical frameworks and case study will be outlined.

Subsequently, the characteristics of Russian disinformation will be researched. Before diving deeper, a short overview serves as an introduction to the topic. Then, the “Firehose of Falsehood” framework (Paul & Matthews, 2016) and Mark Galeotti's insights into Russian disinformation strategies (Galeotti, 2016, 2017, 2018a, 2018b, 2019) will offer a nuanced perspective on the tactics and objectives of Russian information warfare. To grasp the full picture, the context of Russian disinformation will then be explored, relating it to the concepts of hybrid warfare and information warfare.

Chosen for its timely and critical implications, the case study on the Russian vaccination disinformation campaign during the COVID-19 pandemic is a pivotal element of this chapter. Here, the previously examined theory guides the analysis of Russia’s operations’ impact in the real world. At the same time, the applicability of the frameworks will be illustrated. Various countermeasures established during COVID-19 will then be discussed, especially their limitations.

The section on understanding resilience then transitions the discussion from diagnosis to potential remedies, delving into the concept of resilience in the information warfare domain. The conceptual origins and various definitions of resilience will be elucidated. It will be presented as a required key element in how European states can counter Russian disinformation. This will be demonstrated by three instances of states successfully leveraging resilience to defend against Russian manipulation amidst COVID-19. The insights gleaned from this analysis feed into policy recommendations, which emphasize resilience, including media literacy, as essential defenses against disinformation.

Following, the contributions will be discussed, and the study's limitations outlined. I also identify avenues for future research, including longitudinal studies about resilience. The conclusion then synthesizes the findings, emphasizing the significance of resilience in countering disinformation. Through this structured examination, the chapter aims to contribute to a deeper understanding of disinformation as a tool of information warfare and the critical role of resilience in safeguarding democratic values and public trust.

Methodology

Overview of Research Design

The research design of this chapter is structured to systematically explore the effectiveness of resilience strategies in countering Russian disinformation campaigns. At its core, the study employs a qualitative research approach, leveraging both theoretical exploration and case study analysis to address the complexities inherent to disinformation and its countermeasures. This dual approach ensures a balanced exploration of the theoretical underpinnings and practical applications of counter-disinformation efforts that can be employed by European states. Thus, it is setting the stage for a comprehensive analysis of how state actors can fortify their defenses against the evolving threat of disinformation. This methodology section aims to set the foundation for subsequent exploration of the frameworks and case study, without already delving into their specific content.

Selection of the Theoretical Frameworks

The selection of theoretical frameworks for this chapter was guided by a rigorous set of criteria aimed at ensuring the relevance, applicability, and comprehensiveness of the analysis regarding Russian disinformation campaigns. The specific criteria are as follows.

The chosen frameworks, the "Firehose of Falsehood" (Paul & Matthews, 2016) and Galeotti's characterization of Russian disinformation (Galeotti, 2016, 2017, 2018a, 2018b, 2019), were evaluated based on their ability to provide a deep understanding of the mechanics, strategies, and impacts of **contemporary Russian**

disinformation. They offer a robust foundation for analyzing the multifaceted nature of disinformation campaigns and the requirements for effective counterstrategies.

Equally important is the frameworks' **significant scholarly authority and acknowledgment**. The "Firehose of Falsehood" framework has been cited more than 600 times, as per Google Scholar. It thus represents a foundational scholarly contribution. Mark Galeotti, in turn, is a renowned scholar and expert in Russian security affairs, with a prolific academic and professional background that has established him as a leading authority on Russian politics, organized crime, and intelligence operations (Wikipedia, 2024c). Together, they support a comprehensive, forward-looking analysis.

The selection was also informed by the **interdisciplinary nature** of the frameworks, which draw from political science, sociology, psychology, and media studies. This interdisciplinary approach is vital for comprehensively addressing the multifaceted challenge of disinformation, ensuring that the analysis encompasses its diverse aspects.

The inclusion of **empirical evidence** and case studies is crucial for grounding theoretical discussions in observable phenomena. Both frameworks are based on empirical examples and data illustrating the real-world application of Russia's tactics.

Selection of the Case Study

Complementing the theoretical exploration, a case study approach was adopted to ground the analysis in real-world application. The COVID-19 vaccination disinformation campaign was selected as a pertinent example, showcasing the contemporary relevance of Russian disinformation efforts. Given the campaign's profound impact on public health and societal trust, this case can be classified as an *extreme case* (Flyvbjerg, 2006). The campaign provides a concrete instance of the theoretical concepts at play, offering a lens through which to analyze the spread and consequences of disinformation amid a global health crisis. The case study not only illustrates the broad societal implications of state- sponsored disinformation but also provides a rich dataset for qualitative analysis, thanks to its extensive documentation and the urgency of the pandemic's context. This wealth of empirical evidence enables an in-depth exploration of disinformation strategies, underpinning the development of effective, resilience-based countermeasures against such campaigns. (EEAS, 2021; Lucas et al., 2021)

Incorporating this case study into the chapter enhances the study's applicability to current global challenges. By examining the intersection of disinformation campaigns and public health initiatives, this research contributes valuable insights into the multifaceted nature of disinformation and the imperative for coordinated, resilient responses.

Two other essential cases – Russian disinformation during the 2016 U.S. presidential election and the 2022 Russian invasion of Ukraine are discussed in Appendix A.

Understanding Russian Disinformation

Serving as the theoretical foundation of the chapter, this section seeks to enhance our understanding of Russian disinformation. First, the reader is more generally introduced to Russian influence campaigns. Then, for a more tangible discussion of Russia's tactics, the "Firehose of Falsehood" framework by Paul and Matthews (2016) is examined. Following is a strategic and historical characterization of Russia's strategy. The chapter will be concluded by dissecting the concepts of hybrid warfare and information warfare, providing essential context to complete our understanding of Russian disinformation.

Introduction to Russian Influence Campaigns

The contemporary landscape of international relations is increasingly influenced by the strategic dissemination of information, with Russia's influence campaigns representing a significant and complex facet of this environment. These campaigns harness an extensive toolkit, including state-backed media, social media platforms, and cyber operations, to craft and circulate narratives that advance Russian geopolitical interests (Schiffrin, 2017; Snyder, 2018). Notable for their adaptability, these campaigns exploit societal vulnerabilities, amplify divisions, and disrupt the cohesion of communities and nations alike (Paul & Matthews, 2016; Pomerantsev, 2015).

The pervasive nature of Russian disinformation efforts is well-documented, with evidence of systematic attempts to sway political processes, manipulate public sentiment, and undermine the credibility of mainstream media across various countries (Bennett & Livingston, 2018). The sophistication of these campaigns is evident in their integration into the information ecosystem, rendering the distinction between authentic and manipulated content increasingly opaque (A. Wilson et al., 2023). This challenge is exacerbated by the deployment of technology, such as bots used to enhance the reach and impact of disinformation (Badawy et al., 2018; Ferrara et al., 2016; Lukito, 2020).

This strategic manipulation of perceptions and narratives is not simply about spreading falsehoods but is aimed at influencing the political and social structures of target countries, ultimately destabilizing them. The evolution of such tactics reflects a transition from historical propaganda methods to an era where digital platforms are central to the dissemination and amplification of disinformation (Jowett & O'Donnell, 2018).

In essence, Russian influence campaigns are a formidable and adaptive force in modern geopolitics, utilizing a wide array of tools to manipulate public perception and destabilize societies. Understanding the full scope of these campaigns and their implications for democratic institutions and international relations is crucial. This chapter

sets the stage for a comprehensive exploration of the strategies, objectives, and impacts of Russian disinformation efforts, crucial for developing countermeasures against it.

Russia's Tactics: The Firehose of Falsehood Framework

The "Firehose of Falsehood" framework, elucidated by Christopher Paul and Miriam Matthews in their seminal 2016 RAND Corporation report, provides a systematic analysis of disinformation strategies as employed by Russia. Based on four key principles that distinguish these campaigns from traditional methods of propaganda and misinformation, the framework is instrumental in understanding Russian disinformation efforts.

High-Volume and Multichannel: This principle underscores the strategy of disseminating a large volume of messages across a wide array of channels. Unlike traditional propaganda, which might aim for persuasive coherence and credibility, Russian disinformation floods the information space, impeding individuals in navigating the overload and discerning truth from falsehood. This tactic exploits the capabilities of modern technology and social media, which enable the rapid spread of information.

Rapid, Continuous, and Repetitive: Russian disinformation campaigns are characterized by their relentless pace and the repetition of messages. This continuous stream of information, irrespective of its veracity, aims to capture and dominate the attention of the audience, often creating an aura of omnipresence around certain narratives. The repetitive nature of these campaigns plays on the psychological tendency of repeated exposure increasing believability.

Lack of Commitment to Objective Reality: One of the most distinctive features of the "Firehose of Falsehood" approach is its indifference to truth. These campaigns often disseminate contradictory statements as well as a blend of true and false information, not necessarily to convince the audience of a particular fact but to create confusion and cynicism about the possibility of discerning any truth at all.

Lack of Commitment to Consistency: Contrary to traditional strategies that value message consistency, Russian disinformation campaigns freely contradict themselves, changing narratives as needed. Drawing on research from experimental psychology, the authors observe that "potential losses in credibility due to inconsistency are potentially offset by synergies with other characteristics of contemporary propaganda" (Paul & Matthews, 2016, p. 8). This continuous and flexible adaptation of narratives further complicates efforts to counteract or debunk Russian disinformation.

Russia's Strategy: Opportunistic and Fragmented

Mark Galeotti's characterization of Russian disinformation as both opportunistic and fragmented provides a nuanced lens through which to examine the strategic underpinnings of these campaigns. Unlike the "Firehose of Falsehood" model, which

focuses on the overwhelming volume and relentless pace of disinformation, Galeotti delves into the diversity and adaptability that define Russian efforts. This perspective is crucial for understanding the multifaceted and evolving nature of disinformation as wielded by Russia.

Galeotti posits that Russian disinformation campaigns are opportunistic, seizing upon existing societal divisions, political discontent, and any fertile ground for sowing confusion and distrust (Galeotti, 2017). This approach allows for a high degree of flexibility, enabling actors to tailor messages to specific audiences and exploit real-time events or sentiments to maximize impact. The opportunistic nature of these campaigns means that they do not adhere to a single narrative but instead deploy a myriad of stories, themes, and messages designed to resonate with diverse audience segments. Here, Galeotti's assessment meets the fourth principle of the "Firehose of Falsehood" framework, namely the *Lack of Commitment to Consistency*.

In 2013, Galleotti was the first to write about the "Gerasimov doctrine" (Galeotti, 2019), based on Russian General Gerasimov's (2013) article articulating his "vision of total warfare that places politics and war within the same spectrum of activities" (McKew, 2017). It must be noted that this vision was in fact intended to serve as an observation and explanation of the type of warfare Russia must face *from the West* (Bartles, 2016). The "Gerasimov doctrine" still increasingly gained traction in academia and in security discussions to explain Russia's hybrid warfare activities, especially in Crimea. However, according to Galeotti who first coined the term, this supposed doctrine does not exist and, in fact, not any one Russian "doctrine" exists (Galeotti, 2018b).

This can be directly tied to Russia's conduct of disinformation campaigns. As explained in Bykova (2022, pp. 441–442), "Putin is not the sort of charismatic leader who has a well-thought and well-executed plan for Russia. He is more of an opportunist than a skillful strategist" and "frequently changes his course". Today's Russian state is a "hyper- presidential, largely de-institutionalised political system[,] essentially an 'adhocracy'" (Galeotti, 2017, p. 14). Russia's influence campaigns are equally fragmented and opportunistic, carried out by a multitude of "political entrepreneurs", such as "spies, or diplomats, journalists, politicians, or millionaires" (Galeotti, 2017, p. 14).

Those characteristics are not a novel phenomenon, despite the contemporary buzz around the topic. Historical perspectives on Russian warfare tactics reveal a long-standing proclivity for integrating a wide array of methods, as seen in the tsarist era's use of irregular combatants and Soviet-era subversive activities (Galeotti, 2016; Hargrove, 2016; Madeira, 2014; Marshall, 2009). The Russian military tradition has been marked by a pragmatism that leverages asymmetry and indirect approaches, often as a compensatory measure for conventional capability gaps. "From the tsars through the Bolsheviks, the [Russian style of warfare embraced] the irregular and the criminal, the spook and the provocateur, the activist and the fellow-traveller" (Galeotti, 2018a,

p. 23). Such characteristics can also be found in Tolstoy's (2008) "War and Peace", with combatants engaging in combat by any means necessary, disregarding the conventional rules of engagement. Russia's contemporary tactics sound like a modern-day echo of Tolstoy's narrative (Galeotti, 2016).

Russia's fragmented disinformation ecosystem is shown in more detail in Appendix B.

The Concepts of Hybrid Warfare and Information Warfare

Hybrid warfare has emerged as a prevalent term within security and military discussions, particularly considering Russia's recent geopolitical maneuvers, such as the annexation of Crimea in 2014. This event prompted a NATO reassessment of modern warfare tactics, recognizing Russia's "new and less conventional military techniques" as a significant concern (UK House of Commons Defence Committee, 2014, p. 12). Hybrid warfare, a concept originally introduced by Hoffman (2007), was intended to challenge the U.S. military's entrenched beliefs and doctrines regarding the utility of force. It highlights how non-state actors have successfully used a combination of conventional and unconventional, kinetic and non-kinetic operations to achieve synergistic effects. Essentially, hybrid warfare signifies the blending of military and non-military means to achieve strategic objectives.

The Crimean annexation brought the concept of hybrid warfare into prominence, especially highlighting the role of non-military tools such as information warfare (Renz, 2018). Scholars have explored Russian military literature for traces of an emerging doctrine of hybrid warfare, notably in Gerasimov's discussion on the significance of non-military tools in conflicts (Renz, 2018). However, it is important to recognize that the concept of hybrid warfare is primarily a Western analytical construct, not deeply rooted in Russian military doctrine (Giles, 2016). Nonetheless, the practical execution of such strategies in Crimea – a blend of subtle information maneuvers and the presence of military forces – exemplified a shift towards "contactless" warfare, emphasizing minimization of direct force (Thornton, 2015). With this, Russia "[turns] a US strength (its firepower and technological sophistication) into a weakness (rooted in the requirement that its use is properly justified)" (Thornton, 2015, p. 5) – one of the key challenges in meeting those attacks.

For the full picture, we must not just look at the Russian context. In the United States, "efforts to encourage favorable attitudes towards the [U.S.], its values and interests in international discourse and popular opinion is [sic!] known as 'public diplomacy'" (Kofman and Rojansky (2015, p. 6), see also Cull (2008) and Gregory (2011)). However, a full discussion of public diplomacy versus hybrid warfare (or information warfare), particularly any discussion of the ethical dimension, is out of scope of this chapter.

While hybrid warfare offers a broad framework for understanding modern conflicts, it has also been criticized for its lack of precision, leading to ambiguous interpretations

and applications (Libiseller, 2023) – see Appendix C for an illustration. The academic community has yet to reach a consensus on a definitive framework for hybrid warfare, despite NATO's adoption of the term post-Crimea (Weissmann, 2021). This ambiguity extends to related concepts such as Information Warfare (IW), Psychological Operations (PsyOps), and others, where definitions remain fluid and contested (Giles, 2016). Western discourse often focuses on the semantics of these terms (Hoffman, 2014; McDermott, 2016), while pragmatic Russia, appears to view them as parts of a unified whole in the broader context of information warfare (Giles, 2016).

Focusing on information warfare provides a more targeted and precise analysis of contemporary conflict dynamics, particularly in the context of Russian geopolitical strategies. Information warfare, a critical component of hybrid actions, involves the strategic use and manipulation of information to achieve a competitive advantage. This encompasses efforts to influence public opinion, disrupt adversary decision-making processes, and undermine confidence in democratic institutions through the dissemination of disinformation. Information warfare's effectiveness lies in its ability to subtly influence perceptions and behaviors, making it a potent force in the modern geopolitical landscape (Wigell et al., 2021).

In conclusion, while *hybrid warfare* provides a useful lens for examining the multifaceted nature of modern conflicts, the concept of *information warfare* offers a more precise and focused framework for understanding and countering the specific challenges posed by disinformation. Prioritizing information warfare enables scholars and policymakers to devise strategies that not only protect democratic values and institutions but also reinforce the resilience of information ecosystems against the complexities of geopolitical strategies. This approach highlights the critical role of information in modern conflict and underscores the urgency for comprehensive countermeasures that safeguard the integrity of democratic systems in the face of disinformation campaigns.

Case Study: COVID-19 Vaccination Disinformation Campaign

We're not just fighting an epidemic; we're fighting an infodemic.
(Dr. Ghebreyesus, Director-General of the WHO, in February 2020)[4]

The COVID-19 pandemic has been paralleled by an "infodemic," characterized by a surge in misinformation and disinformation that has compounded the global crisis (Islam et al., 2020). Russia, among other state actors, seized this opportunity to conduct disinformation campaigns, exploiting existing anxieties and distrust to undermine public confidence in vaccines and health authorities (Lucas et al., 2021). This orchestrated effort exploited the pandemic's inherent uncertainties and societal fears, revealing a sophisticated interplay of information warfare tactics designed to erode

4 Found in The Lancet Infectious Diseases (2020)

confidence in global health initiatives and institutions (Lucas et al., 2021). Understanding and learning from this case is a crucial part of developing countermeasures against similar influence operations.

Impact Analysis of Russian Tactics and Strategies

Application of the "Firehose of Falsehood" Framework

A hallmark of Russian disinformation tactics during the pandemic was the prolific use of the "firehose of falsehood" strategy, marked by a high volume and rapid dissemination of misleading content across multiple platforms (EEAS, 2021). Sergey Sukhankin's work highlights Russia's propagation of the idea that the United States created the virus,[5] employing a vast array of channels – from social media to state-controlled media – to disseminate this narrative worldwide, aiming to sow discord among international actors and degrade trust in the U.S. government's handling of the pandemic (Sukhankin, 2020).

To illustrate this campaign, figure 1 shows a German article by NewsFront (2020), a website that is part of the Russian "disinformation and propaganda ecosystem" (Global Engagement Center [GEC], 2020, p. 31). NewsFront's owner, Konstantin Knyrik, views his outlet as a player in the "information war […] declared against Russian" (Rossbach, 2018). It has been described by Time magazine as "by far the most successful and ambitious" Russia-backed disinformation outlet with regards to COVID-19 and vaccines (Shuster, 2021) and accused by the U.S. State Department as being "guided by the FSB[6]" (Gordon & Volz, 2021; found in Wikipedia, 2024d). Therefore, it is a prime example of Russia's vast and fragmented disinformation network. Parallels to the "firehose of falsehood" framework are also evident: Its continuous output makes NewsFront a fierce maintainer of Russia's voluminous firehose of falsehood.

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5 An unsubstantiated allegation, see Jiang and Wang (2022) or the detailed overview on Wikipedia (2024a).

6 Russia's security agency FSB is the successor of its infamous KGB (Wikipedia, 2024b)

Figure 1: NewsFront (2020) article on purported U.S. bio lab origins of COVID-19

The tailored dissemination of disinformation to specific demographics and regions showcases Russia's strategic use of inconsistency. For example, Russian state-owned media applauded the (Russia-friendly) Serbian government's vaccination campaign while spreading confusing and often contradictory narratives in (Russia-hostile) Ukraine (Keegan, 2022). Additionally, in Ukraine, disinformation campaigns sought to undermine the medical response to COVID-19, using propaganda to exacerbate political divisions and weaken trust in public health directives (Patel et al., 2020).

Examining Opportunistic and Fragmented Disinformation Campaigns

Russia's disinformation strategy is characterized as both opportunistic and fragmented by Mark Galeotti. This offers a nuanced framework to understand the intricacies of its campaigns, particularly in the context of the COVID-19 pandemic. This approach underlines the adaptability and diversity of Russian efforts.

The fragmented nature of Russian disinformation campaigns is crucial to their success. By engaging a multitude of actors, including "social media accounts, fake news outlets, state-controlled global satellite media, bloggers, pseudo-scientists and supposed scholars, experts and Russians living in the West" (Sukhankin, 2020, p. 5), Russia ensures its narratives reach diverse audiences. This strategy is not committed to a single storyline but rather spreads various disinformation threads to resonate with different demographic segments. Here, the campaigns' fragmentation merges with Russia's disregard for consistency, as introduced in the context of the "Firehose of Falsehood" framework.

This array of "political entrepreneurs" (Galeotti, 2017, p. 14) seizes existing societal divisions and political discontent, tailoring messages to exploit these fractures further. During the COVID-19 pandemic, Russia adeptly capitalized on the global state of

confusion and fear, deploying a range of narratives designed not only to question the origins of the virus, but also the competence of international organizations. Russia opportunistically discredited the European Union, portraying it as ineffectual during the pandemic to foster instability within the bloc (Sauliuc, 2021). Russia also focused on vaccine hesitancy by spreading false narratives regarding the safety and efficacy of Western vaccines (EEAS, 2021). Russia was able to extend their pre-pandemic campaigns where they already used bots to heat up the vaccine debate on social media (Broniatowski et al., 2018). The COVID-19 pandemic was a welcome opportunity to widen the debate, using their previously trialed tactics.

The psychological impacts of Russian disinformation campaigns are profound, leveraging the ubiquity of social media to achieve widespread dissemination. Studies have shown that exposure to COVID-19 disinformation can exacerbate feelings of anxiety, fear, and confusion, undermining societal cohesion and public health efforts (Hoyle et al., 2022; S. L. Wilson & Wiysonge, 2020). This psychological manipulation reflects a strategic application of information warfare principles, exploiting the blurred lines between war and peace in the digital age.

This opportunistic and fragmented approach to disinformation, especially during the COVID-19 pandemic, underscores Russia's adeptness at navigating the global information environment. By exploiting existing fears and uncertainties, Russia's disinformation campaigns effectively sowed discord and mistrust, complicating global efforts to respond cohesively to the pandemic (Achimescu et al., 2021; Earnshaw et al., 2020). The strategy aligns with Russia's broader geopolitical aims of destabilizing perceived adversaries through non-kinetic means, demonstrating an adept understanding of the power of information in contemporary conflict (Sukhankin, 2020). The adaptability and multifaceted nature of these efforts highlight the challenges in countering disinformation and underscore the importance of a robust societal defense to safeguard public trust and health.

Analysis of Countermeasures and Their Limitations

In combating the COVID-19 infodemic, a diverse array of countermeasures was deployed globally. Despite these efforts, the persistence and evolution of disinformation campaigns underscored the inherent limitations of these strategies in fostering long-term societal resilience.

The response to the COVID-19 infodemic involved public awareness campaigns, content moderation, and the promotion of factual information. Public health organizations and governments initiated campaigns to disseminate accurate COVID-19 information, aiming to counteract prevalent myths and misinformation (Muñoz-Sastre et al., 2021). But the effectiveness of these campaigns was often undermined by the rapid spread and appealing nature of manipulative narratives on social media platforms, with a significant proportion of COVID-19 misinformation present on these platforms (Gabarron et al., 2021).

Social media platforms and fact-checking organizations have been at the forefront of identifying and mitigating disinformation. Some accounts were blocked on social media, including many that are linked to NewsFront mentioned above (EUvsDisinfo, 2021a, 2021b). Yet, the sheer volume of content and the sophistication of disinformation tactics present significant challenges (Karinshak & Jin, 2023; Paul & Matthews, 2016). Automated moderation tools can inadvertently suppress legitimate discourse, and fact- checking is frequently a game of catch-up with rapidly spreading narratives (EEAS, 2021; Sukhankin, 2020).

The primary limitations of existing countermeasures lie in their reactive nature and fragmented approach. These strategies, while necessary, fail to address the root causes of societal vulnerability to disinformation, such as low digital literacy and pervasive distrust in institutions. The global and decentralized nature of the internet further complicates the enforcement of regulations across jurisdictions, underscoring the need for a more comprehensive strategy.

The EU's response to Russian disinformation during COVID-19 was limited, as well. Fundamentally, its approach was marked by non-binding guidelines laid out in its Action Plan against Disinformation, 2018 (2018, p. 37), an approach criticized even by Meta's CEO Mark Zuckerberg (Vériter et al., 2020). The EU's more extensive joint communiqué about COVID-19 disinformation from June 2020 similarly falls "short of strong pre-emptive and accountability mechanisms" (Vériter et al., 2020, p. 572). Therefore, during the pandemic, EU member states were unable to "collectively communicate and confront the 'infodemic'" (Vériter et al., 2020, p. 572). A detailed chronology of the main EU actions during the COVID-19 pandemic can be found in Appendix D.

There is growing recognition of the lack of effectiveness of the EU's Strategic Communication (StratCom) policy (Vériter et al., 2020) and the need to promote societal resilience (Jungwirth et al., 2023). This approach involves not only combating disinformation directly but also strengthening the capacity of societies to resist, adapt to, and recover from the impacts of disinformation. As disinformation campaigns become increasingly sophisticated, developing and implementing policies that foster a resilient public sphere will be critical in safeguarding public health and democratic institutions against future infodemics.

Resilience against Russian Disinformation

Defining Resilience in Information Warfare

The concept of resilience first originated in the ecological (Jermalavičius & Parmak, 2018) and psychological studies (Gareis, 2021, p. 295), where it denotes positive adaptation amidst adversity (Fletcher & Sarkar, 2013, pp. 4–8). Since then, it has been widely discussed in security studies as a potential defensive mechanism to mitigate the impact of information warfare (Jermalavičius & Parmak, 2018; Jungwirth et

al., 2023). To develop a balanced understanding of resilience, we will consider the concepts used in practice and by academics, before reconciling both viewpoints. To illustrate the raw concept, various countermeasures used during COVID-19 will be shown and mapped to it. We will then discuss the types of additional countermeasures that are still required – informed by policy documents and research, grounded in resilience.

The notion of resilience has been widely picked up by practitioners, including the EU (Jungwirth et al., 2023) and NATO (Hassain, 2022). The European Commission defines resilience as “the ability not only to withstand and cope with challenges but also to undergo transitions, in a sustainable, fair, and democratic manner” (European-Commission, 2020, p. 6), denoting a “proactive understanding” of the society becoming more resilient (Jungwirth et al., 2023, p. 27).

In the academic studies of security and disinformation, no uniformly applied definition or concept has emerged, yet (Prior & Hagmann, 2014). But Keck and Sakdapolrak (2013, p. 13) have developed a “concept in the making” based on three dimensions, which has since seen wide adoption. They define societal resilience as the combined capacity of a community or nation to withstand and bounce back from adversities, based on *coping capabilities*, *adaptive capabilities*, and *transformative capabilities*. It encompasses the immediate management of crises (*coping*), learning from past experiences for future readiness (*adapting*), and instituting reforms that enhance long-term societal robustness and well-being (*transforming*) (Keck & Sakdapolrak, 2013).

It becomes evident that the academic model of resilience offers a structured and in-depth framework that aligns with and enhances the practitioners' operational definitions. By intertwining the practical resilience measures adopted by entities like the EU with the theoretical dimensions proposed in Keck and Sakdapolrak (2013), more robust and dynamic defense mechanisms can be developed. This fusion not only reinforces our immediate resilience to disinformation but also fosters a proactive culture of learning and transformation, ensuring sustainable and democratic resilience against future threats.

Resilience Countermeasures during COVID-19

During the COVID-19 pandemic, some countermeasures against Russian disinformation were more effective than others. Guided by three examples, I will show how some states successfully strengthened societal resilience during COVID-19.

In June 2020, the EU launched the European Digital Media Observatory (EDMO) tasked with the creation of a multidisciplinary community of fact-checkers, media literacy experts, and academic researchers. Its objective is to detect, analyze, and expose disinformation threats (Tackling COVID-19 disinformation - Getting the facts right, 2020; European Digital Media Observatory [EDMO], 2024). This initiative reflects the EU's *transformative capabilities* by fostering a collaborative environment

that enhances societal resilience to disinformation. EDMO also addresses the fragmented aspect of Russian campaigns by creating a networked response, mirroring the adversary's diversified and decentralized approach. This collaborative environment enhances the collective ability to respond to varied threats. Closely related, the EU also maintains its EUvsDisinfo project that is part of the European External Action Service's (EEAS) East StratCom Task Force. Established in 2015 to counter Russian disinformation (Eastern Partnership, 2015, p. 1; European External Action Service, 2020), it provides an open-source repository of disinformation cases (and counter statements), as well as analysis and reports (EUvsDisinfo, 2023). For citizens, analysts, and journalists, this repository is a valuable corrective against disinformation, increasing users' *coping capabilities*. The more than 940 items tagged with "coronavirus" are a testament to its resilience-building efforts during the pandemic (EUvsDisinfo, 2024). Overall, the project is an important communication outlet for the EU, enabling it to reply to and shape narratives (Sairanen, 2020, pp. 41–58) and, effectively, to conduct counterpropaganda (Glorio, 2018, pp. 57–61; Romerstein, 2008, p. 137).

However, given the difficulty of correcting disinformation after individuals have been exposed to it (Hameleers & van der Meer, 2020; Margolin et al., 2018, pp. 196–197), another approach instead looks to mitigate future instances of disinformation (Traberg et al., 2022). Based on inoculation theory (McGuire, 1961), the idea of "prebunking" is to expose an individual against the techniques used for spreading disinformation and misinformation. Already in the 1960s, U.S. soldiers were intentionally exposed to mild doses of propaganda, a "vaccine for brainwash" (Traberg et al., 2022, p. 1). The rationale was that they would be hardened against the full firehose of propaganda they would face during their deployment overseas. Today, short "vaccination" videos and games highlight common manipulation techniques, teaching users to discern untrustworthy content (Roozenbeek et al., 2022). During the pandemic, a diverse collaboration including the UK government has developed the mini-game *Go Viral!* where users gain points by effectively spreading misinformation – with some guidance by the game about which techniques work best (Basol et al., 2021; Hassain, 2022). With this game, British policymakers strengthened societal resilience, especially *adaptive capabilities*. By pre-emptively educating the public on disinformation techniques, resilience against future instances of fake news can be increased (Maertens et al., 2021; Roozenbeek et al., 2022). This combats the opportunistic nature of Russian campaigns, designed to exploit timely or divisive issues.

Finland's measures against disinformation during COVID-19 revolved around a government-initialized communication campaign. By successfully creating a decentralized network across government departments, civil society, business, and academia, the campaign "Finland Forward" successfully increased social cohesion and trust indicators, contributing to Finland's high vaccination rate (Hassain, 2022, pp. 13– 16). This initiative is representative of Finland's overall approach of countering disinformation by increasing resilience, as outlined in its 2017 security strategy (Security Strategy for Society, 2017, p. 23; Hassain, 2022, p. 13). It highlights that "trust in society and trust between citizens are central to ensuring resilience", emphasizing that

"trust is built during normal conditions" (Security Strategy for Society, 2017, p. 22). In Finland, the "fight against fake news [starts] in primary school" (Henley, 2020), with media literacy and trust in government as the key defenses against disinformation (Schia & Gjesvik, 2020). By fostering critical thinking and strengthening its public education system (Lessenski, 2023; Schia & Gjesvik, 2020, p. 421), it plays the long game against disinformation. As shown, this long-term approach paid off during COVID-19 and continues to be successful. Finland can be considered as the country most resilient against disinformation, given that it tops resilience-frameworks from academia (Humprecht et al., 2020) and leads the European Media Literacy Index (Lessenski, 2023). The authors of this index note that the ranking essentially depicts potential for resilience against disinformation (Lessenski, 2023, p. 4), just like education as a whole (van Prooijen, 2017). Finland's long-term enhancement of societal robustness and well-being are a prime example of *transformative capabilities* in resilience.

Improving Resilience against Disinformation in the EU

The complexity and adaptability of Russian disinformation campaigns demand a multifaceted response that addresses the technological, social, and political dimensions of information warfare. The EU acknowledges this complexity and recognizes the need for greater expansion of resilience countermeasure, as the 2nd EEAS Report on Foreign Information Manipulation and Interference (FIMI) Threats shows (EEAS, 2024, p. 13). While a complete discussion of every aspect of the EU's response is out of scope of this study, a quick overview can be found in Appendix E. In the present chapter, some select types of countermeasures required to strengthen resilience will be analyzed in detail.

The case of Finland shows how media literacy and trust in government can bolster resilience. In the EU, initiatives to develop media literacy are lacking. In the budget from 2021 to 2027, a mere 2 Mio. € per year are assigned to media literacy (European Court of Auditors, 2021, p. 37). They are "not coordinated under an overarching strategy for strengthening societal resilience, particularly in media literacy, which would include tackling disinformation", as the European Court of Auditors (2021, p. 37) points out. Furthermore, they state that "while education is a national issue, disinformation does not respect borders and affects all" (p. 35). Thus, best practices should be shared and common tools developed among European states (p. 35).

Nonetheless, there are different national conditions regarding resilience, based on "a combination of structural characteristics, features of its knowledge-distribution institutions including its media system, and the activities and capabilities of its citizens" (Dragomir et al., 2024, p. 1). In addition to nations, lower subdivisions should also be considered specifically. To account for the targeting of smaller sub-groups, there should also be media literacy campaigns developed at the local and regional level (Bleyer-Simon et al., 2022, p. 29). Therefore, while an overarching European strategy will not even suffice, it should not discourage European resolve to tackle disinformation.

The EU has been accused of "*geopolitical and regulatory dissonance*" regarding its approach to online disinformation (Casero-Ripollés et al., 2023, pp. 7–8). On the one hand, it maintains a strong security policy against disinformation threats. On the other hand, it employs soft laws for content moderation, based on voluntary compliance by online platforms (Casero-Ripollés et al., 2023, pp. 7–8). As the recent Digital Services Act adopts a "co-regulatory approach" (European Commission, 2024), the EU "[does] not replace this logic" of "geopolitical and regulatory dissonance" (Casero-Ripollés et al., 2023, p. 1). More resolute actions could be a step towards policy coherence. This also includes developing "greater European narrative proactivity" by creating communicative frames and improving public diplomacy (Benedicto Solsona, 2021, p. 1). For instance, deepening the efforts by EUvsDisinfo could lead to a more proactive defense against Russian disinformation. Considering that this would represent a strong change in the EU's communication strategy, this could be seen as the *transformative* element of resilience.

Discussion

In this chapter, I have delved into the multifaceted realm of Russian disinformation campaigns to unveil their impact on European states and societies. My exploration was anchored by two principal research questions that sought to unearth the patterns characterizing Russian foreign disinformation campaigns (RQ1) and the strategic countermeasures European states could deploy to mitigate such destabilizing endeavors (RQ2). Through a comprehensive analysis, I found that Russian disinformation campaigns are not only fragmented and adaptive but are also designed to opportunistically exploit societal vulnerabilities and sow discord among the targeted populations.

My findings underscore the sophisticated utilization of the "Firehose of Falsehood" framework by Russia, a tactic that leverages high-volume and multichannel dissemination of messages to overwhelm and manipulate public opinion. This approach, characterized by a relentless stream of information, lack of commitment to objective reality, and inconsistency, poses significant challenges to countering efforts. With this approach, Russia saturates the information space and cultivates an environment of confusion and mistrust. By examining these tactics against the backdrop of the COVID-19 vaccination disinformation campaign, I provided empirical evidence of Russia's ability to adapt its strategies. Specifically, its various "political entrepreneurs" (Galeotti, 2017, p. 14) adeptly exploit timely global crises, amplifying the potential for societal disruption.

Comparatively, my study reveals that while European states have initiated countermeasures to combat disinformation, these efforts often suffer from fragmentation and a reactive nature. Initiatives such as the European Digital Media Observatory (EDMO) and EUvsDisinfo, though commendable for their role in fact-checking and raising public awareness, underscore the necessity for a more cohesive and proactive strategy that goes beyond mere detection and correction of false narratives. The

resilience model, emphasizing *coping*, *adaptive*, and *transformative capabilities*, presents a holistic framework that European states can adapt to fortify their defenses against the sophisticated nature of disinformation campaigns.

The significance of my study lies in its imperative of adopting resilience-based strategies to safeguard democratic values and public trust. By contextualizing the patterns and impacts of Russian disinformation within the broader discourse of information warfare, this research not only enriches academic scholarship but also provides practical insights for policymakers. It underscores the urgent need for a concerted effort to foster a resilient public sphere, capable of withstanding and adapting to the complexities of disinformation campaigns.

Moreover, my analysis situates the phenomenon of disinformation within the wider implications for international relations, democracy, and the integrity of public discourse. This study illuminates the critical intersections between technology, politics, and society, urging a reevaluation of how democratic societies perceive and respond to the threats posed by disinformation.

Chandler (2013) criticizes the “societalization of security” inherent to using societal resilience as defense against disinformation. However, this study lays out how resilience measures such as media literacy initiatives have helped states like Finland increase their fortitude against Russian manipulation. Given their reach into people’s hearts and minds, disinformation campaigns cannot be countered without sufficiently considering the social dimension of security: Nowadays, Finland tops resilience rankings. Advancing the notion of resilience could also be seen as unnecessarily escalating the looming conflict. But this logic is flawed, as increasing resilience should be seen as “a preventive action aimed at solidifying societies and avoiding escalation of crises both within and outside of the EU and NATO” (Wieslander, 2016, p. 138).

In summary, this chapter reinforces the argument that understanding and countering disinformation requires a nuanced appreciation of its implications on national security, public health, and democratic governance. By providing a comprehensive analysis of Russian disinformation tactics and the European response, I contribute to a deeper understanding of the challenges and opportunities in combatting disinformation in the digital age. Finland’s efforts in improving media literacy serve as an inspiring example for developing a resilient society. My study serves as a call to action for European states and the global community to prioritize the development of resilience strategies that are capable of navigating and mitigating the complexities of information warfare in the 21st century. In the global election year of 2024, the resilience of the EU, the U.S., and numerous other societies will be tested in the face of Russian information manipulation (EEAS, 2024, pp. 23–33).

Limitations and Future Research

This research focuses on European responses to Russian disinformation, potentially overlooking the global dimensions of disinformation campaigns and the varied success of countermeasures in different geopolitical contexts. For instance, possible interaction effects between disinformation from various actors could be investigated, as well as (defense against) Russian disinformation in African states (Siegle, 2021).

Similarly, while the study provides valuable insights into Russian disinformation and European countermeasures, the extent to which these findings can be generalized across different actors and regions may be limited. Researchers and policymakers should be cautious in applying the study's conclusions beyond the specific context examined.

Moreover, there is a need for longitudinal studies to evaluate the effectiveness of resilience-building initiatives over time. Such research could provide insights into how these measures influence societal vulnerability to disinformation in the long run. While the European Court of Auditors (2021) called for evaluations to enable assessment of European initiatives, measuring resilience remains a key challenge (Prior & Hagmann, 2014). Nonetheless, quantitative methods would complement and deepen the qualitative insights provided by this study.

Further exploration into the relationship between public diplomacy and information warfare could provide insights into how nations can effectively communicate their values and policies internationally while countering disinformation. Specifically, criticism by Sairanen (2020, pp. 56–58) regarding counterpropaganda could be addressed.

It remains to be seen how the possibilities of artificial intelligence (AI) may alter Russia's disinformation approach. However, EEAS (2024, p. 11) notes that AI usage in disinformation currently "constitute[s] an evolution rather than a revolution", maybe even "[holding] more benefits for defenders than attackers". Still, future research is required to validate these claims and monitor the ~~r~~evolution.

To offer more educational value, especially in the context of Information Systems, concrete impacts of disinformation campaigns on businesses, as well as strategies and remediations they should adopt, should be further researched (Wachtel et al., 2022).

Conclusion

In this chapter, we've delved into the complex web of Russian disinformation campaigns and their impact on European states. We have come to realize that far from a grand strategy, Russia's information interference is fragmented and opportunistic. I also illustrated some of the campaigns' key characteristics – *high volume*, *rapid and repetitive*, *disregard for objective reality and consistency* – by applying the "Firehose of Falsehood" framework to the COVID-19 case study. Furthermore, we have

examined how disinformation plays into the bigger picture, as a key element of information warfare.

Through my analysis, it becomes evident that resilience – encompassing *coping*, *adaptive*, and *transformative aspects* – is paramount for Europe's defense against disinformation. A standout example of effective resilience is Finland, whose comprehensive approach integrates media literacy education from an early age, fostering a society well-armed against the pitfalls of disinformation. As its Security Strategy for Society (2017, p. 22) declares, “trust in society and trust between citizens are central to ensuring resilience”, and “trust is built during normal conditions”. This model serves as a beacon for other nations grappling with similar challenges, demonstrating the tangible benefits of embedding resilience and critical media literacy at the core of national defense strategies.

In conclusion, the fight against disinformation requires more than reactive measures; it demands a proactive and comprehensive strategy that prioritizes resilience and media literacy. By drawing lessons from Finland's success and emphasizing the development of a resilient, critically engaged society, European states can fortify their defenses against the insidious threat of disinformation. I hope they succeed in safeguarding democracy and preserving public trust in this increasingly complex information landscape.

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Appendix

A Application of the “Firehose of Falsehood” framework to other cases

The application of the “Firehose of Falsehood” framework to Russian disinformation campaigns reveals a strategic approach designed to undermine trust, sow discord, and destabilize democratic institutions. By analyzing specific instances of Russian disinformation campaigns, the framework's principles are illustrated. Here, in addition to the study’s main case of COVID-19, two further cases will be touched upon.

For example, during the **2016 US presidential election**, Russian operatives employed a multichannel strategy, utilizing social media platforms, fake news websites, and traditional media outlets to spread misleading information. The rapid and continuous nature of these efforts made it difficult for voters to discern accurate information, influencing public opinion and electoral outcome. Due to the vast coverage of this episode in the literature and social discourse (Badawy et al., 2019; Jamieson, 2020; Mueller, 2019), the 2016 US presidential election will not be further analyzed in this chapter.

Russia’s disinformation campaigns supporting its **invasion of Ukraine in 2022** (and before) are another showcase of its strategic deployment of multichannel disinformation tactics. Leveraging social media, state-sponsored news outlets, and cyber operations, Russia has aimed to shape international perceptions of the conflict, undermine Ukraine's legitimacy, and sow division among international allies. The rapid and continuous dissemination of misleading narratives about the conflict's origins (Klug & Baig, 2023; Sarotte, 2021; Sicherheitshalber, 2024), the nature of Ukrainian governance (Düben, 2023; Snyder, 2022), and the involvement of Western countries (Hughes, 2022; Wong, 2022) has significantly complicated the global response, highlighting the effectiveness and adaptability of Russian disinformation strategies in real-time geopolitical conflicts. Notably, the U.S. and UK have responded by regularly releasing intelligence reports to the public (Boot, 2022). However, as Paul and Matthews (2016), the authors of the “Firehose of Falsehood” framework show, the simple release of consistent and truthful information is bound to be insufficient.

Through these applications, the “Firehose of Falsehood” framework not only elucidates the operational tactics of Russian disinformation campaigns but also emphasizes the challenges they pose to counter-disinformation efforts. Understanding these principles and their practical implications is crucial for developing effective strategies to bolster societal resilience, promote critical media literacy, and safeguard the integrity of democratic discourse in the face of evolving information warfare tactics.

B Russia's fragmented ecosystem of disinformation

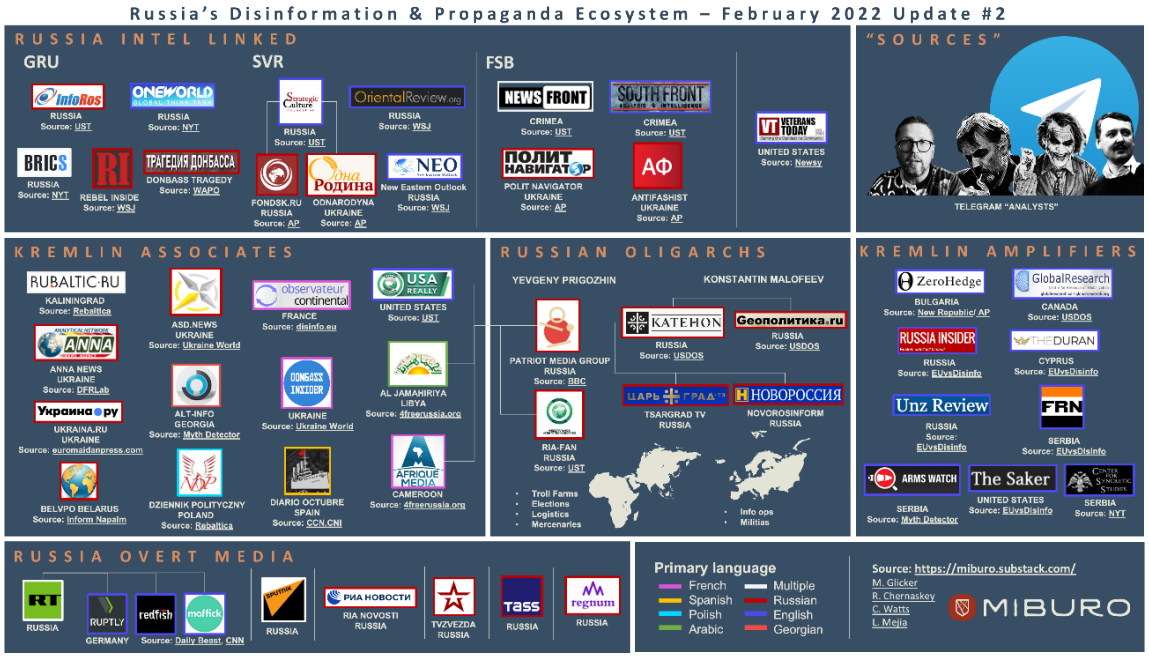

Figure 2: Specific Examples for Russia's Disinformation and Propaganda Ecosystem (Glicker & Watts, 2022)

Figure 3: Conceptual Overview by the U.S. GEC (GEC, 2020)

Figure 4: Putin's coordination of Russian active measures (Galeotti, 2017)

C Hybrid Warfare and Hybrid Threats – An imprecise term

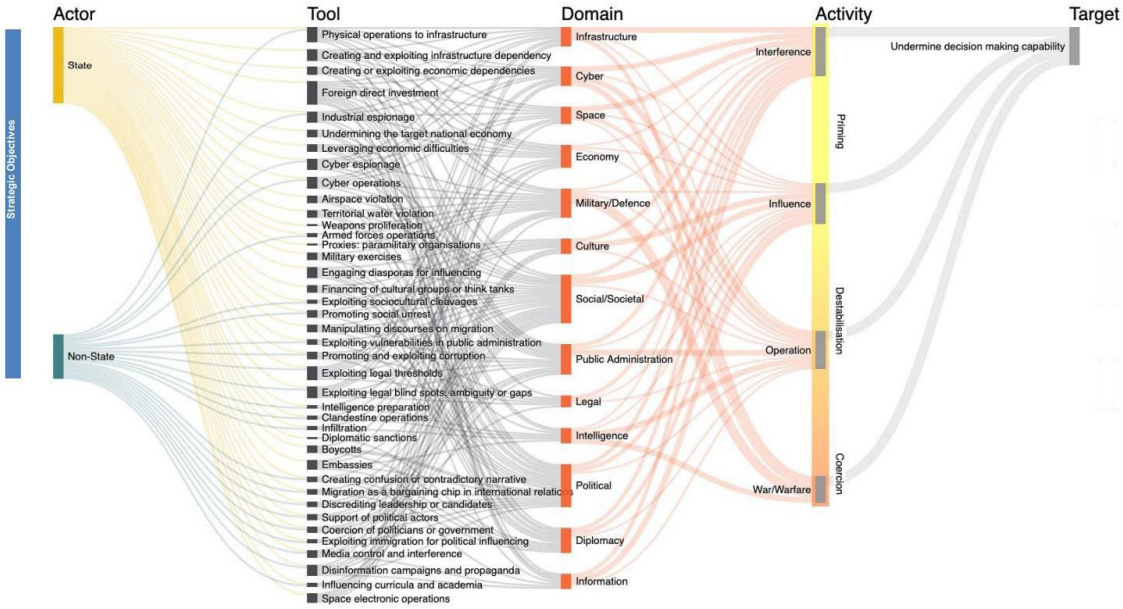

Figure 5: Conceptual visualization of hybrid threats (Giannopoulos et al., 2021)

This overview of hybrid threats, published by the European Commission, can serve as an illustration of the diffused and imprecise nature of the term. Consequently, the term *information warfare* is used more regularly in this chapter.

D Chronology of main EU actions during COVID-19

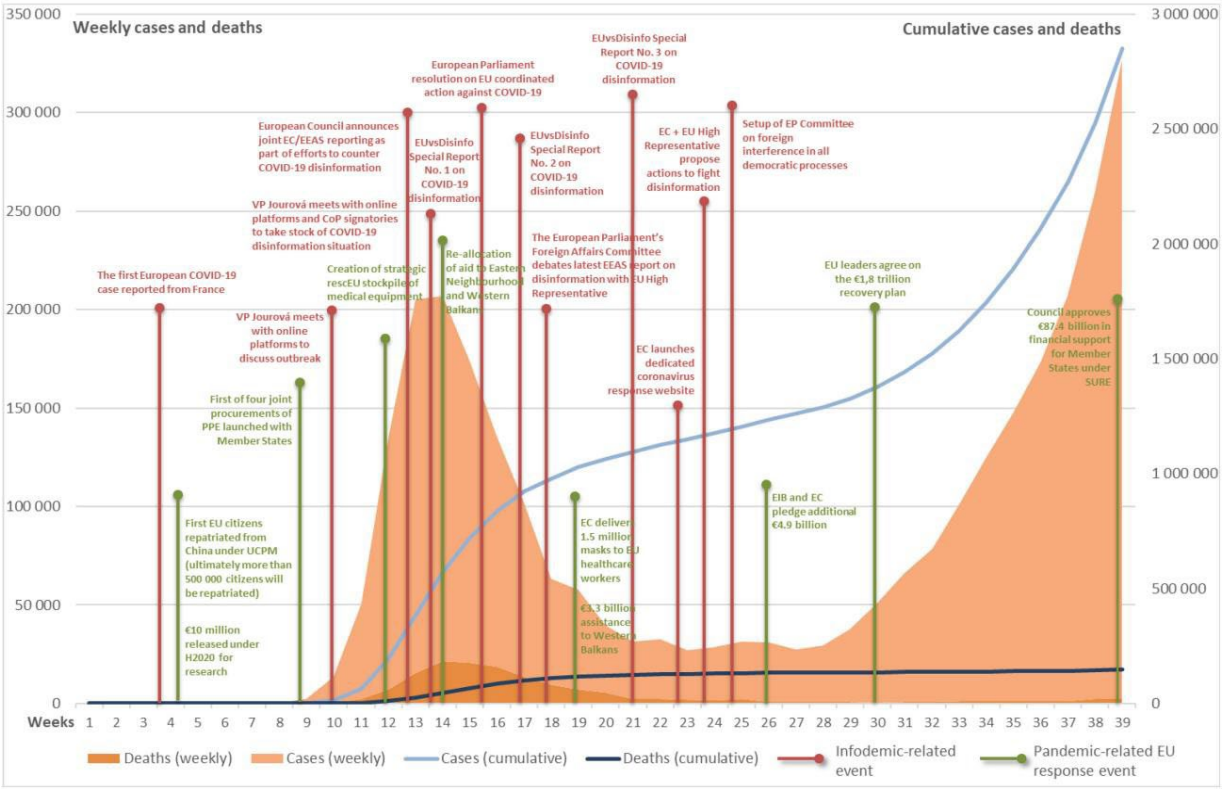

Figure 6: Chronology of main EU actions during COVID-19 (European Court of Auditors, 2021)

E Overview of potential EU measures against disinformation

Figure 2: Visualisation of the FIMI Toolbox: Situational Awareness, Resilience Building, Disruption and Regulation and EU External Action.

Figure 7: Visualization of the FIMI Toolbox (EEAS, 2024)

This diagram shows that the EU recognizes resilience as a key element in countering Foreign Information Manipulation and Interference (FIMI).

Chapter 2

A structured review on the effects of algorithmic management and automated decision-making systems on labour relations

Julian Granitza

*"By actively using his body, both as a means of locomotion and to establish relations in the spatiotemporal food delivery economy, Barthelemeus found a great satisfaction in working through the Deliveroo platform." (*Duus et al., 2023)

Over the past decade, Digital Labour Platforms (DLP) have caused major transformative shifts in the labour landscape. The premise: provide the self-employed, companies and consumers a way to connect through platforms to exchange services and goods. This process is facilitated through algorithmic management, recommender systems and automated decision-making to account for the incredible amounts of data that need to be processed. Pioneers like Uber, Fiverr and Care.com introduced a revolutionary form of 'day labour' that offers piece-wise execution of so-called microtasks. Such platforms may now be summarized under the term " Gig Economy", a mode of work that challenges traditional employment structures by offering extensive flexibility and autonomy for either side of the deal. Projected gross volume of the Gig Economy for 2023 is over 450 billion dollars (Mastercard & Statista, 2019). Whatever the benefits of gig work, its emergence has sparked concerns among workers' rights advocates across all sectors of gig work, citing the core component of the Gig Economy's business model as the reason for a decline in worker benefits, wellbeing and autonomy: (potentially) bogus self-employment. A major portion of gig workers have been employed by DLPs as independent freelancers or contractors. As a result, long standing labor legislation regarding minimum wage, social security and other benefits that come with conventional employment cease to apply, essentially leaving a loophole that offloads considerable entrepreneurial responsibility onto the individual (Fleming, 2017). Scholars have coined the phrase "algorithmic precarity" as an umbrella term to summarize the use of algorithmic management and automated decision-making systems and its detrimental effects on the individual worker in the Gig Economy. Many researchers and politicians argue that the automation of certain managerial tasks, leaving the likes of performance monitoring, data collection and

work allocation to computerized algorithms, has unprecedented pitfalls when said algorithms do not “serve the creation of value for all actors versus the creation of value primarily for the [platform]” (Meijerink & Keegan, 2019; p.25).

Within the past few years, governmental bodies have aimed to regulate the use of emerging technologies in a rapidly modernized labour market. Especially in the case of platforms which offer what this chapter will call low-skill labour opportunities, scholars have identified extreme risk for precarity. Notable events in this regard are the 2020 California Proposition (California Secretary of State, 2020), or Prop22, mandating new benefits for platform workers while upholding independent contractor classification, the 2021 ruling of the UK supreme court (Sarah Butler, 2021), arguing that, although being rightfully classed as contractors, drivers were dependent on the platform and therefore entitled to certain benefits that came with being classed as workers, and Spain’s “Riders’ Law” (Eurofound, 2021), granting a rebuttable presumption of employment to food- delivery workers. As of February 2024, Eurofound records 378 initiatives and court cases related to the platform economy in the EU alone (Eurofound, 2024). As a result, in their whitepaper published in 2021, Uber itself claimed that the pandemic caused by COVID-19 had “revealed the fundamental inequity of our current employment system”, prompting the EU and other policymakers to fix traditional employment models since they “are forcing platforms and workers to make a choice between flexibility and security” (Uber, 2021; p.28). The EU commission responded with a proposal of a directive “on improving working conditions in platform work” (EU Commission, 2021). It lays the foundation for EU member states to form new legislation concerning platform work and aims to reach its goals by “facilitating the correct determination of […] employment status”(p.9), improving the transparency of platform work itself and “the protection of the personal data of persons performing platform work” (p.10).

This chapter will establish a theoretical and practical backdrop of the Gig Economy and its different castes, give a summary on recent labour law literature dealing with the EU’s efforts toward the Platform Work Directive (PWD) and introduce earlier attempts from the research field of social sciences and management to review this rapidly growing body of research. Subsequently, by means of a systematic literature review, this chapter will examine how algorithmic management shapes dynamics of labor relations, and furthermore discuss the implications it has for the future of work. Additionally, it will link related discussions about the use of AI within society and reinforce the necessity for more groundbreaking regulations that go beyond platform work and legislative “quick fixes”. Finally, it will elaborate how opportunities as promised by these technological revolutions put humanity at a crossroads: surrender to techno-induced hegemony of mega corporations or “indeed harness […] full automation for a leap into ‘luxury communism’” (Deranty & Corbin, 2022; p.12).

Gig Economy and Managerial Automation

To understand how the Gig Economy separates into different sectors, how scholars have characterized algorithmic management and how the efforts of the EU have echoed within the labor law research community, this chapter will elaborate some useful underlying concepts. In addition to this, an overview of previous reviews concerning algorithmic management (AM) will be given.

The Gig Economy has found its place in various sectors of economies around the world, created new forms of labor relations, e.g. third-party food-couriers, and for some has disrupted the market to crush competitors, e.g. metered taxis vs ride-ordering platforms (Mays et al., 2023). Beyond that, professionals have had increasing interest in offering their services online to complete individualized tasks for clients on a freelance basis.

A Taxonomy for the Gig Economy: Historically, scholars have resorted to inconsistent classifications of DLPs either along the sectors they operate in, or along what the respective writer deemed appropriate skill-level classification required to complete the tasks facilitated by the platforms. This arbitrary classification, however, is insufficient to formalize empirical fieldwork necessary to characterize different platforms. To establish a scientific basis for conceptual differentiation between different platform business models and modes of operation, Kruse et al. (2023) formulated a comprehensive taxonomy characterizing DLPs along four main dimensions: Contractor, Interaction, Facilitation and Client. Within those dimensions, 13 sub-dimensions make way for 36 characteristics for DLP classification. Broadly speaking, it allows for clear distinction of platforms between sectors, e.g. between Upwork & Uber, with *contractor execution* and *execution* as distinguishing criteria, but also within sectors, e.g. Uber & inDriver, with *allocation of price determination* as distinguishing criteria. This taxonomy, therefore, not only allows distinction based on how contracts are concluded and how their specific conditions are determined, but also the associated work characteristics. This goes without assuming some arbitrary amount of required skill, but by distinguishing core value creation methodologies. It proves to be especially helpful as policymakers and judges have consistently struggled to transfer existing criteria, that deals specifically with the misclassification of labor relations, e.g. bogus self-employment, into these digitalized markets. Identification of bogus self- employment, even outside DLPs, is an ongoing struggle for policymakers. The framework is a first building block to understanding the Gig Economy and its connection to traditional employment relations, and therefore traditional ways to determine an employment relation as introduced by Williams et al. (2020).

Algorithmic Management: DLPs are technology-enabled meta organizations (Möhlmann et al., 2021), the technology being large-scale data collection and processing, as well as algorithmic management. This type of management is key to the business model of e.g. Uber, since it “must be highly efficient and scalable, and involves resources and activities not wholly controlled by traditional managers” (Möhlmann et

al., 2021; p.2005). It can hereby be defined as large-scale collection, as well as the use of data to create functions and algorithms that are traditionally taken care of by human managers. Möhlmann et al. (2021) describe the use of AM along two axes, *Algorithmic Matching* and *Algorithmic Control*. This provides a second building block to understanding the labor relations in the Gig Economy.

Algorithmic Matching can be divides into three dimensions: (1) *algorithm as a marketplace*, an enabler of a scalable and efficient marketplace to let transactions take place; (2) *use of input- and output data*, ensuring good, consistent experiences by considering the requirements of all sides in the transaction; (3) *dynamic pricing*, defined as optimizing for economic efficiency and effectiveness, setting prices according to existing, or missing for that matter, supply and demand, avoiding the deterioration of the market either sides of the deal.

Algorithmic Control again, divides into three dimensions: (1) *algorithm as a boss*, to automate the supervision of the service provider and their compliance with certain platform regulations; (2) *the use of process data*, to evaluate the performance of the service provider; (3) *behavioral nudging*, to influence behavior of the service provider to optimize the labor process on behalf of the other sides of the deal.

Agency as an indicator of Human-AI and labour relations: Identifying the nature of labour relations has historically included the amount of agency, as in the degree of autonomy and freedom, assumed by workers. Möllers et al. (2023) examine the relations of artificial intelligence (AI) and humans in a workplace configuration utilizing a two-axis framework. The two axes, *Flow of Agency*, the directions in which either agent, AI or human, transfers agency to the other, and *Augmentation*, the degree to which AI takes over tasks of the labor process. When viewed in relation to the Gig Economy (Kruse et al., 2023) and AM (Möhlmann et al., 2021), this notion of agency in Human-AI and labor relations provides grounds to classify specific platforms and their use of AM in the matching and control process. Accordingly, one should view agency as a tool to evaluate the use of AI in the Gig Economy and the resulting changes in labor relations. Although Möllers et al. note ‘Algorithmic Management’ as a specific workplace configuration, the degree to which workers transfer agency to AI on platforms with high augmentation of

the labour process is rather ‘Human in the loop’ or ‘Full Delegation to AI’, where the humans merely function as a physical extension of the algorithm.

Platform Work Directive

As illustrated by the fact that the anticipated PWD constitutes one of the first attempts to regulate the use of AI in the workplace (EP News, 2024), and the presumed ‘Brussels Effect’ (Bradford, 2020) it will have on other regions around the world and the international ‘social acquis’ (Aloisi et al., 2023), it seems only just to summarize briefly

the intentions and views of labour law scholars on employment classification, but especially provisions for algorithmic management.

Kullmann (2022) explores ways to improve the legal presumption that may be proposed in the PWD. They cite the increasingly weak negotiating power resulting from the informational imbalance in platform work as the reason to look for ways to implement a legal presumption of employment inter alia the Recommendation No 198 of the International Labour Organization (ILO, 2006). Based on some indicators, in connection to a transfer of burden of proof that no employment relation is present, they explore a way to establish such a legal presumption that makes use of already existing, more traditional employment relationships, in contrast to utilizing a more sophisticated framework that takes into account the specifics of the labor process (Kruse et al., 2023), the extent of AM (Möhlmann et al., 2021) and worker agency (Möllers et al., 2023). Keulen (2023) deals to a great extent with democratization of work and introduces the concept of participatory algorithmic design - work cooperatives under which workers may exert more agency, essentially making their relationship with the platform more akin to those of genuine self-employed. However, they also note the limited feasibility and sustainability when such cooperatives enter competition with deregulated traditional platforms operating under the common capitalist imperative. Although the commission in its July 2023 version of the PWD proposal has introduced a rebuttable legal presumption, which is based on seven indicators, it remains a major discussion point, according to media reports (Bourergy- Gonse & Radosavljevic, 2024).

Chapter III of the directive details a major building block that regulates the use of personal data of workers in automated monitoring and decision-making systems (EU Commission, 2021). Veale et al. (2023) emphasize the importance of this aspect to preempt “tensions, potential misinterpretations and perversions” (p. 308). They begin by discussing the genuine self-employed of the Gig Economy, highlighting their potential vulnerability despite solutions to misclassification of work-relations. These vulnerabilities include issues such as *unaccountable non-payment*, sudden *account suspension or closure without explanation or recourse*, *ineffective and unfair automated decision making* and *uncommunicative customers and platform administrators*.

In the following, they take up intricacies of these issues, such as transparency. As for the requirement to provide intelligible and transparent information towards the main parameters contributing to AM, Veale et al. note the lack of strengthening explicit provisions in comparison to the General Data Protection Regulation (GDPR). The technical background of such systems quickly limits the extent to which the ‘main parameters’ may be explainable “ex ante”, as modern neural networks and ML-algorithms may include hundreds of parameters and non-linear decision boundaries – concurrently, they argue for limits on the complexity of the algorithms themselves, therefore drastically improving the faithfulness of the “global explanations” as they are “not explanations at all if they are not understandable”(p.315).

Furthermore, they ideate “ex post” transparency measures, such as the provisions for human review. They argue for mechanisms in the human oversight of systems for stronger substantive review in appeals of significant decisions taken, creating accountability on the platform’s side. Lacking “global explanations”, they suggest “local explanations” should be made possible by the PWD to “ensure that the [decision] is supported by evidence” (p.321). While there is recent guidance on collective agreements by solo self-employed (European Commission, 2022), the PWD also mandates platforms consult with employee representatives or the self-employed, but Veale et al. criticize the lack of ‘best practices’ concerning such consultation. They also mention feasibility issues across borders, since platforms may incur considerable additional overhead if required to communicate in national language, and according to local laws and customs for worker representation and consultation.

The authors also elaborate the implications the PWD has on the use of ‘civic technologies’ – digital forums used for “collective sensemaking” (p.327) of the information provided by the platforms. While noting the importance in practice, they mention the contradiction that platforms shall not monitor such forums by taking away the, to date, most potent chance to establish a fairer relationship in algorithmic design between platform and worker. Confidentiality of communications, in addition to the ban on processing data on the psychological state of the worker, may also hamper the investigations mandated towards the psychological effects AM has on workers.

Previous Work

In the following, a summary of academic reviews on how AM shapes labour relations will be given.

Subramony et al. (2023) reviewed a variety of management scholarship that deals with how “technology shapes work in the 21st century” (p.1) and identified ‘algorithmic management in online platforms’ and ‘worker experiences and outcomes in the gig economy’ to be among the most prevalent topics in practice. For the former category, they argue that “Most studies […] are case studies and not anchored in theoretical foundations” and recommend researchers adopt methodologies from “theory driven empirical research” (p.11). As mentioned in a previous section, they note potential structural disparities in how AM affects the labour process on different platforms. For the latter category, they elaborate key findings such as the fact that, rather than being a movement of self- emancipation, platforms merely pose a new “way to make money” (p.16) that comes with considerable risk of precarity for the most vulnerable of worker groups. They mainly focus their guidance for further research on how positive impacts of the Gig Economy may be enhanced and the understanding of policy “across global boundaries” (p.17).

Deranty & Corbin (2022) deem *AM*, as well as *platform work and the politics of AI work* as two of three core issues discussed in social sciences. They highlight “the capitalist imperative and nationalistic pressures” (p.1) as notions that shape

discussion around AI's influence on labour relations. In their concluding remarks, Deranty & Corbin call out the stress AI would potentially put on "already ailing systems of social protection" (p.12). They critically look beyond "blue-sky literature", contextualize the current value that such opportunistic pieces bring, and point out the need for propositions that are oriented around "economic and political reality" (p.12). Mapping battlegrounds relating to the capitalistic imperative, such as the (mis-)classification of labor relations and ethical AI development, as well as nationalist imperative, such as the questionable enforcement of "principles of 'good AI' when [the states] are engaged in high stakes contests over geopolitical hegemony" (p.13), they note that it is "the kind of world in which AI will be developed and deployed" (p.13) that matters for the future of work and labor relations.

Methodology

Considering the background that was given for Algorithmic Management, the Gig-Economy, the associated political landscape and recent reviews of literature, this chapter specifically aims to answer the research question:

RQ 1: How does the use of algorithmic management shape the dynamics of labour relations in the Gig Economy?

And to advance the debate around employment classification and ethical use of AI at the workplace, particularly for the most precarious, such as food-couriers, e.g. Just Eat and taxi-drivers, e.g. Uber:

RQ2: What could be an innovative emerging contractual model of platform-based employment?

To investigate the first question, a systematic literature review as "a means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest" (Kitchenham et al., 2009) was conducted. The framework proposed by vom Brocke et al. (2009) recommends five steps toward successful documentation of literature search.

The first and second steps are the *definition of review scope* and *conceptualization of the research topic*, i.e. the statement of specific research questions and a thorough establishment of background information to set the scene for conceptual research regarding the dynamics of labour relations in the Gig Economy. AM may hereby be defined by the framework of Möhlmann et al. (2021) elaborated on in *2.1*, the body of literature and its relations shall be examined by means of the taxonomy as published by Kruse et al. (2023).

The third step constitutes the literature search itself, which was conducted on Scopus by means of the search string "*TITLE-ABS-KEY (algorith* AND manag* AND empl* AND (gig economy OR platform work OR digital labor platform OR online labor platform* OR sharing economy OR crowdwork)) AND PUBYEAR > 2020 AND PUBYEAR*

< 2025 AND (LIMIT-TO (SRCTYPE , "j") OR LIMIT-TO (SRCTYPE , "p")) AND (LIMIT-TO (LANGUAGE , "English"))" which yielded 29 relevant journal articles and conference proceedings after screening for topical coherence and not accounting for literature reviews. To not include literature previously covered in literature reviews by Deranty & Corbin and Subramony et al., the year was limited to publication after 2020. Using the keyword '*empl**' special focus was laid on literature containing direct references to employment relations Furthermore, it limited the research scope of this chapter.

As per the fourth step, *literature analysis and synthesis* were carried out by identifying core concepts, a procedure laid out in the Concept Matrix of Webster & Watson (2002).

Thus, chapter 5 provides an agenda for [RQ2] as step five of the framework, following the argumentation scheme proposed by Toulmin (2003). The next sections implicitly provide *Grounds*, *Warrant* and *Backing* to a *Qualifier, Claim* and *Rebuttal* presented in conclusions.

Findings

In the following, a descriptive analysis based on previously established categorizations of the Gig Economy and AM is presented. Of the 29 papers 25 were published in unique journals, highlighting the topical breadth of the research field. The recurring publications are the *ACM International Conference Proceeding Series*, *Information Technology and People*, as well as *New Technology, Work and Employment*. Afterwards, the analyzed papers are be presented in terms of single recurring theories.

Deficiencies of Structural and Relational Understanding

Distinguishing concepts of Algorithmic Management: When analysing the 24 empirically working articles qualitatively, one may notice, that along the two axes of AM as per Möhlmann et al. (2021) there is no meaningful distinction to be gained Figure 9. This is supported by the fact that most articles dealt with two or more concepts of tensions presented by Möhlmann et al.. Qualitatively speaking, there is no clear distinction in research between the two concepts matching and control, however, judging by the scholarly discourse, matching and control have vastly differing effects on employment relations. This reinforces the claims made by Subramony et al. (2023), that AM with respect to labour relations is seldomly discussed with theoretical concepts in mind. Broadly speaking, the two axes were either touched upon explicitly or implicitly, which shows the potential for distinction of concepts that shape the labour relations in the Gig Economy. Consequently, this could influence how legislators view these categories in relation to each other, and lead to more informed and clear-cut guidance, which was called out by Veale et al. (2023) to be missing from the recent drafts of the EU directive.

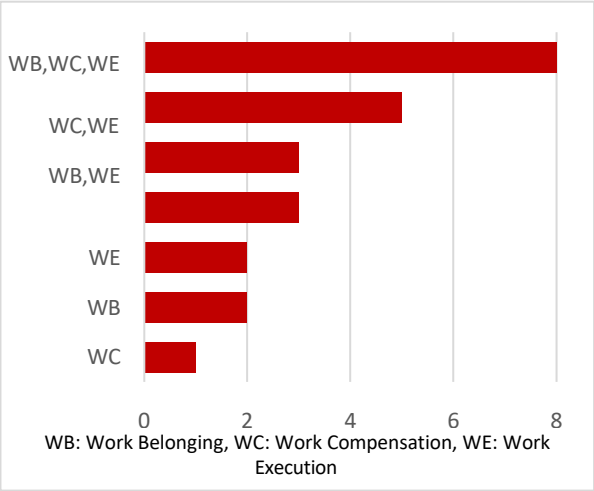

Figure 8: Work Tensions

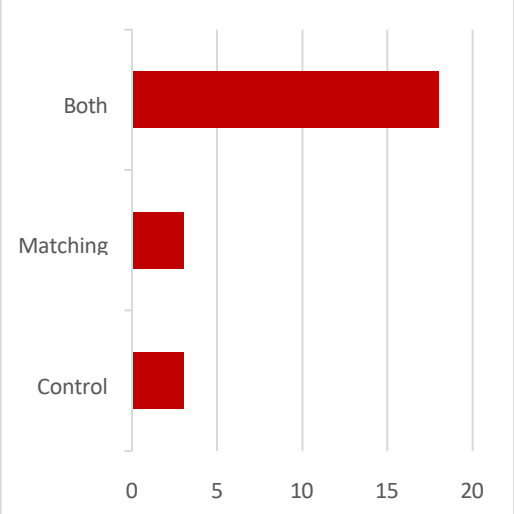

Figure 9: AM Axes

Distinguishing Gig-Platforms by Labour Process: The taxonomy of Kruse et al. (2023) provides a crucial starting point for research to identify major gaps concerning different parts of the platform economy. As identified by other reviewers, such as Deranty & Corbin (2022), researchers have predominantly looked toward the most precarious and vulnerable Gig-Workers that surrender the highest amounts of agency (see Möllers et al., 2023) to *opaque matching algorithms* and are subject to *extreme amounts of algorithmic control* to the point where the labour process is entirely dictated by the algorithm. This is a natural process, in which the most striking precarities raise the largest concerns, especially in markets with comprehensive social welfare systems. In the latest iteration of the EU directive, the neoliberal government of France has started questioning the presumption of employment stated in the directive, stating: "[the presumption] should not cover all situations of persons performing platform work, in particular where self-employment accurately reflects the reality of the contractual relationship" (Bourergy-Gonse & Radosavljevic, 2024). From the review of Subramony et al. (2023) we learn that there may be structural differences in the influences of AM on the labour relations, which is further supported by the findings section. Additionally, the conceptualizations of precarity inducing effects of AM on the labour process are recurring across all[7] different business models, to varying degrees and ways of impact. As an example, Möhlmann et al. (2021), by examining the business model of Uber, introduce dynamic pricing as a core component of algorithmic matching. However, the taxonomy of Kruse et al. dictates that business models with structurally different pricing strategies may be viable. When looking into practice, inDriver (2024) emerges as such an example, offering dynamic pricing that is controlled by drivers, instead of an algorithm. Such differences in business models influence the

7 This chapter does not examine in detail this relation, but merely notes a tendency in articles beyond those cited in this review.

agency assumed by workers drastically, may in turn reduce psychological stress induced by *algorithmic control*. To what extent granting this agency shifts the perception of *algorithmic control* is examined in the vastly different context of care-platforms by McDonald et al. (2023), noting the influence of mere *pricing suggestions* to the worker (see behavioural nudging, Möhlmann et al. (2021).

To sum up, the descriptive findings of this chapter suggest a deficiency of structural and relational understanding between the core concepts of Algorithmic Management among scholarship and highlight the need for theory-backed research as noted by Subramony et al. (2023). A final thought is directed towards the extensive review of EU labour law components, their "interlinkages, overlaps, and potential areas for further elaboration and even legislative reform", Aloisi et al. (2023, p.1) present in an ILO working paper calling the EU directive "An unfinished Task". They aptly point out "that in order to improve the working conditions of platform workers, regulators need to rethink the traditional rigidities associated with the subordination paradigm" (p.1). In other words, they advocate for a shift away from conventional frameworks that strictly categorize workers as either employees or independent contractors. Instead, they propose more flexible approaches that better address the unique challenges and dynamics of modern work-relations.

Finding the Theories

Although the previous section highlighted core deficiencies concerning the theoretical backing of scholarship, distinct articles among the empirical research establish theories of how AM shapes the labour relation when de-coupling it from the conceptual confines put into place by Möhlmann et al. Such theories are first presented in a concept matrix as proposed by Webster & Watson (2002) to establish units of analysis. Since the conceptual delineation of theories is limited, it allows for drawing connections between individual papers and presenting their findings.

Theories	**Mentions**
Labour Market Formalization	7
Co-Creation of HRM practices	8
Self-Exploitation	2
Unwanted Waiting Time & Work-Life Balance	10

Table 1: Frequency of Theory Mentions

Labour Market Formalization: Scholars, alongside the platforms themselves, have noted a key benefit of platform work: a significant reduction of hurdles to enter a formalized employment relationship (Altenried, 2021; McDonald et al., 2023; Insebayeva & Beyssembayev, 2023; Haidar, 2023; Filipetto et al., 2023). While the latter three discuss labour market formalization in the context of historically informal labour markets, that is Argentina and Kazakhstan, the former do so by theorizing in the opposite domain, the highly formalized labour markets of Australia and Germany.

Filipetto et al. (2023) systematically map, and therefore theorize, formalization of three distinct sectors: domestic service (Zolvers), home repairs (HomeSolution) and ride-hailing (Uber). They show three trajectories facilitated explicitly by the platforms: *formalization*, *precarization* and *continuity*. As per their results, the degree of each of these phenomena depends highly on the "business model, […] the pre-existing formal/informal dynamics within the occupation and the general labour market situation" (p.1).

These findings are qualitatively supported by Insebayeva, Beyssembayev and Haidar, where the former notes that Kazakhstan, as a country with soviet heritage, profits from the formalization of the labour market, claiming it facilitated improvements in quality and consistency of services. In some way, DLPs have also enabled precarious workers to gain visibility and enjoy more labour law protection along with a more secure income stream because the platform provides enough work. A finding reinforced by Haidar (2023, p.958): platforms provide "a formidable employment refuge" since they "more than double[…] the legal minimum wage" and the alternative would be unemployment, a key argument in favour of *formalization* of labour markets. In the case of freelance professionals, the platform economy is assumed to have softened the economic blow coming from the pandemic starting in 2020. In other words, *continuity* was a key driver for platform work in the professional freelance sector. Rani & Furrer (2021) mention that developing countries deliberately invested into infrastructure to strengthen the Gig-Economy in a battle to formalize the labour market.

In Australia, McDonald et al. (2023) observe all three of the phenomena in examining a care-work platform. They observe trends of *formalization* in previously informally organized work, i.e. 'Babysitting', while others seek *continuity* by going from formally employed to formally self-employed, e.g. since their employer went out of business. Additionally, they observe challenges contributing to *precarization*, more precisely behavioural nudging, accelerating the prevalent devaluation of care-work by making workers insecure about wages they could demand. In the case of Germany, Altenried (2021) describes the substitution of Berlin's food-courier workforce with predominantly migrant workers during the pandemic. They claim, that in highly formalized labour markets, the comparatively informal work arrangement particularly attracts migrant workers, as they may be accustomed to informal labour markets and are not properly integrated into the domestic labour market, for they do not hold local citizenship. In other words, an 'informalization' of the labour market is taking place. They propose "to situate the Gig Economy in a long genealogy of contingent and precarious labour"[8] (p.11).

Co-Creation of HRM Practices: The platform economy realigns traditional HR practices and the extent to which they are applied to contractors (Keegan & Meijerink, 2023). HR activities predominantly reserved for employees, such as performance

8 Especially business models relying on inherently informal arrangements such as (bogus) self-employment.

monitoring, are now applied to contractors. Waldkirch et al. (2021) goes one step further to claim that workers engage in the crowd-creation of HRM practices. As such, they illustrate a bottom-up approach in professional environments, where workers coach each other into creating more value, and in precarious environments crowdsource counter measures to the controlling and surveillance mechanisms coming from the top.

Sivarajan et al. (2021) elaborate psychological contracts (PC) and the effects that breaches of promises by the platforms have on the crowd-coaching of workers. They show tendencies of developing 'jugaads' – quick fixes to undermine the algorithm's authority over the labour process by engaging with individuals that experienced similar breaches in PCs.

Workers voice the desire to belong to some greater entity, to connect with others and discuss challenges and hindrances of their life and work. Some DLPs claim to have tried to foster relations between co-workers, but at cost of the workers' compensation. They concluded that higher compensation for the workers was more important than connecting with others engaging in similar work (Insebayeva & Beyssembayev, 2023). Watkins (2022) has introduced the notion of 'Communities of Practice' to the Co-Creation of HRM practices, and criticizes that the "specific sociotechnical arrangement of the online forum, distanced digital participation, and the precarity, not just of the work itself necessarily, but of legitimate membership in the work community, drives a form of interaction that is distinct from how other types of communities coordinate and share support and information" (p.1582). Consequently, they argue that asserting accountability is carried out laterally by workers' peers in online forums, in addition to algorithmic control of the platforms, although they attribute this lateral flow to the considerable pressure the latter puts on workers. This is supported by findings presented by Mendonça & Kougiannou (2023), arguing that severe changes to the algorithms hamper the co-creation of HRM practices and especially "the workers' capacity to organize collectively" (p.1), as even between different classes of workers on the labour platform, the stark differences how workers gain access to the labour process, as well as the labour process itself fosters adversarial relationships, much like traditional workforces that are fragmented along certain borders.

Lastly, Maffie (2024) introduces the notion of 'Cross-organization co-workers', by which AM has a contradictory duplicity to relationships and interactions between gig-workers and traditional service workers. On the one side, there is an adversarial relationship that is fostered by AM by driving platform workers into bullying and pressuring their peers to give them preferential treatment to provide faster and more tailored services to the platform's customer. On the other side, when such adversarial relations are overcome by workers realizing the potential cross-organizational symbiotic relationships they could build, cross-organizational value creation takes place. Workers that usually live in social isolation may enjoy more conventional levels of social and economic support, experienceless loneliness and even gain access to privileges that are normally withheld from regular customers. This dynamic is observed, but not

discussed by Duus et al. (2023). Furthermore, cross-organizational alliances between traditional and gig-workers may be a trajectory along which workers can achieve goals beyond satisfying a customer, “such as resisting managerial control” (Maffie, 2024, pp.25f).

Unwanted Waiting Time & Work-Life Balance: ‘Unwanted [also unpaid] waiting time’ is a concept that is traditionally connected to regular self-employment. Duus et al. (2023) introduce such down-time as a core concept that is triggered through ‘data troubles’ that are present in the spatiotemporal environment of platform work. They observe drivers developing techniques to circumvent this unwanted waiting time by examining the constraints of their work-environments, but also the potential shortcomings of the algorithms they were managed by. It is obvious that considerable knowledge of the underlying algorithms provided them with an advantage, leaving couriers with more desirable orders in shorter time. On the other hand, part-time workers considered unwanted waiting time an opportunity to transfer perceived work-time into ‘living life’, although they did not see it as an opportunity to get closer to a bigger goal, such as studying for a degree. However, James (2024) presents the Gig Economy as a considerable opportunity to increase work-life balance (WLB), as down-time may be used by those with extensive childcare commitments, radically cutting down on ineffectively used downtime normally associated with freelancing. They also mention it may reduce risk of precarity and uncertainty for such workers, predominantly women. The author further criticizes the missing WLB provisions ‘painstakingly conceived’ over the last decades. What should also be mentioned is that WLB has cultural heritage and is linked to national customs (OECD, 2020), where standing concepts may be readily undermined by AM due to its disregard for individual provisions and enforced conformity throughout their business models, especially in those exacerbating precarity (James, 2024).

Self-Exploitation: Vieira (2023) introduce three ‘postdisciplinary control mechanisms’ as the key underlying factors of self-exploitation that workers engage in predominantly because AM drives them to do so: *Precarity*, *Entrepreneurial subjectivity* and *Gamification*. They show how platforms forge mechanisms that “acquire the commitment of workers to detrimental labour process designs and ultraprecarious situations” (p.506), imposing additional implicit *matching* and especially *control*.

Li et al. (2023) quantitatively analyse work engagement outcomes utilizing a challenge- hindrance appraisal model. They point out algorithmic fairness as a catalyst of *gamification* and improved challenge appraisal, which leads to overall increased commitment. Orhan et al. (2022) specifically investigate the matching algorithm as a driver of self-exploitation on a microtasking platform (Amazon Mechanical Turk), where workers are pushed to embrace *entrepreneurial subjectivity*.

Duus et al. (2023) devote their research toward the spatiotemporal relation of work engagement and temporal experiences of platform work. Workers put in emotional work to build extensive expertise concerning the algorithm; platforms hitchhike the

invested mental capacity towards increased profits. Furthermore, workers, despite employing different techniques to circumvent it, cannot eliminate unwanted waiting time, often resorting to a sort of ‘standby’ or even working across different platforms intensifying their mental load.

Watkins (2022) identifies habits to put extra-occupational labour into curating contributing online forums; similarly, Sivarajan et al. (2021) point out workers investing time into developing ways to circumvent the algorithm, which harms the platform and doesn’t significantly improve the individual’s situation. Bucher et al. (2021) observed strategies that couriers develop to “pacify the algorithm” (p.1), scrutinizing how “digital workers have to be hyper-vigilant to how both their own actions as well as their clients’ actions may be interpreted by the platform”. Labourers explicitly avoid conflict and appease clients, turning the clients into an important data-collection extension to enforce compliance, fittingly recognized as “Algorithmic Panopticon” by Woodcock (2020) – enforcement by the illusion of constant surveillance.

Ribbans et al. (2022) inquire about market segregation in DLPs even within a business model, which seems to have detrimental effects on the economical sustainability of the ride-hailing industry. Workers rent newer cars to be able to drive on UberX, rather than UberGo, therefore eventually lose their UberX status and fall into *precarity*.

Watkins (2022) explores communities of practice that are dismantling themselves, resorting to victim shaming, asserting community membership based on ability and familiarity in and with the systems, which is curious, accounting for the short replacement cycles of IT devices and components in all sectors of the Gig Economy. Building collective agency proves difficult, a fact which is also observed by Mendonça & Kougiannou (2023): strategically placed hurdles to take part in the labour process hamper feelings of community belonging.

Lang et al. (2022) quantitatively probe relations of work engagement and perceptions of algorithmic control: They identify a vicious cycle that sees positive reinforcements that ultimately lead to higher risk of burnout.

Discussion

Policymakers have struggled to design real change for the most precarious of platform workers; we have seen the difficulties excessive algorithmic management that operates on the premise of the capitalistic imperative. However, this also includes to acknowledge the genuine benefits it can bring for the overall productivity of the workforce, self- empowerment and flexibility. Furthermore, it is obvious that the Gig Economy as such is not best seen as a single block of business models, as professionals from the freelance community have used platforms like Fiverr and Upwork to enjoy the benefits of *genuine self-employment*. A free-market capitalist system has long been attested to be prone to predatorial business practices – modern society has

therefore opted to introduce social policies to self-regulate gross imbalances of power, facilitating a constant class struggle. Let us take Uber's executives very seriously when they say the recent developments "revealed the fundamental inequity of our current employment system" (Uber, 2021; p.28) and "indeed harness […] full automation for a leap into 'luxury communism'" (Deranty & Corbin, 2022).

There are two main sectors that have be identified as key drivers of precarity: those that benefit from extensive automation and an imbalance of agency, such as food-courier services, ride-hailing platforms, and general service work; and those that involve limited "task significance and meaningfulness," such as repetitive microtasks or low-skill data entry jobs, which roles inherently "decrease self-acceptance and overall quality of life" (Orhan et al., 2022). Other sectors may be crafted and regulated into healthy and mutually beneficial relationships facilitated by multi-sided platforms. These include care-work, craftsmanship and professional-freelancing. This is not to say that ride-hailing cannot be crafted into genuine self-employment, however one may argue platforms have to give back a great deal of agency to the workers, which is more inherent in other sectors due to their individualized work typology. Rather, Kruse et al. (2023), in combination with extensive conceptualization of algorithmic management (Möhlmann et al., 2021) and Human-AI agency relations (Möllers et al., 2023) present a way out of rigid forms of employment classification: View them as adjustment scales for platform characteristics that balance pros and cons to create fairness for the worker, economic viability for the platforms and attractive service models for the consumer. This chapter's findings underscored that unregulated platform work goes against a fundamental consensus that "All workers, regardless of their contractual arrangement or employment status, should enjoy fundamental workers' rights" (Global Commission on the Future of Work, 2019; p.12).

***Claim**: Unregulated algorithmic management on Digital Labour Platforms does not provide universally accepted labour guarantees, unless policymakers are …*

<u>*Crafting Genuine Self-Employment Opportunities*</u>: Across all sectors, *genuine self-employment* should be possible. However, allocation of price determination should be mandated on the client or contractor side, enabling economic self-determination. Prices should allow for a minimum fare that justifies genuine self-employment in line with social policies, in other words: it must provide opportunity to sustainably build extra-systemic safety-nets. Self-determination is consecutively applied to working time as well, as genuine self-employment is only feasible with complete agency on the worker's side. This includes the decision *whether* to accept a work-offer. It transitively leads to an argument for limited algorithmic parametrization and transparency, which would generate the possibility for genuine 'global explanation' of an algorithm, an 'ex ante' transparency measure discussed by Veale et al. (2023). Rating systems facilitated by customer reviews of the individual allows for traceable platform exclusion, an AI-assisted curating mechanism that by limited parametrization allows traceable platform exclusion in case of disputes. All this circles back again to pricing,

as such a platform that is slimmed down algorithmically and in a responsibility sense, justifies limits to the fare- shares imposed on freelancers.

These platform business model fundamentals are based on a great degree of techno-optimism that neoliberal argumentations for digital labour platforms have in common. It should be upon platforms to reach profitability under these circumstances.

To allow for an intermediate step in between the two rigid classes of labour relations, one may consider a …

Digitally Facilitated Cooperative-Platform: Keulen (2023) points out the emergence of cooperative-based platforms that are made by the self-employed, for the self-employed to replace platforms largely based on the radical precarization and responsibilization of the workforce. They criticize the limited economic viability if competing with relatively unregulated DLPs. Therefore, let DLPs embrace the *cooperative notion*: Dynamic, algorithmic pricing should be allowed, enabling platforms to harness network effects, giving them an edge over platforms with limited algorithmic parametrization. Algorithmic transparency should still be enabled through participatory algorithmic design, e.g. giving the platform agency over business design choices, but balancing it with the consultation rights and a mandatory cooperative membership of the workforce, possibly assisted by democratic mechanisms when adopting new algorithmic management mechanisms. This way, the union gains technological expertise and provides agency to the worker (see Pötzsch & Schamberger, 2022). It incentivizes platforms to design fair algorithms to retain the workforce while still allowing for flexibility. Disputes over platform exclusion may be handled by worker representatives. Working hours should be based on the concept of “minimum hour guarantees to create real choices for flexibility and control over work schedules” (Global Commission on the Future of Work, 2019; p.12). This facilitates minimum wage and may be coupled with unionized healthcare and social security programs that provide a safety-net based on accrued working time. This mandates a healthy environment for a genuine living wage and social security. All this should be met with concessions in terms of minimal bureaucracy to not negate the algorithmic efficiency introduced by this technology-induced revolution. E- Gov is a great example of algorithmic enablers of new opportunity, taking away administrative cost.

This concept aims to ensure a balance of power between platforms and workers, while maintaining economic efficiency and flexibility enabled by algorithmic management, fostering the desirable elements, while abolishing those detrimental to the health and prosperity of workers. It rather obliges platforms and the workforce to engage in social discourse, self-regulating based on the consensus what should be possible and what shouldn’t.

If these concepts do not work out for individual platforms, and platforms cannot establish healthy relations with cooperatives, there is still the option of …

Employment: This relationship should come with all the common benefits of employment. The use of AM in the workplace may then be regulated by more general pieces of legislation, e.g. the anticipated 'AI Act' (European Parliament, 2023). The risk of precarity is greatly reduced by traditional employment relations, therefore the impact of AM would be considered a lesser risk as well.

As a result of modern business practices, many companies have left behind the careful consideration of the implications some technologies have on society: 'Fail Fast'. It may be desirable to rather adopt a 'Learn Fast' methodology, facilitated by fair algorithmic design (Schulze et al., 2023; DePrisco, 2022). This paper argues that Uber's case is special and should not be taken as the example standard in research, but rather an exception in terms of worker-platform relations (Sherman, 2024). Its history has seen political intrigue and gross, unethical business conduct as revealed by the 'Uber Files' (The Guardian, 2022). Its financial background has likewise been under heavy scrutiny by researchers (Sherman, 2023), raising true questions about the sustainability of how it grew and its current operations. It rather chases its own tail, with society watching and waiting for it to either collapse or overcome the structural shortcomings of its investment strategy.

With new, innovative legal structures to facilitate the benefits of AM, modern society can try and forge ways to overcome "the capitalist imperative and nationalistic pressures" (Deranty & Corbin, 2022; p.1) while focusing on realistic solutions that mirror the political feasibility. Labour Market Formalization can be accelerated by crafting genuine concepts for self-employment on DLPs, embracing digitally facilitated cooperative-platforms and most importantly abolishing bogus self-employment. The second greatly increases the agency enacted by workers and if mandatory cooperative membership is introduced, difficulties of building collective agency are in turn massively reduced. Moreover, self-exploitation will either be subject to phenomena guided by (self)-employment or be limited through the collective agency workers may exert over algorithms, with society dynamically taking working conditions in their own hands. Effects of missing WLB provisions and unwanted waiting time would also be expected to shrink, as everyone is granted a certain level of labour rights. It may be interesting to see how platforms are competing against each other, to fight for retention, rather than viewing the individual as expendable.

Conclusion & Limitations

This chapter shows how algorithmic management along its two main axes as introduced by Möhlmann et al. (2021) and in relation to different business models as highlighted by a taxonomy presented in Kruse et al. (2023) shapes labour relations in the Gig Economy. Worker agency, as discussed by Möllers et al. (2023), was highlighted as one of the main instruments to find out if labour and power relations are balanced between different sides of digital labour platforms. Findings from a systematic literature review show that *Labour Market Formalization*, the *Co-Creation of HRM practices*, *Self-Exploitation* and *Unwanted Waiting Time & Work-Life Balance* are some of the

more prevalent topics in research. These findings lead to a discussion about new employment concepts, highlighting the need to abandon traditional concepts and develop new ones that can dynamically govern themselves in *Digitally Facilitated Co-operative-Platforms*, as well as options to retain traditional forms of employment relations by utilizing the different adjustment scales available.

The limited scope of this chapter unfortunately does not allow for more extensive review of EU legislation and labour relation phenomena observed in research. Further limiting is the fact, that only 29 papers were analyzed, while the removal of "empl*" from the search string revealed 136 papers on Scopus. This may have broadened the evidence from other sectors of the Gig Economy. In addition, the bigger picture of employment relations is incomplete due to this paper's nature as a chapter, rather than a review by a labour law scholar.

The lack of well-connected theories in research was mentioned on a few occasions and is put on the research agenda for employment relations scholarship. This is especially true for studies that aim to compare effects of AM on labour relations along different dimensions of a Gig Economy taxonomy (Kruse et al., 2023). Additionally, further research could focus on societies that rely on social caste systems and labour relations, as well as the limited willingness of autocratic economies to establish modern employment systems (Huang, 2023). As such, research in the Gig Economy is too de-coupled from related discourse, for instance, the online content-creation community has long fought a struggle against opaque recommender algorithms and found a, albeit partial, solution in creator collectives that run individual platforms like Nebula (Standard Broadcast, 2023) that carefully consider introducing recommender systems into their algorithms. Consider the fight for improved working conditions in the Gig Economy as an extension of other battlegrounds: classifying platforms as critical infrastructure of a digitalized society (Most Recently: "EU hits Apple with €1.8B antitrust fine for abusive app terms"; Hancock, 2024), in a fight against techno-induced hegemony of mega-corporations.

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Chapter 3

Towards the Long-Term Implications of ChatGPT's Use for Students in Higher Education

Anirudh Ravi

Not too long ago, maps were used to guide us to our destinations. Nowadays, a built-in GPS (Global Positioning System) in a smartphone is much faster and far more convenient for the vast majority of society to get to their destination than using a map. But what if GPSs suddenly disappeared? Could society learn to use maps again? Is it even important that this competency has been overwritten by advances in technological capabilities? Similarly, drawing a parallel to the education sector, technological advancements have overwritten, or for a more balanced wording, updated the requirements and competencies expected of students. Existential questions accompanied by skepticism and growing anxiety have reemerged with the rapid proliferation of generative artificial intelligence (GenAI) tools such as ChatGPT. Many aspects of education are undergoing massive transformations, of which the implications remain largely uncertain. Thus, the focus of this paper is to investigate the potential side-effects of ChatGPT's use in higher education, as well as contribute to the discussion of what it means to be a student going forward.

Taking a first glance at a study on the use of calculators in junior high and high school math classrooms in the United States, the attitudes of educators, administrators, and parents reacting to the changes and dangers posed by this technological advancement provide a key parallel point of analysis to the fundamental focus of this paper (Banks 2011). Prior to the introduction of calculators to classrooms in the 1970s, complex computational problems were done by hand (Banks 2011). One could argue that the more important core competency of a math student is conceptual understanding rather than the capability to compute. Results from a study on the effect of calculators on educational performance revealed that using calculators on tests had a positive effect on computational ability but had little to no effect on conceptual ability (Roberts 1980).

Another prominent study by Hembree and Dessart in 1986 not only concluded that students using calculators displayed a better attitude towards mathematics,

but also contributed to the body of research that calculators did not pose a significant risk to basic skills expected by students (Hembree & Dessart 1986). The point here is that in the past, technological advancements in education have been met with skepticism on their impact on learning, but after thorough studies and research, the effects that the tool has on a student's ability to learn determines whether the tool is allowed in the classroom. For example, graphical calculators are banned from standardized testing for a reason – they possess the ability to compromise the integrity of examinations by housing cheats and formulas that give an unfair advantage to those that exploit this tool, but scientific calculators are still allowed.

Applying this logic to ChatGPT, what are the exploits of this tool that can compromise education? Herein lies the crux of the debate, does GenAI, in fact threaten development of traditional skills of students, such as critical thinking and reasoning? Does ChatGPT give an unfair advantage to those who have paid access and/or the ability to maneuver detection software? If the answer is yes, which skills are threatened, and what are the deeper impacts of long-term use of this tool? If the answer is no (which is strongly disputed by this chapter), what could be some of the reasons for which the stance on GenAI is so strongly divided in the status quo? In this chapter, an in-depth analysis of how ChatGPT was used in a university setting will be used to answer some of these crucial fundamental questions for education in the status quo.

Methodology

Existing Literature

A literature review was conducted with a two-fold objective. Firstly, to determine what *methods* were used to accomplish the research of how ChatGPT affects learning within this field. Secondly, to uncover the *themes* that emerge amongst the attitudes of scholars towards the use of ChatGPT in education, specifically within the student perspective. In addition to the literature review, grey literature was utilized in the research of the history, evolution, and cases in which ChatGPT made a detrimental impact on education.

The author of this chapter used the Scopus database as a primary literature review tool. Then, the database was scanned within "Abstracts" using input strings "ChatGPT" AND "higher education" to generate a preliminary pool of 192 papers to choose from at the time that this paper was written. Refining this selection pool further by adding – "implications" in the *Search within results* field, the pool was then reduced to 123 papers, as it is important to the contribution of this paper to investigate the existing research covering this specific topic. Additionally, three limits were placed on the search criteria to narrow the scope of the search to 72 papers, by filtering for keywords "Higher Education", "ChatGPT", and "Students".

In regard to document type, it is important to note that only articles were considered for this chapter.

The next step was to refine the search further by limiting the articles of this literature review to only journals titled in English, that contained “education” and “learning” in the source title, as well as a few papers with “information systems” specifically handpicked as relevant to this topic. This was done because the effects of ChatGPT on higher education is one on hand the main focus of this paper, and on the other hand, fieldwork in the form of interviews was conducted on information systems students at the University of Muenster. In addition, only literature written in English was considered. Lastly, only open access literature was considered in order to unscore the conviction that access to academic knowledge should be free. This reduced the final number of papers to 41, of which the author of this chapter scanned each abstract to determine which papers were most applicable to forming a basis of existing literature to reconstruct. Surprisingly, the oldest piece of literature dates back to 2023 (37 out of 41), with four articles already published this year in 2024. Table 2 below depicts the criteria used to create the final pool of literature.

Criterion	Criterion Description	Inclusion/Exclusion
Language	Articles written in English	Included
Source Type	Journal	Included
Document Type	Article	Included
Access Restriction	Literature is not open access	Excluded
Journal Content	Journal titles do not contain Education	Excluded
	Journal titles do not contain Learning	Excluded
	Selected Journal titles contain Information Systems	Included
Abstract Content	Abstract does not mention ChatGPT	Excluded
	Abstract does not mention Higher Education	Excluded
Article Content (Keywords)	Article does not mention Implications	Excluded
	Article does not mention ChatGPT	Excluded
	Article does not mention Higher Education	Excluded
	Article does not mention Students	Excluded

Table 2: Criteria for inclusion and exclusion of references

The exact query that was used for the literature search is given below:

(ABS (chatgpt AND "higher education")) AND (implications) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (EXACTKEYWORD, "ChatGPT") OR LIMIT-TO (EXACTKEYWORD, "Higher Education") OR LIMIT-TO (EXACTKEYWORD, "Students")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (OA, "all")) AND (LIMIT-TO (SRCTYPE, "j")) AND (LIMIT-TO (EXACTSRCTITLE, "Journal Of Applied Learning And Teaching") OR LIMIT-TO (EXACTSRCTITLE, "Computers And Education Artificial Intelligence") OR LIMIT-TO (EXACTSRCTITLE, "Journal Of University Teaching And Learning Practice") OR LIMIT-TO (EXACTSRCTITLE, "Australasian Journal Of Educational Technology") OR LIMIT-TO (EXACTSRCTITLE, "Education Sciences") OR LIMIT-TO (EXACTSRCTITLE, "Stem Education") OR LIMIT-TO (EXACTSRCTITLE, "Review Of Education") OR LIMIT-TO (EXACTSRCTITLE, "Journal Of Information Technology Education Innovations In Practice") OR LIMIT-TO (EXACTSRCTITLE, "Journal Of Higher Education Theory And Practice") OR LIMIT-TO (EXACTSRCTITLE, "Issues In Information Systems") OR LIMIT-TO (EXACTSRCTITLE, "International Journal Of Stem Education") OR LIMIT-TO (EXACTSRCTITLE, "International Journal Of Management Education") OR LIMIT-TO (EXACTSRCTITLE, "International Journal Of Learning Teaching And Educational Research") OR LIMIT-TO (EXACTSRCTITLE, "International Journal Of Information And Education Technology") OR LIMIT-TO (EXACTSRCTITLE, "International Journal Of Emerging Technologies In Learning") OR LIMIT-TO (EXACTSRCTITLE, "International Journal Of Educational Technology In Higher Education") OR LIMIT-TO (EXACTSRCTITLE, "Innovative Higher Education") OR LIMIT-TO (EXACTSRCTITLE, "Higher Education Policy") OR LIMIT-TO (EXACTSRCTITLE, "European Journal Of Investigation In Health Psychology And Education") OR LIMIT-TO (EXACTSRCTITLE, "European Journal Of Engineering Education") OR LIMIT-TO (EXACTSRCTITLE, "British Journal Of Educational Technology") OR LIMIT-TO (EXACTSRCTITLE, "Assessment And Evaluation In Higher Education"))

Finding the Research Gap

Upon completion of scanning all 41 paper abstracts, 3 papers were discarded due to irrelevancy to this specific research topic. All remaining 38 papers were included in the literature review based on the taxonomy by Cooper shown below in Table 3 (Cooper 1988).

Within the scope of this seminar, the literature review was used to compile a synthesis of the various methodologies and outcomes of the research done on ChatGPT in higher education, with a specific focus on implications from a student's perspective. To clarify, the primary goal of this chapter is to present the results of interviews along with the analysis, rather than dissecting the 38 papers in full. This is especially prevalent pertaining to this specific research topic due to its infancy and lack of conclusive scientific findings. From analyzing these papers however, there were some key discoveries that led to the formulation of this paper's methodology and research questions.

Characteristics:	Categories:			
Focus:	Research outcomes	Research methods	Theories	Applications
Goal:	Integration		Criticism	Central issues
Organization:	Historical		Conceptual	Methodological
Perspective:	Neutral representation		Espousal of position	
Audience:	Specialized scholars	General scholars	Practitioners and politicians	General public
Coverage:	Exhaustive	Exhaustive and selective	Representative	Central/pivotal

Table 3: Classification of Literature Review (adapted from Cooper 1988)

While it is true that several papers address a similar research scope, there is a research gap when it comes to first-hand investigations into the experience of students using ChatGPT to complete assignments over a longer period of time (8 weeks). For example, one of the papers selected for the literature review written by researchers from Bangladesh utilizes interviews and a qualitative analysis method but lacks a standardized user experiment such as the one that this chapter is based upon (Niloy et al., 2024). Another paper that also explored university students' perceptions on AI uncovered those students from said university in Hong Kong expressed "a generally positive attitude towards GenAI" and also had "concerns about accuracy, privacy, ethical issues" amongst others (Chan 2023). Critically speaking however, the Hong Kong study and this one differ in several key ways; 1) that study was done at an Asian university, 2) various disciplines were considered, 3) surveys were used instead of interviews.

Several papers form into a theme of accepting GenAI through the technology acceptance model (TAM) and navigating the safe use of these tools in education due to its unavoidability and potential for enhancing student learning outcomes such as a study done on an engineering course in Southeast Asia by Vietnamese researchers (Pham et al., 2023). A number of others take a more critical stance on ChatGPT, focusing on academic integrity as the backbone of research. A particular interesting paper suggests that humans and AI can now co-create together in a way that can avoid all detection by existing plagiarism detection software, highlighting an urgent need for a redefinition of what academic integrity means going forward (Perkins 2023). These inverted perspectives are embedded at the crux of this literature review; the first embodying an unrelenting optimism for technological advancement, the second more pragmatic approach - accepting the inevitability of transformation and finding a way to incorporate it into classrooms in the most optimal way by considering GenAI tools impact on academic integrity.

Overall, several themes spanned across the spectrum of painting the picture of ChatGPT and GenAI in education, but the nuances within this spectrum are lacking. By continually developing approaches such as gathering input from students

of different cultural backgrounds and focusing on specific disciplines, research can help navigate through this time of great transformation in education. The author of this report contends that due to the infancy of this research (as indicated by the recency of published articles only dating back to 2023), there are no conclusive syntheses yet to be completed on this specific research topic. Rather there exists various differing methods of analysis to start a growing discussion on the topic of how ChatGPT will transform education from the students' perspective.

Empirical design and Sample

This paper aims to contribute to this discussion in a unique way from the perspective of Information Systems Master's students attending a German University with a high degree of internationalization.

The process of recruiting the sample for this study was to interview fellow Information Systems Master's students that had participated in the class: Interorganizational Systems offered in the winter semester of 2023/2024. Students of this class, of which the author was also a participant of, were instructed to use ChatGPT for weekly assignments by the lecturing professor of the course. These assignments constituted of three main components: 1) reading selected chapters or articles pertaining to a relevant topic in the field of interorganizational networks, 2) creating a prompt and recording the response from ChatGPT, 3) reflecting upon the response from ChatGPT. Out of 12 total groups in the class, 6 representatives from separate groups who had completed all these assignments agreed to participate in a structured interview. The structured interview methodology was used in order to ensure that all participants were given the same questions in the same order to be able to qualitatively assess their responses and introduce a coding method for analysis.

All participants held at least a bachelor's degree at the time of recruitment. All were in the same age group between 21-25 years. Male and female students were not equally represented (4:2), however due to the imbalance of men and women in the information systems program, having at least some representation by women was beneficial to this study. Moving on to the internationalization aspect of this study, four different countries of citizenship were represented (Indian: 2, Turkish: 2, Pakistani: 1, German: 1). Finally, a wide range of final assessment grades on the assignments (between 16,9 and 18.2) allowed for a deeper look into the level of effort given in the course and how the participants felt about their scores.

Data Collection

Using a structured interview methodology, of which the transcript is included in the appendix of this chapter as well as presented in this section, the participants

were asked a total of 10 questions through a virtual call using a combination of two tools depending on the interviewee's preference (WhatsApp & Microsoft Teams). These questions were broken down into six distinct categories: 1) *understanding of the task*, 2) *experience using the tool*, 3) *viewpoint towards ChatGPT*, 4) *academic integrity*, 5) *impact on learning*, 6) *satisfaction level – effort vs. outcome*. These categories along with the exact questions are shown below in Table 4.

Understanding of the task	*Experience using the tool*	*Viewpoint towards ChatGPT*	*Academic integrity*	*Impact on learning*	*Satisfaction level – effort vs. outcome*
Did you (and your group) use ChatGPT to complete the weekly assignments for Interorganizational Systems?	Was it useful?	Do you see any issues with using a tool like this in the future?	Was there any instance in which you used ChatGPT to complete the assignment without doing the weekly reading?	Did using ChatGPT help you to learn during the course?	Do you think your grade for the assignments were justified?
Can you describe, for this particular assignment type, how you used ChatGPT?	What was (or were) the biggest benefit(s)?	If the use of GenAI was not suggested by the Professor, would you have used ChatGPT anyways?	Was there any instance in which you used ChatGPT to reflect upon the prompt and response that it provided, and then copied or paraphrased what it had generated?		

Table 4: Interview Question Breakdown

The author of this chapter used methods of qualitative content analysis from Mayring to record and analyze the interview responses (Mayring 2014). In regard to the responses, a comprehensive protocol was used to transcribe the spoken text from the interviewees into a written response (Mayring 2014, p. 45). This method was chosen over clean read or smooth verbatim protocol to allow for a more natural interview process as the interviewees spoke fluently and freely which was a great benefit to the results of this study. Stopping the interviewee's response to be able to record each word precisely was not the preferred method of transcription. In addition, a brief introduction consisting of broader talks about the purpose of the study, as well as a disclaimer that all responses were confidential and immune to negative consequence, induced a safe and welcoming environment to illicit the most honest answers, especially in the categories of *viewpoint towards ChatGPT* and *academic integrity*. For example, if a participant felt that if they revealed that they used ChatGPT to complete the assignment without reading the material provided by the professor could result in a lower grade or punishment, then the responses would not reflect the actual attitudes and actions of the students.

The discussion section explores the results of the interviews. The results were coded using inductive category assignment and a coding guideline from Mayring

(Mayring 2014, p. 79-87). Prior to evaluating to conducting the interview, the primary research questions were formulated.

RQ1: What are the attitudes of Master's students at a German University in an Information Systems program towards the use of ChatGPT to complete text-based assignments?

RQ2:What are the risks of using ChatGPT to complete recurring assignments involving reading and generating text-based responses?

The author of this chapter acknowledges that the sample size of six students is relatively small and subject to sample bias, however due to the scope of this chapter, the output of the interviews was more than substantial to form a foundation for further research to springboard upon. Broader questions in this field have already been explored such as "what are the risks and challenges of ChatGPT usage in education, and what is the overall impact of ChatGPT in education" in other another paper in this research field (Vargas-Murillo 2023, p. 124-125).

ChatGPT: A Brief History & Use Cases in Education

The Evolution of GPT

In simplest terms, ChatGPT is an AI chatbot capable of producing text that resembles that of a human and carry out actions in response to specified instructions. The GPT in ChatGPT stands for Generative Pre-trained Transformer, which is a form of large language model that mimics human speech through deep learning (Yosifova 2023). According to data from SensorTower, a market research company based in San Francisco, ChatGPT was at one point (overtaken by Threads in July 2023 (Duarte 2024)) the fastest growing consumer internet app of all time, reaching the 100 million active user milestone in just 2 months after release, much faster than the 9 months it took TikTok and 30 months (2 and a half years) it took Instagram to achieve the same feat (Hu 2023). However, there was a steady development to reach the current level of ChatGPT, in which the model was tested and improved over several different versions.

Starting from GPT-1, the timeline of ChatGPT's conception continued with GPT-2 to GPT-3, which was a shift from 117 million parameters with GPT-1, to 1.5 billion with GPT-2, to 175 billion parameters with GPT-3 (Yosifova 2023). The exponential increase in parameters has led to more refined responses over the several different iterations. During this time period of GPT's development, other applications were launched by OpenAI, the company behind ChatGPT. For example, Codex was launched by OpenAI, which translates language into code (Yosifova 2023). After GPT-3, a precursor to ChatGPT was introduced, coined InstructGPT, which aimed to reduce toxic outputs and increase truthfulness of

responses (Yosifova 2023). Not long after InstructGPT, GPT-3.5, the model behind ChatGPT, was released in November 2022 (Yosifova 2023). The current state of ChatGPT at the moment that this chapter has been written is GPT-4, which is far more powerful than all the predecessors mentioned in this brief history and evolution of ChatGPT. Moving forward, a glance into the capabilities of this tool will be introduced across various aspects of education.

The Good: Promising Use Cases in Education

Several different applications exist for ChatGPT in higher education, ranging from teaching and learning to research and administration (Sabzalieva 2023). Specifically in regard to tasks that are handled very well by ChatGPT, the following types of tasks act as apt examples: 1) memorization exercises, 2) math calculations, 3) fact retrieval questions, 4) basic research questions, 5) simple translation tasks, 6) simple data entry tasks, 7) simple text correction tasks, & 8) text summarization tasks (Graichen 2023).

While these are rather simple tasks, more advanced applications of ChatGPT are rather varied across different disciplines of study. For example, in a field such as medicine, which is heavily memorization based, the application of ChatGPT is different to

economics, which is more analytical in nature. The tool shapeshifts to the users' requirements, whether the need is generating ideas, providing guidance through complex topics, or assisting with writing a dissertation, ChatGPT can provide valuable assistance (Graichen 2023).

Shifting the focus from task-oriented to role-oriented, the roles that ChatGPT can play in a classroom is manifold. Contrasting with the calculator, which can only be used for computations, ChatGPT can morph to the needs of the student or user. In a study done by UNESCO, several roles were identified as to the applicability of ChatGPT: 1) possibility engine, 2) socratic opponent, 3) collaboration coach, 4) guide on the side, 5) personal tutor, 6) co-designer, 7) exploratorium, & 8) study buddy (Sabzalieva 2023, p. 9). Many of these roles are designed to aid students in their discovery of knowledge or tackling difficult assignments and have a huge potential for beneficial impact when it comes to learning. However, there is also a case to be made that ChatGPT and other GenAI tools have the capability to be used in a counter-productive and unethical way, akin to a double-edged sword. The next section will delve into several different ways that ChatGPT is making educators rethink their curriculums and their methods of teaching.

The Bad: The Risks of GPT on Education

Cases of Academic Misconduct

With the current state of examinations and learning assignments, students have already begun using ChatGPT to gain an advantage in the classroom. A lot of media coverage has been shone on the idea that GenAI tools make it easier for students to cheat in the classroom, but a recent Stanford study refutes this claim (Spector 2023). According to researchers in this study, the rates at which students cheat is largely the same – right around 60% to 70%, contesting the idea that these tools exacerbate the issues of academic integrity in the classroom (Spector 2023). However, this is only a study done on K-12 students, and since this chapter is rather focused on higher education, a more apt representation of the situation can be gleaned from a BestColleges survey of 1,000 current graduate and undergraduate students, which reveals that 51% (over half) of the participants believe that using ChatGPT (and other AI tools) on exams and assignments constitutes as cheating (Nietzel 2023). The most important finding from this study is that "most students said their instructors are not discussing the use of ChatGPT", with over half of the students (54%) stating that they did not receive any instructions on how to use GenAI tools from their professors (Nietzel 2023).

Several cases of academic integrity have arisen as a result of a lack of communication of proper ethics in using the tool and an inadequate regulatory framework. In addition, the inability to detect whether an assignment has been completed or aided by ChatGPT without citation has also led to students receiving an upper hand in the classroom. At the University of Manitoba, an academic integrity specialist revealed that at the beginning of the summer semester in 2023, there were no plagiarism cases related to ChatGPT, but at the end of the semester, they were facing a few cases per week (Brass 2023). Timothy Main, a writing professor at Conestoga College in Canada stated that he has "caught dozens" of ChatGPT plagiarists and is in "full crisis mode" regarding what steps to take to combat the proliferation of GenAI based cheating in the classroom (Gecker 2023). A simple search using the following string in Google - "how to make ChatGPT undetectable", returns hundreds of articles to help users bypass AI detection software, even the most powerful and prominent ones such as Turnitin. For example, a student can be tasked with writing a summary based on readings or concepts that were discussed in class, and ChatGPT is capable of fully automating it. Even software has been developed for the sole purpose of outsmarting detection software such as BypassGPT, which works by completely rewriting or paraphrasing the input from ChatGPT (BypassGPT 2024). As technology advances, it will become increasingly difficult for educators to keep up, let alone stay one step ahead of potential cheaters.

History seems to be repeating itself, as it did with calculators when they were first introduced. The cases mentioned above indicate that students are using a tool to gain an unfair advantage. By saving time on tasks they deem trivial,

students risk becoming unaware of the consequences that this could have on their education in the long term. ChatGPT is the king of shortcuts in the classroom. The cascading effect of what taking shortcuts means and how it could translate negatively to the workplace upon graduation is the bigger question that needs pressing answers. By finding ways to "outsmart" the system, one could argue that this does not necessarily constitute as cheating, but rather a failure on the part of the assessors and educators to not create foolproof methods of examination and homework assignment. However, the author of this chapter contends that while a regulatory framework and education on AI ethics are crucial to the hindrance of cheating and plagiarism using ChatGPT, a textual tool of this magnitude will breed a multitude of software offspring that will aid in the pursuit of academic dishonesty such as the aforementioned BypassGPT. Simply banning these tools in the classroom seems less feasible than finding a way to account for these workarounds to detection software, i.e., transforming the way that assessments and examinations will be conducted across all disciplines.

Cases of Misinformation

Misinformation is defined as wrong information, which is not to be confused with disinformation, which is deliberately spread to deceive people (Cambridge 2019). There are numerous cases in which the responses from ChatGPT indicate a clear bias. One such example was found in a study by researchers at UCLA, which observed a stark contrast in the way that ChatGPT characterized men and women (Wan et al., 2023). Relating this to education, responses to prompts that ask for historical evidence could easily be skewed to favor the male gender and underrepresent the female gender. Gender bias is not the form of misinformation that has been found in ChatGPT's responses. In a case that is far more alarming, a study done on ChatGPT's responses to the topic of self-managed medication abortion revealed that the tool exaggerated the risks, which in turn endangers "public health and reproductive autonomy" by spreading false and misleading information (McMahon 2024). Another test done on the reliability of the responses of GPT-3 by Canadian researchers highlighted a staggering problem with the tool which "agreed with incorrect statements between 4.8 percent and 26 percent of the time, depending on the statement category" (Khatun 2023, Tucker 2024). The dangers of gender bias, misleading or incorrect information, along with other forms of misinformation to students in higher education stems from a lack of fact-checking, which leads to blatant misrepresentations of actual academic knowledge. Students must become familiar this these risks and hallucinations of the tool, learn to recognize them, and do the due diligence of fact-checking the information they receive from GenAI tools to combat the spread of misinformation.

GPT Outperforming Students

In addition to the risks associated with academic integrity, such as plagiarism and misinformation, there is the risk that GenAI tools can render students obsolete. For example, what is then the purpose of manual research, or reading and

summarizing valuable texts? GPT has already shown that it is capable of doing tasks such as these at an unprecedented level for educational tools. One such example of a GenAI tool showcasing this development is a study done comparing the performance of OpenAI's Codex (the same company behind GPT), which is a model trained on over 50 million GitHub repositories, to that of students in a college level introductory programming course (Finnie-Ansley et. al., 2023). What they discovered was truly astounding; "results show that Codex performs better than most students on code writing questions in typical first year programming exams" (Finnie-Ansley et. al., 2023). While this may not directly constitute as rendering students obsolete, the idea that a tool can outperform entire classrooms begs the same question posed by the other risks in this chapter; what is education's response to the proliferation of GenAI tools?

Finding the Correct Response

Last year (2023), two of the world's most prominent universities, Oxford and Cambridge banned the use of ChatGPT due to fears of plagiarism (Wood 2023). Also, in the same year in Australia, all schools deployed the same ban on AI tools such as ChatGPT (Cassidy 2023). While these panicked responses are a clear indication of the havoc that GenAI tools have on educators, simply "banning" these tools is neither pragmatic nor sustainable. As already outlined in this chapter, there are multiple workarounds for detection software. In addition, going back to pen and paper exams is also quite backwards in practice, as the advent of remote learning and the requirements of certain disciplines such as computer science also render this solution inapplicable. Capturing the potential of GenAI learning tools in the classroom starts with educators understanding the tool and learning to work with it themselves. By interacting with ChatGPT and intertwining it into their lessons and curriculum, educators can shift from a passive role to an active one, directing how this tool will affect their classrooms. Going forward, it is unequivocally vital that instructors adapt their assignments and examinations in ways that clearly navigate the limits of GenAI tools to find the perfect balance between the inversions of digitalization.

Findings

Using the method of inductive category assignment as mentioned in the methods section (Mayfair 2014, p. 84), the codings are provided below along with the text passages that contain clear semantic elements from the six interviews (Interviewees A-F). The four main category definitions determined to help answer the two research questions of this chapter are as follows: usefulness of ChatGPT, benefits of ChatGPT (areas of influence), level of misuse, and concerns with use. For each main category definition, there are a varied amount (3-6) of inductive categories that illustrate the variance of discovered themes within the main category definition. At the end of the coding, a table containing the inductive

category frequencies for each main category definition is provided to illustrate the spectrum of views that were collected in this chapter.

Usefulness of ChatGPT

B1: Highly Useful

Interviewee C & D – “Yes it was very useful.”

B2: Moderately Useful

IntervieweeA – “The precision was around 60-70% efficient, we had to paraphrase a lot of what it gave us.” Interviewee F – “I think so, yes.”

B3: Minimally Useful

Interviewee B – “For first prompts, gives you an understanding of the topic, but after continuing to question it, it becomes uncontrollable.”

Interviewee E – “To some extent yes. When I asked it to frame a question, it gave me a really random question that I was not expecting. It completely changed my question instead of framing it within the context. I asked it to understand the paper after lightly skimming the paper, but it didn’t work.”

Benefits of ChatGPT (Areas of Influence)

B1: Contextualization/Increased Understandability

Interviewee B – “The benefit was even if I don’t understand the paper, it gave me a general understanding of what my paper gives me.”

Interviewee C – “Contextualization of complex theories based on the readings. It helped us to understand things we did not understand and asked it to explain things to us. This was really helpful, as it elaborated and made the readings more understandable.”

B2: Example Answers to Questions

Interviewee E – “Sometimes it gave me an amazing prompt… I did not think I could create such good questions on my own. Made me create better questions.”

Interviewee F – “Personally, it was interesting to see how AI was trained to answer questions.”

B3: Saves Time

Interviewee B – “It saves time.” Interviewee D – “Saving time.”

Interviewee E – “Saved me time creating questions.”

B4: One-Stop-Shop for Information

Interviewee D – “We can get data from many different papers and websites easily, this tool is a one stop to get data from the entire internet.”

Interviewee F – “To get an overview of what is available on the internet, along with the sources.”

B5: Source of Creativity (Springboard for Ideas)

Interviewee A – “It gives you the starting point, and insights of how to go further into the topic.”

B6: Helps with Learning

Interviewee A – “Yes, I learned in more depth using ChatGPT.”

Interviewee B – “I would say yes, generally, it gave me what the professor wanted us to know, and the perspective of the cases. It gave us a nice general outline and knowledge.“

Interviewee C – “Yes, we used the tool in a way that helped us to learn the fundamental concepts using the prompts we have created.”

Interviewee D – “Yes, to a certain degree, anyways I am reading and finding out the prompts, as well as the answers to create a shortlist of possible final assignment material.”

Interviewee E – “ChatGPT helped me to learn how to complete the exercise, but only a little bit for the content of the course. It has helped me a little bit to understand the paper better.”

Level of Misuse

B1: Extremely Severe (Complete full assignment without doing reading at all, paraphrase response from ChatGPT and pass off as own work)

Interviewee A – “for example I was actually not in Germany, and had to submit 1 topic, so I just used it for week #3 and made my own assumptions to use the question from ChatGPT and it worked perfectly.”

Interviewee B – “it was for me the case a few times, since my groups communication was lacking, since I didn’t have time I didn’t read it. The feedback was the best from the professor when I didn’t read the paper. We still got positive feedback even if we didn’t read the papers.”

B2: Moderately Severe (Paraphrase response from ChatGPT and pass off as own work, but partially did the readings)

Interviewee D – “Yeah, for example instead of doing 6 readings, I would do 3 of them, with combination with tools like ChatPDF. Sometimes I use multiple AI tools to make it easier for me.”

Interviewee E – “Yes. I created my own reflection and asked it to paraphrase my reflection.”

B3: Low-None

Interviewee C – “No we all read the readings.” (also never copied or paraphrased what it generated)

Interviewee F – “No, I did not” – in reference to using ChatGPT to complete assignment without reading or paraphrasing any of its output.

Concerns with Use

B1: Loss of Motivation/Increased Dependency

Interviewee D – “The issues for the professors, students would stop thinking with their brain, and they copy and paste it for their assignments. The biggest disadvantage is that people would stop brainstorming and thinking for themselves and go for the easy way.”

Interviewee E – “the fact that ChatGPT is right in your hands, you become less determined to create a better question. I didn’t have time to actually work on my question framing, so when you

have something that makes it much easier, I just used the tool. Each week, I became more dependent on ChatGPT as time went on."

B2: Accuracy of Information

Interviewee A **– "**the issues are the precision; it needs some improvement."

Interviewee F – "I also know about the issue about the training of AI models. There was something in the news about bad labor requirements for people to check and train the AI, and assessing the data that it uses."

B3: Lack of References

Interviewee A **– "**also the lack of references due to copyright issues."

B4: Lack of Context

Interviewee A – "sometimes it lacks contextualization."

B5: Privacy Concerns

Interviewee C – **"**of course, if ChatGPT will be used in the future, that substantially increases the privacy concerns of the users, ChatGPT could definitely be harmful to society."

Interviewee F – "I know about data security issues that OpenAI has, I was hesitant to use it in the first place."

B6: Detracts from Learning

Interviewee F – "No, not really. Because I did not use the content that ChatGPT provided to learn for the exam."

Table 5 depicts the frequencies of each main/inductive category. Additionally, graphical representations of this table are included in Appendix A.

Usefulness of ChatGPT			Benefits of ChatGPT			Level of Misuse			Concerns with Use		
Category	#	%	Category	#	%	Category	#	%	Category	#	%
Highly Useful	2	33.33%	Contextualization/ Increased Understanding	2	33.33%	Extremely Severe	2	33.33%	Loss of Motivation/ Increased Dependency	2	33.33%
Moderately Useful	2	33.33%	Example Answers to Questions	2	33.33%	Moderately Severe	2	33.33%	Accuracy of Information	2	33.33%
Minimally Useful	2	33.33%	Saves Time	3	50%	Low-None	2	33.33%	Lack of References	1	16.66%
			One-Stop-Shop for Information	2	33.33%				Lack of Context	1	16.66%
			Source of Creativity	1	16.66%				Privacy Concerns	2	33.33%
			Helps with Learning	5	83.33%				Detracts from Learning	1	16.66%

Table 5: Coding Frequencies

Discussion

The first interesting observation gleaned from the results of the coding is the strong balance in the response of the interviewees. The main categories can be broken down into positive and negative halves with *usefulness of ChatGPT* and *benefits of ChatGPT* belonging to the former half, and *level of misuse*, and *concerns with use* belonging to the latter half. Within these main categories, an additional balance was observed, with the number of inductive categories also remaining equal with – (3), (6), (3), (6) – respectively. While *usefulness of ChatGPT* and *level of misuse* are scaling categories (far broader and generic in nature) and attempt to gauge the responses on a qualitative basis and assign a level to them, *benefits of ChatGPT* and *concerns with use* are more specific in pinpointing a coding outcome and reduce the level of grey area in interpretation.

One of the key observations for the scaling categories is that they are evenly distributed across all inductive categories, with 2 out of 6 participants aligning with each. This indicates that the participants felt a different level of usefulness from the experience of working with the tool but not necessary aligning usefulness with finding a way to "cheat", for example Interviewee C & D both agreed that the tool was highly useful, but only Interviewee D misused the tool to do the assignment without completing the readings. Continuing with this point, the opposite was also observed, where a student responded that the tool was not useful – Interviewee B – and exhibited extremely severe misuse of the tool by passing off the submitted work as their own without completing the reading at all. In addition, what makes this even more interesting is that the grades given by the professor were even higher when the student did not do the work in an honest manner, incentivizing the student to keep misusing the tool to achieve better results in the classroom.

In relation to the more specific main categories, it was observed that 5 out of the 6 participants said that ChatGPT helped with learning, with the main benefits being that it helped them to understand the paper better, learn the fundamental concepts of each section, and even one participant said it helped them learn more in-depth. On the other hand, the only student that said that it detracted from learning stated that the content provided by ChatGPT did not help them for the final exam. A truly remarkable observation in this direction is that other than Interviewee C, the other four students (80%) who stated that ChatGPT is helpful for learning, exhibited moderately to extremely severe misuse of the tool. This could potentially be an additional point of research down the road, where it is examined at which point does the use of GenAI tools exceed the bounds of academic integrity in students that find these tools useful, however in the scope of this seminar, further analysis into this topic is not feasible. Also, it is noted that other than helping with learning, the most frequently cited benefit of ChatGPT is the fact that it saves time. All participants who stated this as the benefit (100%) – Interviewee B, D, & E – exhibited moderately to extremely severe misuse of the tool.

Interviewee	Average grade for Questions & Comments (avg. 17,4; median 17,3)	Final mark (avg. 2,3, median 2,44)
A	17,4	worse than the average and median
B	17	equal to the median, better than the average
C	18,2	better than the average and median
D	16,9	worse than the average and median
E	17,3	worse than the average and median
F	17,6	better than the average and median

Table 6: Assessment outcomes

Conclusion & Limitations

A few limitations of this study that could be improved upon by subsequent research are the small sample size, the minimal amount of research within this specific topic, and the submission restrictions (20 pages). However, both research questions were answered within the scope of these limitations. For RQ1 - The attitudes of Information Systems students at the University of Muenster in an English-speaking Masters program towards Chat-GPT are rather balanced as indicated by the distribution of the scaling categories, as well as the more specific categories (3,6,3,6 – Table 4: Interview Question Breakdown). The level of usefulness and misuse is equally varied amongst these students. Even with a small sample of interviews, several unique inductive categories were discovered which encompassed a wide range of possible responses for RQ2; what are the risks with using ChatGPT to complete recurrent text-based assignments. Privacy

concerns, increased dependency, and issues with tool performance can be combined to form the block of risks that students feel are associated with using ChatGPT for such assignments. In conclusion, this chapter served as a voice that echoes the sentiments of students in a higher education setting and can be developed further for deeper analysis with an increased sample size in the future.

In conclusion, finding the new meaning of education is a journey to embrace. Such as the times when calculators and search engines were introduced to classrooms, education is now in a state of rapid transformation. Embracing the sharpness of double-edged swords lets one tap into both the good and the bad of digitalization to find the best way balance the power of technological advancements. ChatGPT is arguably the most powerful tool ever created for education. As most eloquently stated in Spider-Man however, “with great power comes great responsibility”. Teaching students from a young age the correct way to use these tools for their own benefit and stressing the impact it will have on their growth as students and employees is one way to change education. Another way to tackle this issue is to restructure assignments and examinations in ways that avoid these tools completely, i.e., no more text- or coding-based assignments. To those with the power to change education, speak to the students. Hear what they have to say. As this study shows, students find these tools useful, but are not able to help themselves from taking shortcuts and the easy way to an A. Empowering the next generation with the unbridled power we never had as students of the past but also giving them the necessary training and direction on ethical use of these tools is paramount to preserving academic integrity going forward. Referring back to the example of the calculator, while the ability to compute mathematical functions was rendered mostly obsolete, the conceptual ability stayed intact. Which competencies will be replaced by ChatGPT? Will writing and coding courses be replaced by prompt engineering courses? Only time will tell. Stay tuned for the final verdict.

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Appendix

A Graphical Representation of Coding Frequencies (Interview Results)

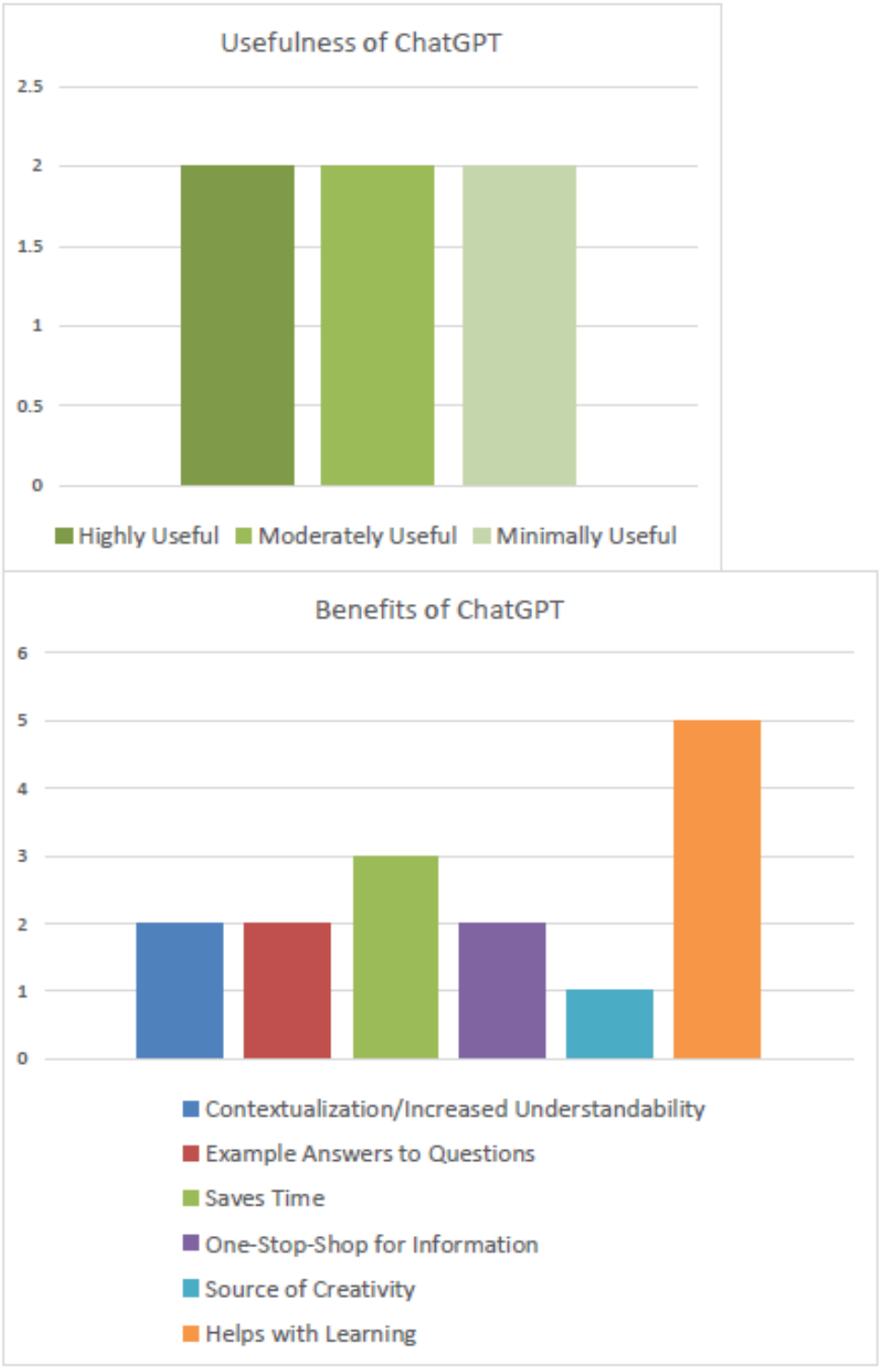

Figure 10: Perceived usefulness and benefits of ChatGPT

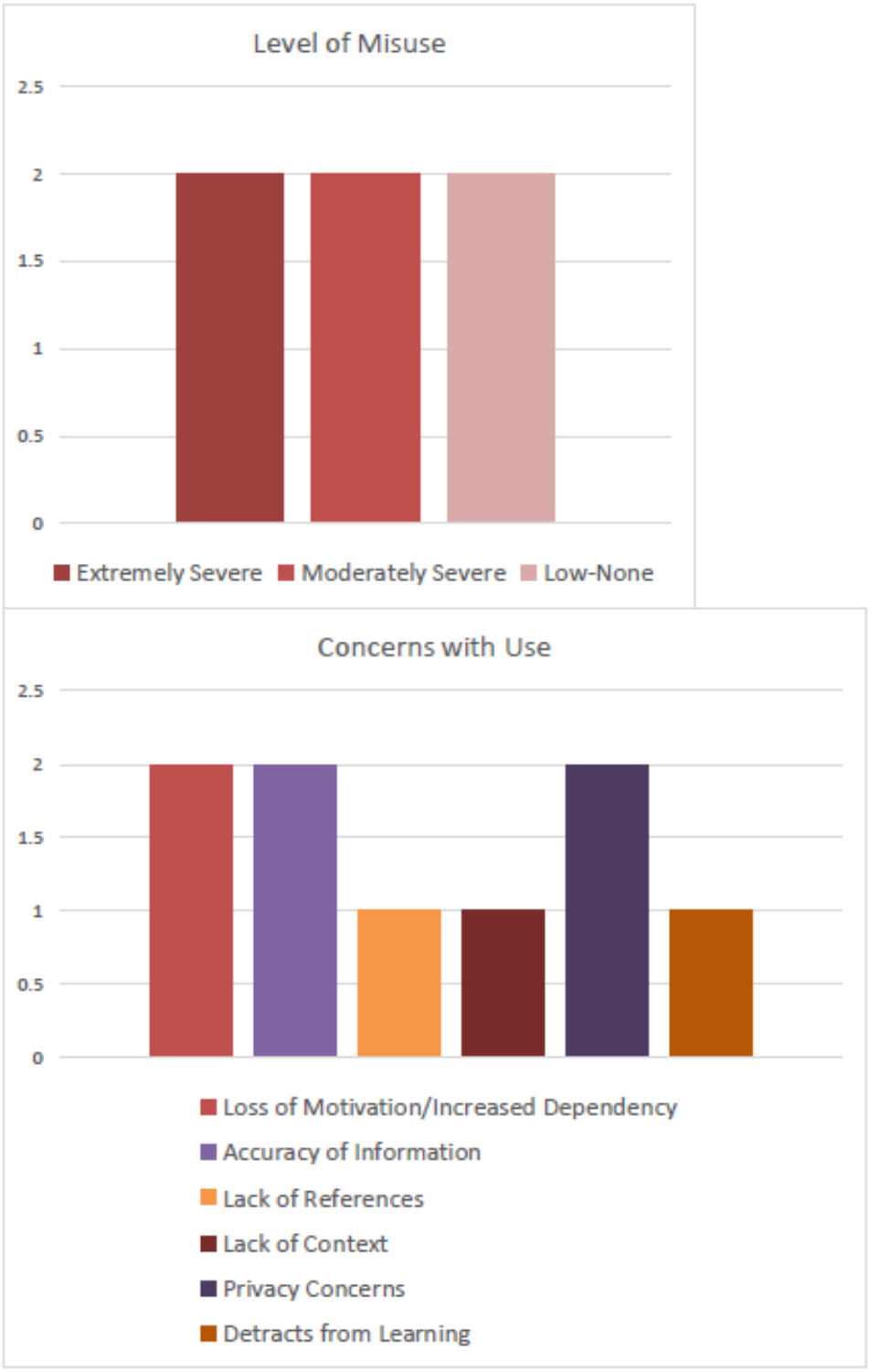

Figure 11: Perceived level of misuse and cerns with use

B Interview Transcripts (Anonymized)

Interviewee/ Group Questions	Interviewee A, Group 1.1	Interviewee B, Group 2.1	Interviewee C, Group 3.2	Interviewee D, Group 4.1	Interviewee E, Group 5.1	Interviewee F, Group 6.1
Q1: Did you (and your group) use ChatGPT to complete the weekly assignments for Inter-organizational Systems?	Yes, we did.	Yes. As well, as You.com	Yes.	Yes.	Yes.	Yes.
Q2: Can you describe, for this particular assignment type, how you used ChatGPT?	For example, we took a paragraph and put in in ChatGPT to make a summary of it. I used a prompt for ChatGPT to ask it to make related questions using a paragraph. "Can you please put in questions from the summary to make the question relate with the future."	I generally for myself, me and my group didn't come together to discuss, I started with a simple single and short question to get the idea of what ChatGPT is thinking about the topic, and then depending on the answer, I asked a detailed question with its explanation as context.	All of us have created four questions of each topic. After that we have presented all these questions in a survey in WhatsApp. Then we have gone through all the questions, and decided on one single question for each topic. Then we prompted it to ChatGPT and got the results and discussed among each other. Then everybody has given his comments on the output of ChatGPT, and have reflected on it.	We thought of a prompt and fed it to ChatGPT to retrieve the results, and sometimes the output was questions, so we had to work with the tool to get an answer from it. For my part I generated the reflection using ChatGPT and tried to build upon it.	We divided the tasks, two groups, three papers. We studied the paper and tried to create our own prompt. I asked ChatGPT to customize my question, giving it a set of points and a badly structured question, to frame a better question for me based on my insights. [How many times did you iterate this process?] 3-4 times. 1st time gave 2-3 questions, one liners. I had to ask the tool to make it a bigger question.	We collected all our ideas for possible questions, then decided on one of them altogether. Then we copy-pasted the already prepared question, and checked whether the answer was manageable. Then we assessed the answer considering quality and content. Then we wrote a comment. We usually evaluated how wellformulated the answer was, then were there any additional aspects to the paper than what we already knew or was the answer just summary.
Q3: Was it useful?	The precision was around 60-70% efficient, we had to paraphrase a lot of what it gave us.	For first prompts, gives you an understanding of the topic, but after continuing to question it, it becomes	Yes, it was very useful.	Yes, it was very useful.	To some extent yes. When I asked it to frame a question, it gave me a really random question that I was not	I think so, yes.

		uncontrollable.			expecting. It completely changed my question instead of framing it within the context. I asked it to understand the paper after lightly skimming the paper, but it didn't work.	
Q4: What was (or were) the biggest benefit(s)?	It gives you the starting point, and insights of how to go further into the topic.	The benefit was even if I don't understand the paper, it gave me a general understanding of what my paper gives me. It saves time.	Contextualization of complex theories based on the readings. It helped us to understand things we did not understand and asked it to explain things to us. This was really helpful, as it elaborated and made the readings more understandable.	We can get data from many different papers and websites easily, this tool is a one stop to get data from the entire internet. Saving time.	Sometimes it gave me an amazing prompt. Saved me time creating questions. I did not think I could create such good questions on my own. Made me create better questions.	To get an overview of what is available on the internet, along with the sources. Personally, it was interesting to see how AI was trained to answer questions. There was a particular observable structure in the answers.
Q5: Do you see any issues with using a tool like this in the future?	The issues are the precision; it needs some improvement. And sometimes it lacks contextualization, and also the lack of references due to copyright issues.	No, I do not see an issue. I think it is generally helpful with our study, more classes should incorporate the use of it.	Of course, if ChatGPT will be used in the future, that substantially increases the privacy concerns of the users, ChatGPT could definitely be harmful to society.	The issues for the professors, students would stop thinking with their brain, and they copy and paste it for their assignments. The biggest disadvantage is that people would stop brainstorming and thinking for themselves and go for the easy way.	I would not recommend using the tool in the long run, because what happens I used the benefits of ChatGPT and I would depend more on it. I had so many other things to do, I don't think I made the effort on creating a good question, the fact that ChatGPT is right in your hands, you become less determined to create a better	I do, I was not too sure if I wanted to use it in the first place. I know about data security issues that OpenAI has, I was hesitant to use it in the first place. I also know about the issue about the training of AI models. There was something in the news about bad labor requirements for people to check and train the AI, and

					question. I didn't have time to actually work on my question framing, so when you have something that makes it much easier, I just used the tool. Each week, I became more dependent on ChatGPT as time went on.	assessing the data that it uses.
Q6: Was there any instance in which you used ChatGPT to complete the assignment without doing the weekly reading?	Yes, we did, for example I was actually not in Germany, and had to submit 1 topic, so I just used it for week #3 and made my own assumptions to use the question from ChatGPT and it worked perfectly.	Yes, it was for me the case a few times, since my groups communication was lacking, since I didn't have time I didn't read it. The feedback was the best from the professor when I didn't read the paper. We still got positive feedback even if we didn't read the papers.	No, we all read the readings.	Yeah, for example instead of doing 6 readings, I would do 3 of them, with combination with tools like ChatPDF. Sometimes I use multiple AI tools to make it easier for me.	Yes.	I did not.
Q7: Was there any instance in which you used ChatGPT to reflect upon the prompt and response that it provided, and then copied or paraphrased what it had generated?	Yes.	See above.	No.	Yes.	Yes. I created my own reflection and asked it to paraphrase my reflection. I also did it the other way but it was not able to give me an adequate reflection.	No I did not.
Q8: Do you think your grade for the assignments was justified?	Absolutely yes, with the use of AI it was fairly graded.	We managed to get the same points with less effort, so yes. ChatGPT saved us lots of time to get	Yes.	Yes, I think it was perfectly justified.	It was ok, I did not know how my other group members, but I believe that the others in my group have	Yes.

		the same points.			completed the assignments in a similar fashion. I also feel like its not, because even I did not put a lot of effort in the assignments, I did not do justice to the exercises. I used ChatGPT as a shortcut.	
Q9: Did using ChatGPT help you to learn during the course?	Yes, I learned in more depth using ChatGPT.	I would say yes, generally, it gave me what the professor wanted us to know, and the perspective of the cases. It gave us a nice general outline and knowledge.	Yes, we used the tool in a way that helped us to learn the fundamental concepts using the prompts we have created.	Yes, to a certain degree, anyways I am reading and finding out the prompts, as well as the answers to create a shortlist of possible final assignment material.	ChatGPT helped me to learn how to complete the exercise, but only a little bit for the content of the course. It has helped me a little bit to understand the paper better.	No, not really. Because I did not use the content that ChatGPT provided to learn for the exam.
Q10: If the use of GenAI was not suggested by the Professor, would you have used ChatGPT anyways?	Absolutely.	Definitely.	Yes, I would have.	Yes, definitely. I use it in almost every course I take, because it helps me to fetch data quickly and solve my assignments. In addition, I get the data from the internet and rewrite it in my own words.	Yes, but not as extensively as I did during the course.	No.

Table 7: Interview transcripts

Chapter 4

Sustainability of Blended University Models: A Study on the Sustainability of Higher Education Approaches using the Example of the University of Münster

Daria Luise Stumkat

The phrase "data is the new oil" has been used as a metaphor to highlight the growing importance of data in the modern world, particularly in the context of the digital economy. While it's important to note that the comparison is not meant to be taken literally, it does emphasize the significant role data plays in today's society.

The rise of digitalization some 20 years ago promised to redeem the environmental sins committed in the past century. Still, 20 years in, this belief of increased resource efficiency and digital solutions to past problems holds fast (Coroama & Mattern, 2019). At the same time, however, climate change looks more threatening than ever, and the many indirect effects of digitalization turn efficiency gains into increased resource consumption (Coroama & Mattern, 2019; Loeser et al., 2017). Slowly, the "dark side" of digitalization, with its energy-consuming data centers, resource-intensive technologies, and short replacement cycles of IT devices and components is coming to light. Increasingly, the extent of the impact of digital technologies is realized and actions are taken to investigate and improve this environmental footprint. Still, the quantification of specific actions remains difficult. Numbers diverge on, e.g., the energy intensity of emails or video streaming (Kamiya, 2020). So how can a balance between environmental sustainability and digital competency be achieved?

The education sector is responsible for its fair share of greenhouse gas (GHG) emissions (Carr et al., 2019). With the COVID-19 pandemic kick-starting the home office debate both in organizational as well as in university contexts, open educational resources on the rise, digital ways of teaching, inverted classrooms and lecture streams becoming more widespread, accepted, and convenient, universities that have not historically engaged in sustainability matters slowly begin to investigate (Carr et al., 2019). A study on the International University of La Rioja found that an online-only model of teaching can save up to 83% of carbon emissions as compared to on-campus university models (Perales Jarillo et al., 2019). At the same time, traditional on-campus universities recognize the need for digital solutions and increasingly implement what researchers call "blended models" – a combination of in-presence and

digital teaching approaches (Contreras-Taica et al., 2022). However, not much research has been conducted on those blended models that emerged especially in the post-COVID-19 world (Contreras- Taica et al., 2022). On the research that has been carried out opinions diverge, with some researchers suggesting a possible reduction of the environmental footprint, under the condition that significant changes in regulations and logistics are carried out (Gamba et al., 2021). Others conclude that approaches which utilize both campus facilities as well as online resources may contribute more carbon emissions than online or traditional on-campus models (Caird et al., 2015; Perez-Lopez et al., 2021; Versteijlen et al., 2017). They attribute this, amongst others, to the fact that these approaches rely on online learning platforms as well as face-to-face services, thus creating additional opportunities for energy consumption (Versteijlen et al., 2017).

In general, studies focus mainly on student and staff commutes, infrastructure, consumption, and waste, and pay little attention to emissions generated by information and communication technology (ICT) (Carr et al., 2019). And while ICT is often seen as inherently sustainable (Bourke & Simpson, 2009), few studies have investigated the ecological footprint associated with ICT usage in detail. The present chapter aims to do its part in filling that research gap by conducting an individual case study on the environmental footprint of ICT usage in everyday university life at the University of Münster. By investigating the day-to-day life of an Information Systems (IS) Master student and the environmental impact resulting from the involved university activities, it is able to highlight the areas where ICT usage does, and where it doesn't generate a considerable impact on GHG emissions. While the findings are context-specific and not necessarily generalizable, the case study provides a framework for other areas of study and other universities to build upon to calculate their own environmental footprints related to ICT usage and simultaneously shows that the carbon emissions generated by ICT usage are not, as is often assumed, negligible. It furthermore highlights areas where redundancies are created and room for improvement is given in terms of technology usage. By calculating the environmental impact of one specific case, alternatives can better be compared, and parallels can be drawn. As such, this chapter will answer the following research questions:

RQ 1: How do the digital tools used, and activities carried out in the IS Master program at the University of Münster contribute to its environmental footprint?

Further,

RQ 2: What are the comparative environmental impacts of different teaching methods (e.g. live lectures vs recorded lectures) used? What are areas for improvement, and what could improvement look like?

To answer the aforementioned research questions, the rest of this paper is structured as follows. In the background section, the carbon footprint is introduced as a measurement unit underlying this chapter, and existing sustainability research in the context of higher education institutions is discussed. The next section delineates the chosen research design: a case study approach as suggested by Eisenhardt (1989), investigates the University of Münster as a research setting, and presents the data collection and calculation methods. The subsequent section analyze the findings and

their implications, followed by a reflection on this chapter's limitations, an outlook on future research, and conclusion.

Background

Spurred on by developments such as the COVID-19 pandemic and the imminence of global warming, researchers have begun investigating the role higher education institutions play in GHG emissions, recognizing the responsibility that universities hold in achieving carbon neutrality and raising students aware of the importance of sustainability. In the following, the carbon footprint will be introduced as a measurement unit suitable to measure sustainability and prevalent studies on the sustainability of higher education institutions are discussed.

The Carbon Footprint as Measurement Unit of Sustainability

Over the years, many different methods have emerged to account for the ecological impact of services, products, and technologies. From the water footprint, measuring humans' consumption and pollution of water (Hoekstra & Chapagain, 2007), the material footprint, indicating all materials extracted from nature in order to satisfy consumer demand (European Environment Agency, 2023), over energy intensity to the biodiversity footprint, which measures the impact human activity has on the variability of living organisms in all of earth's ecosystems (United Nations, 1992), multiple indicators have been used to approximate humans' influence on the environment. With the rise of media coverage of global warming and climate change, however, the climate footprint (CF) has emerged as the measurement unit of choice for many researchers and policymakers alike (Finkbeiner, 2009).

The CF, in essence, measures the climate change impact of GHG emissions. Wiedmann & Minx, (2008, p. 5) define it as the "total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product", choosing to focus on carbon dioxide (CO_2) only in their definition, and argue that other gases are too difficult to quantify. Opposing this, Wright et al. (2011) argue that limiting the measurement to only include carbon dioxide would account for only two-thirds of overall GHG emissions generated, and result in significant calculation gaps. Nowadays most widely accepted is the definition proposed in the Greenhouse Gas Protocol, a corporate accounting and reporting standard published by the World Resource Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). Aside from carbon dioxide, this definition includes the remaining five greenhouse gases covered by the Kyoto Protocol – namely methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) (WRI & WBCSD, 2015). Following this definition, the carbon footprint is calculated in measurement units of carbon dioxide equivalent (CO_2e) emissions, summing up all the GHG emissions emitted by a product, act, or service, and signifies the warming effects of those gasses in the atmosphere in line with the gases' individual global warming potential (Gohar & Shine, 2007). As

CO_2e has emerged as the measurement unit of choice and is used in most, if not all, of the research underlying this chapter, it, too, will be applied in the context of this study, to allow for the best possible comparability and integrity of results (Faber, 2021; Finkbeiner, 2009).

Sustainability in Higher Education Institutions

As mentioned before, there has been limited research on the environmental impact of higher education institutions (HEI) (Caird et al., 2013). The research that does exist focuses on student and staff commutes and travel, such as Caird et al. themselves, or Perez-Lopez et al. (2021), who investigate the impact of mobility using the case of a Spanish university. Their findings are in line with those of authors such as Gamba et al. (2021) and Haseeb et al. (2022), who find that mobility constitutes a significant part of emissions generated in HEIs, suggesting that reducing the number of commutes would positively affect the CF of the investigated institutions. Similarly, Perales Jarillo et al. (2019) investigate the case of the online-only International University of La Roja, and find significant CF savings generated through the university's digital teaching model.

Heller et al. (2022) measure the CO_2 Emission savings generated by overseas students not traveling to the UK for their studies, and Ørngreen et al. (2019) suggest that using video conferencing tools can yield a positive result for the environment and should be considered as an effective alternative to meeting face to face. While these studies show clear environmental benefits of reduced travel, the environmental impact of ICT usage allowing for those distanced modes of delivery remains notably absent or a mere afterthought. Larsen et al., in their 2013 analysis, find scientific and technological equipment to have a footprint equal to that of electricity used, and overall slightly higher than that of travel. Versteijlen et al. (2017), on the other hand, also investigate ICT, but ultimately focus on the emissions generated by student and staff mobility.

However, particularly with the emerging discourse of online education as a measure to reduce the carbon impact of HEIs, it seems sensible to investigate the impact of the technologies involved. Bourke & Simpson (2009) note that there is a general assumption that distance learning is inherently sustainable, but as researchers such as Carr et al. (2019) and Caird et al. (2013) point out, little attention is given to how this mode of delivery impacts carbon emissions. What research does exist suggests that the CF of digital teaching models may be substantial. Faber (2021), when investigating the emissions generated by a virtual conference, found the emissions to be substantial. Further, authors Filimonau et al. (2021), while investigating the GHG emissions generated at a UK university during the COVID-19 lockdown, found that, although the university's CF reduced overall, the carbon footprint generated by digital teaching and learning formats was almost equal to that of student and staff mobility prior to the COVID-issued lockdown.

Research Design

As the previous section illustrated, there is merit in investigating the ICT involvement in HEI emissions. Here we will thus introduce the research design employed to answer the question of ICT emissions generated in the context of Münster's university modules. To begin, the overarching case study approach as presented by Eisenhardt (1989) will be presented. Following this, the University of Münster will be introduced as a research setting, and finally, the data collection and calculation methods will be explained.

Case Studies

According to Yin (2003), case studies are empirical descriptions of specific cases of a phenomenon and are typically based on multiple data sources. In contrast to, for example, laboratory experiments, which remove the phenomenon from its real-world context, case studies highlight that context's importance and emphasize developing theories and constructs, bridging the gap between qualitative evidence and deductive research (Eisenhardt & Graebner, 2007). As such, a case study is particularly suitable in fields where not much research exists, or where new theories are supposed to be developed (Eisenhardt & Graebner, 2007; Yin, 2003). It stands to reason, then, that a case study is suitable to answer the research questions, as this exploratory, qualitative research approach is best used on subjects that are context-specific and where not much research has been carried out (Contreras-Taica et al., 2022; Eisenhardt & Graebner, 2007).

This paper follows the case study approach introduced by Eisenhardt (1989) with its 8 consecutive steps. Initially, Eisenhardt (1989) proposes the definition of a research question. Steps 2 and 3 then involve the case nomination and selection of data collection methods, which are introduced in the following two sections. As a fourth step, Eisenhardt names "entering the field", which includes flexible, overlapping data collection and analysis to take advantage of emerging themes and features unique to the case at hand. In this step, the day-to-day life of IS Master students was documented, and corresponding details as to the environmental impact of each module were collected. The fifth and sixth steps then involve the data analysis and hypotheses generation, respectively. While in the former step, the collected activities and their environmental footprints were synthesized, the latter step is intended to extend, sharpen, or confirm existing theory, and in this case is touched upon in the discussion, as a series of actionable insights to reduce the ensuing CF. Finally, Eisenhardt describes the last 2 steps as being a comparison with existing literature and reaching closure, in order to analyze the case's generalizability, raise the theoretical level, and reach theoretical saturation wherever possible (Eisenhardt, 1989).

The University of Münster as Research Setting

The University of Münster, with approximately 43.000 Students, is the fifth-biggest in Germany (Canibol, 2013; University of Münster, n.d.-b). Having its beginnings in the late 16th century in the form of a Christian college, the current university was founded in 1902 and currently takes the 8th rank of German Universities in the Shanghai University Ranking (Shanghai Ranking, 2020).

The University of Münster was chosen as a research setting due to its data availability. On April 5th, 2023, the university senate approved and adopted a sustainability strategy with the overarching goal of making the university sustainable in all its areas of action. This strategy paper formulates concrete plans for the integration of sustainability matters into academic life. Four areas of action are distinguished: (i) research, (ii) teaching, (iii) transfer, and (iv) organization, finances, and operational management. For each of those areas, distinctive sustainability goals were set. Besides the obvious relevance of teaching for this chapter, area (iv) is also of particular interest, as it makes use of sustainability as a guiding criterion in operational processes and decision-making within all of the university's areas of influence. This includes areas such as energy supply, construction, procurement, mobility, and the organization of conferences and events. Focus is hereby placed on resource-conserving ways of operating infrastructure, to achieve climate neutrality. Furthermore, the university's sustainability department is in the process of developing a strategy for active climate protection and compilation of the university's overall CF. (University of Münster, 2023)

To investigate the CF associated with digital teaching methods, focus was placed on the IS Master program. This program has a duration of four semesters and offers seven specialization possibilities, called *tracks*. These tracks contain three complementing modules each, and students are expected to choose two tracks during their studies. Students furthermore are required to attend a project seminar, write a master thesis, and choose seven electives, two of which must be in the format of seminars and the rest of which can be chosen from the remaining tracks and certain economics and data science courses (University of Münster, n.d.-c). A representation of the program structure can be found in Appendix A.

The research focus was further narrowed down to only include the seven tracks and their 21 corresponding modules. As tracks and their corresponding modules make up the core component of this program and represent structured units of study, this made it possible to quantify and measure the carbon footprint associated with each component, facilitating the comparison of environmental impacts across different tracks and modules. It should be noted that, as the program's seminars, electives, and theses tend to be very diverse, investigating these components in the context of this study was not feasible due to limited data availability and high variety. Limiting the research scope to tracks and modules, instead, allowed for a more focused analysis.

Data Collection and Calculation

The CF of the teaching methods employed by the University of Münster was assessed within the Summer Semester (SuSe) 2022, ranging from April to September, and the Winter Semester (WiSe) 2022/2023, from October to March of the following year. The choice of start and end dates was dictated by the data availability for the IS program's main lecture hall, the Leo 18, which, at the time of writing, did not yet include data for the second half of 2023. As in Münster, however, summer terms range from April to September, this meant that the most recent SuSe with data available was that of 2022. The most recent WiSe was, in turn, the WiSe 22/23.

In line with other comparable studies, this chapter incorporated the carbon footprint associated with electricity consumption and natural gas (Filimonau et al., 2021). Water consumption and waste data were left out due to a lack of data availability.

On-campus modules were considered in line with the following pattern: all lectures were assumed to have a duration of 2 hours, with 15 minutes being attributed to students arriving and departing, respectively. While on campus, it was assumed that half of the students used their laptops to follow the lecture and take notes, while the other half resorted to paper or took no notes. It was further assumed that, if there was a lecture recording, all students would listen to this recording at least once, be it due to a missed lecture or as exam preparation. In case a Zoom call or live stream was offered in addition to the in-presence lecture, it was assumed that one-third of all students stayed at home and participated via the Zoom call. In cases where lectures had an online-only format, they were considered to have been attended by all students once. Participant numbers were obtained through the exam statistics published by the examination office (University of Münster, n.d.-d).

Self-study time was considered based on the respective hours attributed in the program's module descriptions (University of Münster, n.d.-c). While these numbers are sure to deviate from reality, this allowed for comparability between modules. Similarly, the distribution between individual study hours and time spent on group work was assumed to be in line with the grading distribution; in modules where grading was 60% exam and 40% group work, it was assumed that 40% of self-study time was spent on group work and the remainder on individual study. For modules where group work did not count toward the final grade, the most frequently used split for grading, which was 40/60, was used to estimate time spent on group work.

Measuring On-Campus Energy Consumption

The on-campus energy consumption was calculated by taking into account the energy and heating data provided for the used study hall, the Leo18, located at the Leonardo Campus, Münster. At the time of writing, heating and electricity data for this study hall exist for both the SuSe 2022, and the WiSe 2022/2023 (University of Münster, n.d.-a). An overview of the energy used for 2022 and 2023 can be found in Appendix B.

As the lecture hall is also used for classes and events other than the IS Master modules, the energy consumption was calculated according to the room allocation plans for each semester, accessible through the university's electronic course catalog (University of Münster, 2022). The energy consumed was aggregated for the SuSe and WiSe, respectively, and divided by the number of hours that the LEO 18.3 was booked throughout the semester. For each module, this was then multiplied by the time spent in the lecture hall. The ensuing CF was calculated by multiplying the consumed energy with the electricity emissions E_e, data for which was found through recent studies of the German Umweltbundesamt (Icha & Lauf, 2023). As such, the calculations for the two semesters were given by the following formula:

$$E_{SuSe} = \frac{\sum_{i=04/22}^{09/22} h_i + \sum_{i=04/22}^{09/22} e_i}{t_o} * t_m * E_e$$

$$E_{WiSe} = \frac{\sum_{i=10/22}^{03/23} h_i + \sum_{i=10/22}^{03/23} e_i}{t_o} * t_m * E_e$$

Where $E_{SuSe/WiSe}$= emissions generated per module over the semester in kg CO_2e, h_i = heating consumption per month in kWh, e_i = electricity consumption per month in kWh, t_o = aggregated time of occupancy in the Leo 18.3, t_m = time of occupancy per module m, E_e = electricity emissions in kg CO_2e/kWh

ICT Usage for Lectures and Self-Study

ICT usage in lecture streams and video conferencing was measured according to Faber's (2021) virtual conferences emission framework, as virtual conferences share significant similarities with digital teaching methods, such as streaming lectures via Zoom. Furthermore, the framework's comprehensive approach to measuring emissions associated with data network traffic and computer hardware made it suitable for assessing those factors in digital teaching components. Finally, its degree of flexibility and transparency of measures used ensures adaptability to various contexts and a high degree of replicability. It should also be noted that the research approach employed here, like many other models, relies on assumptions of technology use, user behavior, and energy emissions. As such, the calculations generated in the following may bear discrepancies to factual numbers. Nonetheless, the following paragraphs will introduce the formulas based on Faber (2021), which were applied in the context of this chapter. The computer emissions data was calculated as follows:

$$C_e = P_c * E_c * \frac{T_L}{Y * 365.25 * H_d}$$

Where C_e = computer emissions, P_c = number of participants counted in computers, E_c = emissions per computer in kg CO_2e, T_L = (aggregated) lecture duration measured in hours, Y = years of useful life of a computer, H_d = daily hours of computer usage.

For the computer-specific data, an Apple M3 Pro with a 12-core CPU, 18-core GPU, and 512GB storage was considered, with a total product footprint of 202 kg CO_2eq

and an expected useful life cycle of four years (Apple Inc., 2023). Apple has the second-highest market share in student populations in Germany and publishes the carbon footprints of all their physical products (Statista, 2024). To keep the estimation on the conservative side, a fairly new laptop model with low emissions data was considered, though it should be noted that the differences between Apple laptops from recent years have been low. Daily hours of computer usage were 7, based on a study by Safranek (2020), who investigated the time students at Stanford University spent on digital devices.

Network data transfer emissions, the energy used by transferring data between internet users, were calculated in line with the following, while also referring to Faber's (2021) original data for internet energy intensity:

$$N_e = P_c * E_e * I * D * T_L * \frac{3600}{8000}$$

Where N_e = network data transfer emissions, P_c = number of participants counted in computers, E_e = electricity emissions measured in kg CO_2e, I = internet energy intensity T_L = (aggregated) lecture duration measured in hours While Faber also includes server energy use emissions data in his framework, this had to be omitted due to the unavailability of data for the different kinds of servers used in the context of the IS modules.

Further Estimates

It was assumed that students were likely to spend some of their half of their individual work time researching, and the other half developing solutions to in-class questions, exam preparation etcetera. While it was infeasible to gather information on the exact number and nature of activities approximate estimates were made. As such, it was assumed that in one hour spent researching, students would make 15 search queries, watch one YouTube video of 10 minutes in average duration, and download one research paper every two hours. Referring back to Faber's (2021) calculations, the emissions generated for search queries are calculated by the following formula:

$$Q_e = Q * E_q$$

Where Q_e = emissions generated by search engine queries, Q = number of queries, E_q = emissions per query, measured in kg CO_2e

It was further assumed that for group work, students would split their time between communicating, researching, and developing solutions. For communication, the assumption was made that video conferencing was used 50% of the time, in which case calculations were made based on the above formulas. Additionally, groupwork where students were expected to develop software or use complex modeling systems was assumed to be more energy-intensive, in line with findings from (Ciancarini et al., 2020). The authors suggest that software developers spend approximately two-thirds of their time communicating and researching, and one-third of their time on software development. In line with this argument, it was assumed that students from all tracks

spent similar time communicating and researching, and behavior then differed for one- third of the time, in which computation-intensive courses used more energy than others. A detailed list of calculations and used measurements can be found in Appendix D.

Results

Following the strategy introduced in the previous section, the 21 modules of the IS Master were analyzed. Aside from each module's semester and associated track, the following aspects were investigated: number of participants, number of sessions held in- class, recorded, streamed, or held as a video conference including the corresponding durations, the percentage of self-study spent on group work and the type of group work involved, and the percentage of self-study spent on individual work and the type of work involved. In the following, the corresponding findings will first be described in terms of a descriptive overview. After this, the environmental impact across emission categories will be compared, and finally, the commonalities and deviations between modules and tracks will be investigated.

Descriptive Findings

The analyzed data comprises 21 modules across 7 tracks. The average number of participants across modules in 2022 was 41, with a notable standard deviation of 31, due to the significantly higher number of students in the modules Innovation Management (162) and Information Security (79). While the average amount of in-class sessions was 17, there was a wide range of numbers of on-campus sessions across modules, ranging from 0 to 28. Similarly, the average number of recordings was 12, but also displayed a considerable amount of variation.

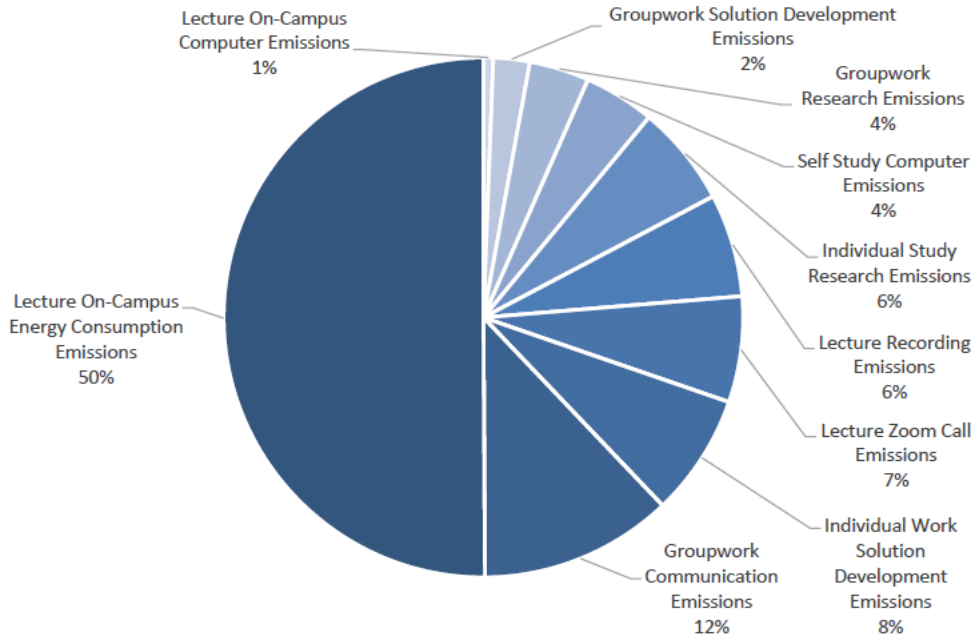

Figure 12: Distribution of contributing factors to the climate footprint

Turning to the CF, totaling 46.573,75 kg CO_2e, the IS Master modules generated a CF similar to that of 2.805.647 kilometers traveled by car – which equals 70 laps around the earth. The average consumption per module comes to approximately 2.2 tons, but numbers between the SuSe and WiSe diverge significantly, with modules held over the winter semester generating almost double the emissions of the modules held over the SuSe, and totaling 72% of emissions generated (see Appendix C). This is explained when looking at Fig. 1, which indicates that on-campus energy usage for heating and electricity is, by far, the largest CF contributor, coming to 50% of overall emissions. With more than 23 tons of CO_2e spent on enabling in-presence lectures, this energy is mainly spent on heating in the winter months. However, Fig. 1 also clearly demonstrates that despite the substantial energy consumption associated with on- campus energy usage, the CF generated by digital tools is comparably significant.

Environmental Impact across Emissions Categories

There are several things worth noting when comparing the CF across emission categories, aside from on-campus energy consumption constituting 50%. For instance, when adding up the CF generated by lecture recordings and digital formats of communication, both for self-study and in the context of lectures, these digital communication methods make up 25% of overall GHG emissions generated. As not nearly all lectures are recorded or streamed, and only half of all group work is assumed to happen online, this implies that the CF of digital streaming and conferencing services could, if used instead of in-person lectures, surpass the one generated by on-campus lectures, directly opposing the frequently expressed claim that digital alternatives are inherently more sustainable. This is also in line with the fact that groupwork communication emissions are, at 12%, the second biggest individual contributor to the overall CF. Combining individual and groupwork solution development emissions, this comes in third overall, at approximately 10%, similar to individual and group work research emissions, also totaling 10%, and followed by overall computer emissions at 5%.

When leaving out on-campus energy consumption and taking a look at the digitally generated emissions of lectures, group work, and individual work, and splitting computer emissions along the 40/60 group work/individual work split used in most modules, then, aside from on-campus energy consumption, group work turns out to be the highest contributor to a module's CF, with 19,8%. This is explained by the comparatively high emissions generated by the assumed 50% of Zoom calls for group communication noted above. Following group work, individual work totals 16,7%, with individual solution development emissions generating the biggest part of its CF. Finally, recordings, virtual conferences, and computer emissions generated in the context of lectures contribute the least to overall emissions. This can likely be explained by the number of hours spent in lectures; while 30 hours are usually allocated to both lectures and tutorials, the factual time spent in the classroom often varies, with some modules going as high as 40 hours, and others remaining as low as mid-twenties.

This explains how, even when accounting for both digital conferencing as well as recordings, the digital footprint of those lectures remains somewhat low. When thinking back to on- campus emissions, it can be observed that lectures are by far the biggest contributor of the three module components.

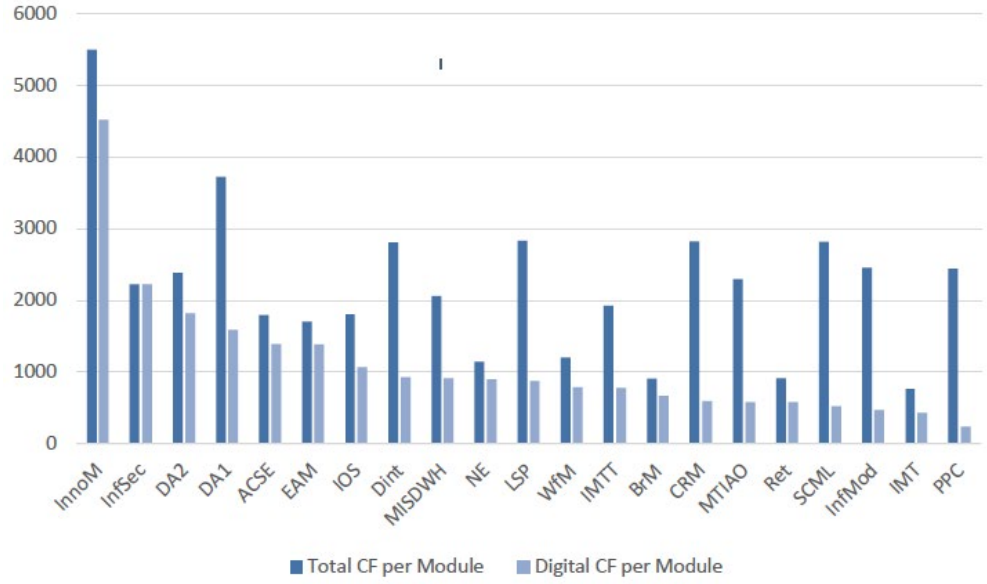

Figure 13: GHG emissions across modules, measured in kg CO_2e

Environmental Impact across Modules and Tracks

Taking a closer look at the GHG emissions generated by the modules themselves (Table 10: Climate Footprint Calculations per Module), one notable outlier becomes easily observable; at 5,5 tons of CO_2e generated, Innovation Management (InnoM), of the Marketing track, consumes more than double the emissions of the average IS module. This outlier is easily explained, however, as modules in the Marketing track can also be chosen by economics students, with whom the Innovation Management course appears to be particularly popular; while the other investigated modules had, on average, 41 participants, Innovation Management far exceeds this with 162 participants. Furthermore, the module's grade is defined entirely through group work. As such, the amount of time spent as a group, combined with the high amount of participants, explains the module's high CF due to groupwork communication emissions. A detailed composition of the CF of individual modules can be found in Appendix C. This also introduces an interesting fact, however; groupwork communication emissions in Innovation Management are higher than most modules' on-campus energy emissions, which, at least in this limited context, suggests that the more participants in one course, the more sensible in-presence options might be, as these are less, if at all, influenced by the number of participants.

As the on-campus energy consumption highly varies between summer and winter terms, it introduces too big of a bias into the analysis to be further included in the comparison of different modules and tracks. As such, the following part will refer to the digitally generated emissions only.

Generally, emissions across modules range widely, with some modules having significantly higher emissions in some categories than others. Following Innovation Management, the most resource-intensive module in terms of digital technologies is Information Security (InfSec). As the module has the second-highest number of participants, 79, and is held entirely online, this comes as no surprise.

Interestingly enough, when calculating the per capita emissions, Data Analytics 2 (DA2), Data Analytics 1 (DA1), and Logic Specification and Programming (LSP) are the modules with the highest emissions per participant, partially due to the high amount of self-study emissions generated by software development and programming. This indicates that these technically oriented modules, which use more resource-intensive digital infrastructure, have an above-average responsibility in attending to their CF.

On the other end of the spectrum, Production Planning and Control (PPC) has the lowest digital emissions, as the course neither provides lecture recordings or streams nor utilizes group work in any way. As such, the only factors contributing to ICT emissions are the computer emissions generated throughout the module, and the network data transfer emissions generated during individual coursework.

When, in turn, looking to compare the different tracks, there are several findings worth noting. The Marketing track (MCM), with 5.7 tons generated in digital emissions, makes up one-quarter of the overall CF generated digitally, as can be seen in Fig. 3. This is unsurprising, as this track includes the outlier Innovation Management. Notably, the second-highest emissions are generated by the Business Intelligence (BI) as well as Business Network (BN) tracks. The former, a software-development-focused track, is dominated by the solution development component, which generates more than 40% of the track's overall emissions (see Fig. 4). Business Networks, on the other hand, has quite low solution development emissions, and instead, factors in heavily with emissions generated through video conferencing, both in lectures and in group work, coming in at almost 45%. The track Information Systems Development (ISD), which comes in third, has slightly lower solution development emissions than the business intelligence track, which can be explained by the overall lower number of participants over the track's courses. Process Management (PM), Information Management (IM), and Logistics, Production, and Retail (LPR), generating the lowest emissions, do so while having group work Zoom calls as their highest emission factors.

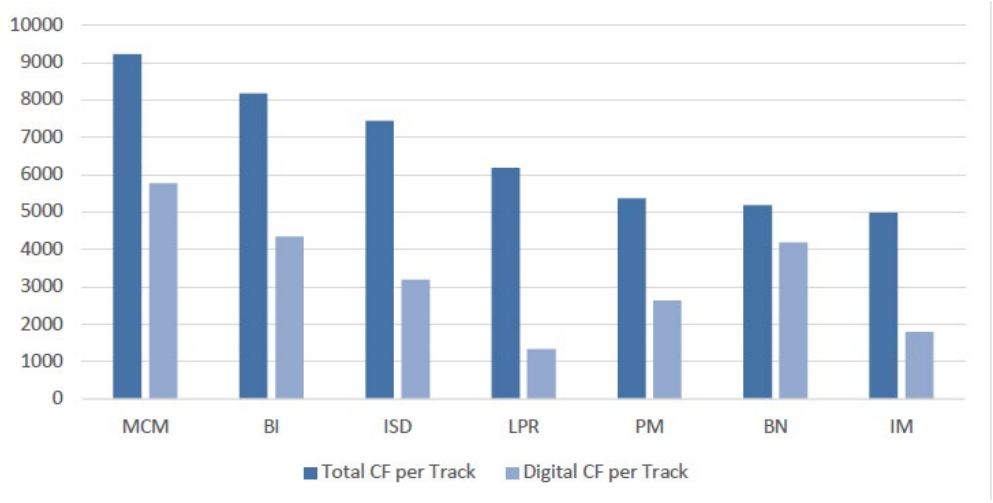

Figure 14: GHG emissions across tracks, measured in kg CO_2e

Looking at the emissions per capita, Information Systems Development and Business Intelligence have the highest emissions at 43.2 and 41.7 kg CO_2e respectively. This suggests that, on a per capita basis, these tracks are more carbon-intensive than the rest. When now comparing the composition of different tracks, it becomes apparent that the two abovementioned tracks are quite similar; their compositions, even at first glance, seem almost identical. In both, the highest contributing factor is individual work solution development. Taken together with groupwork solution development, this makes up more than half of each track's emissions.

Less apparent similarities can be seen when comparing the Information Management and Logistics, Production, and Retail tracks. While the tracks deviate quite significantly in terms of content, their teaching methods appear remarkably aligned, both contributing to the generated CF mostly with the usage of recordings and Zoom calls. The Logistics, Production, and Retail track is also the one that is least resource- consuming, due to its low amount of ICT used in teaching and self-study.

In summary, group work and lectures emerge as substantial contributors to overall emissions. This is particularly evident in the Marketing and Business Networks tracks, where activities related to marketing, consumer management, business, and networking have higher emissions due to the intensity of collaborative activities and the reliance on digital technologies for lectures and group discussions. However, individual work also contributes significantly to emissions, especially in tracks such as Information Systems Development and Business Intelligence, where the nature of computational individual and project work involves substantial energy consumption.

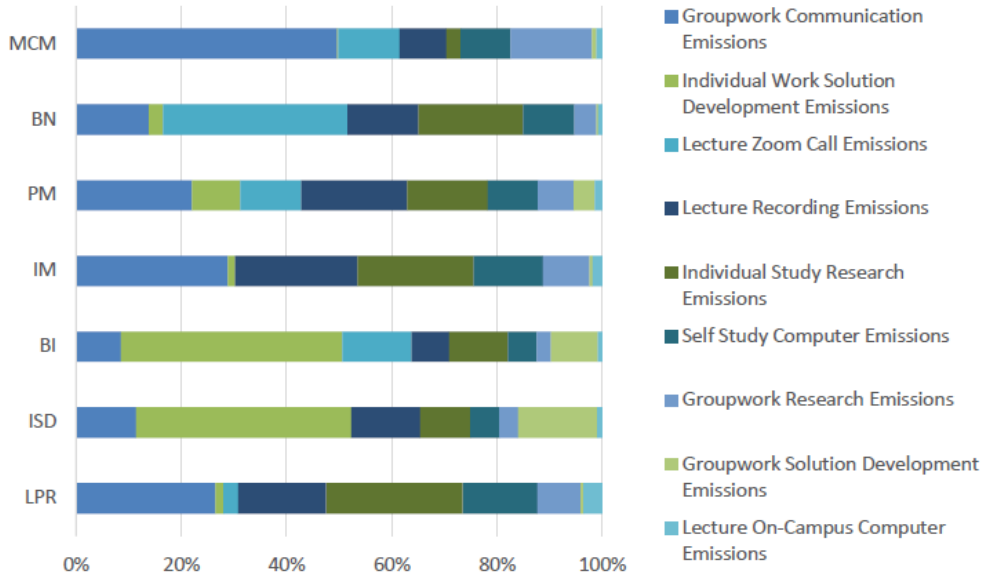

Figure 15: Composition of digital CF across tracks

Discussion

Having seen the impact that digital technologies can have on a university's ecological footprint, the question arises of how those impacts can be mitigated, and what implications this has for the way HEIs operate. The following sections will thus discuss a series of actionable insights that can be gathered by the presented analysis, and, following that, delineate this study's limitations and recommendations for future research.

Actionable Insights to reduce the Climate Footprint of ICT in Education

The increasing transition to digital teaching methods has brought to the forefront an immediate need to evaluate the corresponding environmental impact. The findings show that the CF of ICT is not as negligible as sometimes suggested. As the case of the Innovation Management module showed, the footprint generated by ICT can, in some instances, rival that of heating and energy consumption. This observation challenges the prevailing notion that digital solutions are inherently more sustainable than conventional approaches. It further suggests that efforts to reduce the climate impact of HEIs must include a critical examination of ICT energy consumption alongside traditional focus areas such as building heating efficiency.

Targeting High-Emission Areas

When investigating specific CF contributors, the disparity between digital live streaming and collaborating platforms, such as Zoom, and asynchronous learning tools, such as lecture recordings, becomes apparent. The higher bandwidth requirements of video conferencing contribute to a larger CF, suggesting the preferential use of asynchronous learning methods. This approach not only benefits the environment

but also provides greater flexibility to students. However, as asynchronous teaching methods greatly limit interaction, this substitution is only applicable where video conferencing is used as a one-way stream. Where interaction is desired and communication and collaboration are fostered, the role of conferencing tools cannot be overlooked. However, as video conferencing has long been criticized for limiting interaction student engagement, this suggests the need for a balanced approach that considers both environmental impact and educational efficacy (Ørngreen et al., 2019; Versteijlen et al., 2017). Where lecture recordings or streams are of use, introducing audio recordings as a supplement to slides might present a low-CF alternative worth exploring. While the effectiveness of audio podcasts depends on the subject matter and learning objectives, the general trend to podcasts suggests that the audio-only format might even have merit on its own.

Another area where high disparities were able to be observed is that of the modules with software development and programming components. While simply not developing software is very much not an option in a course where programming practices are to be taught, the high computational intensity of software development underscores the need to educate students on the computational intensity and subsequent CF implications of their work. But while the CF generated through software development might not be able to be omitted, it is possible to calculate or track the generated emissions and offset them accordingly. Authors such as Lannelongue et al. (2021) and Rahman et al. (2011) suggest two possible approaches to do so. Generally, encouraging mindfulness of CF emissions in software development group projects, and introducing green coding practices into the curriculum could cultivate a sustainability-centric mindset among future software developers, and is of particular importance given their responsibility of developing environmentally-friendly software solutions in the future.

Even in modules where the environmental impact of tools used is, comparably, minimal, students could be encouraged to use less energy-intensive alternatives. For example, as Struharová et al. (n.d.) have shown, Microsoft Office tools use consistently more energy than the comparable alternatives by LibreOffice. Similarly, sustainable search engines such as Ecosia could present an alternative to established solutions like Google (Palos-Sanchez & Saura, 2018). However, while exploring less energy-intensive software alternatives could contribute to CF reduction, the impact of such substitutions may, in the broader CF context, be minimal. For each substitute considered, the corresponding trade-offs warrant individual consideration.

Broader Institutional Implications and Strategies

Taking a bird's eye view and addressing the environmental impact on a larger scale may offer a more effective approach to sustainability compared to focusing on individual components. One consideration to be discussed in a broader context is that of seasonally adapting teaching modes. Leveraging seasonal variations in heating costs, with a preference for in-person classes during summer and (increased) online modalities in the winter months could result in significant emission savings. However,

such adjustments would require careful planning to ensure educational quality would not be compromised. Likewise, adapting teaching modes depending on the number of participants or based on the interaction and communication requirements could present a way in which physical and digital teaching formats can be optimized, particularly in cases where HEIs are fueled entirely by renewable energy sources.

Generally, addressing a university's carbon footprint in terms of systemic changes might be more effective than targeting specific areas. Osorio et al. (2022) provide one example of how to approach this endeavor, delineating the path to carbon neutrality of two universities in Columbia. However, the insights provided suggest that the impact of technologies on carbon emissions is more substantial than often assumed. They thus further underscore the need for a holistic approach to sustainability that balances technological innovation with environmental responsibility, the importance of developing a nuanced understanding of the environmental impact of ICT, particularly in the context of HEI, and finding "ed-tech within limits" (Selwyn, 2021, p. 1).

Limitations and Recommendations for Future Research

This chapter analyzed the CF associated with ICT use and digital teaching and learning methods employed in the context of track modules of the IS Master Program at the University of Münster. As such, the limited scope is one of the study's main limitations. The analysis was primarily focused on a subset of components within the digital teaching framework, such as computer usage, network data traffic emissions, and energy consumption of tools employed. This restricted field of reference means that other potentially significant factors contributing to the CF, like the production and disposal of electronic devices used by university staff, were not considered. Furthermore, given the focus on specific modules within a single program at the University of Münster, the presented findings may not be directly applicable to other contexts or disciplines. The unique characteristics of the IS Master program, including course content, teaching methods, and infrastructure, may limit the ability to generalize the results or the applied research design to other educational settings.

It should also be noted that the presented calculations rely heavily on assumptions and secondary data sourced from existing literature. While this approach is practical for an exploratory study, it inherently carries the limitations and biases of the referenced studies. The reliance on literature-derived assumptions for calculating emissions is a double-edged sword; while it enables the estimation of the climate footprint in the absence of direct measurement tools, it also introduces a level of uncertainty. The accuracy of the findings is contingent upon the validity of these assumptions, which may not fully capture the nuances of real-world emissions. Should assumptions be proven as false or figures change, be that due to the advancement of digital technologies or changes in the module compositions, this will, in turn, affect the results presented in this study.

Despite these limitations, this chapter lays a foundational step toward understanding the environmental impacts of digital education. Future research can thus extend the

scope of research in this emerging field. For one, where feasible, studies should strive to directly measure the energy consumption and emissions of digital teaching tools and platforms. This would reduce reliance on assumptions and enhance the accuracy of findings. For another, to improve generalizability, cross-disciplinary and cross-institutional studies should be carried out. Such comparative studies across different educational contexts could highlight best practices and identify specific areas where digital teaching methods could be optimized in terms of sustainability. These best practices could, successively, be turned into guidelines, enabling educators and institutions to make informed decisions that balance educational quality with environmental responsibility.

Finally, an aspect that should not be neglected in future research is that of university student and staff perspectives. Understanding the perceptions and attitudes of both students and faculty towards sustainable digital education practices could offer insights into barriers and facilitators for adoption, and promote more sustainable behaviors in the educational community.

Conclusion

This paper analyzed the environmental footprint generated in the context of the IS master program at the University of Münster. In particular, it focused on the CF associated with ICT usage and explored commonalities and differences across modules and tracks. It further highlighted areas where room for improvement exists and gave suggestions for optimization. It was found that the CF across modules and tracks is as diverse as those modules and tracks themselves. While some modules take place entirely in the digital world, others appear remarkably analog. Overall, it was proven that emissions generated through ICT usage are substantial and worth consideration and inclusion in the university's sustainability strategy. The suggestion, that digital technologies are inherently "greener" (Bourke & Simpson, 2009), was found to not hold fast in this limited context.

This paper's main contributions are threefold. Firstly, it was demonstrated how the digital tools and activities employed in the IS Master program contribute to the overall CF. While the energy consumed for on-campus lectures was the main CF contributor, digital conferencing and recordings took up 25% of overall emissions. It was further shown that some digital teaching methods produced similar outcomes with lower emissions, such as the comparison between lecture recordings and lecture streams, and that similarities between tracks and modules carried over to the footprint of the digital tools used. By introducing an approach to calculate the emissions associated with digital tools and activities used in university contexts, this paper thus provided practical insights to be used and extended by educators and HEIs as a whole. Lastly, this chapter provides a baseline on which future research can build. The employed calculation approach, the identified areas where actions to improve the CF could be taken, and the corresponding initial suggestions for improvement, provide a starting point for interested researchers. As such, this paper contributes to the growing

academic debate on GHG emissions in HEI contexts, particularly that of the sustainability of digital models of teaching.

To conclude, while there lies danger in ignoring digitalization, technological advancements should not be taken as the be-all, end-all. ICTs have the potential to significantly improve the GHG emissions generated by HEIs. However, with that potential comes the responsibility of not viewing digitalization as inherently sustainable, and instead engaging with the core subject matter – digital technologies and their impact on the environment.

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Appendix

A Information Systems Master Course Structure

	Track	Winter Semester		Summer Semester	
Method Tracks	**Information Management (IM)**	Managing the Information Age Organization (MTIAO)	Information Management Tasks and Techniques (IMTT)	Information Management Theories (IMT)	
	Process Management (PM)	Information Modeling (InfMod)		Enterprise Architecture Management (EAM)	Workflow Management (WfM)
	Business Networks (BN)	Interorganizational Systems (IOS)		Information Security (InfSec)	Network Economics (NE)
	Business Intelligence (BI)	Management Information Systems and Data Warehousing (MISDW)	Data Analytics 1 (DA1)	Data Analytics 2 (DA2)	
	Information Systems Development (ISD)	Logic Specification and Programming (LSP)	Data Integration (Dint)	Advanced Concepts in Software Engineering (ACSE)	
Domain Tracks	**Logistics, Production and Retail (LPR)**	Supply Chain Management and Logistics (SCML)	Production Planning and Control (PPC)	Retail (Ret)	
	Marketing (MCM)	Innovation Management (InnoM)	Customer Relationship Management (CRM)	Brand Management (BrM) (Channel Management in Module Descriptions)	
Every Term		7 Elective Modules consisting of at least 2 Seminars taken from modules not chosen above or from Master Studies in Computer Science, Business Administration or Selected Chapters in IS, 1 Project Seminar, 1 Master chapter Module			

Source: University of Münster (n.d.-c)

Table 8: Course Structure of the Master program in Information Systems

B Leo 18 Energy Consumption

Month	Electricity		Heating		Total Energy Consumption 2022 (in kWh)	Total Energy Consumption 2023 (in kWh)
	Us-age 2022 (in kWh)	Us-age 2023 (in kWh)	Us-age 2022 (in kWh)	Us-age 2023 (in kWh)		
January	1.000	1.079	19.316	18.785	20.316	19.864
February	836	875	16.402	16.715	17.238	17.590
March	870	868	14.170	16.329	15.040	17.197
April	952	938	8.971	10.473	9.923	11.411
May	1.136	1.058	2.301	4.399	3.437	5457
June	1.194	1.059	380	557	1.574	1.616
July	1.066	1.024	38	148	1.104	1.172
August	1.028	-	27	-	1.055	
September	960	-	2.826	-	3.786	
October	1.130	-	5.491	-	6.621	
November	1.187	-	10.655	-	11.842	
December	1.025	-	17.784	-	18.809	
Annual Con-sumption	12.384	6.901	98.361	67.406	110.745	74.307
Consumption SuSe 2022	**20.879 kWh**					
Consumption WiSe 2022/2023	**91.923 kWh**					

University of Münster (n.d.-a)

Table 9: Leonardo Campus 18 Energy Consumption

C Further Climate Footprint Diagrams

C.a Distribution of the Climate Footprint across Semesters

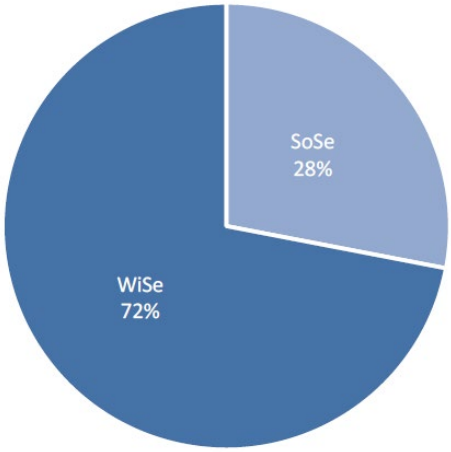

Figure 16: Distribution of CF across Semesters

C.b Composition of the Climate Footprint across Modules

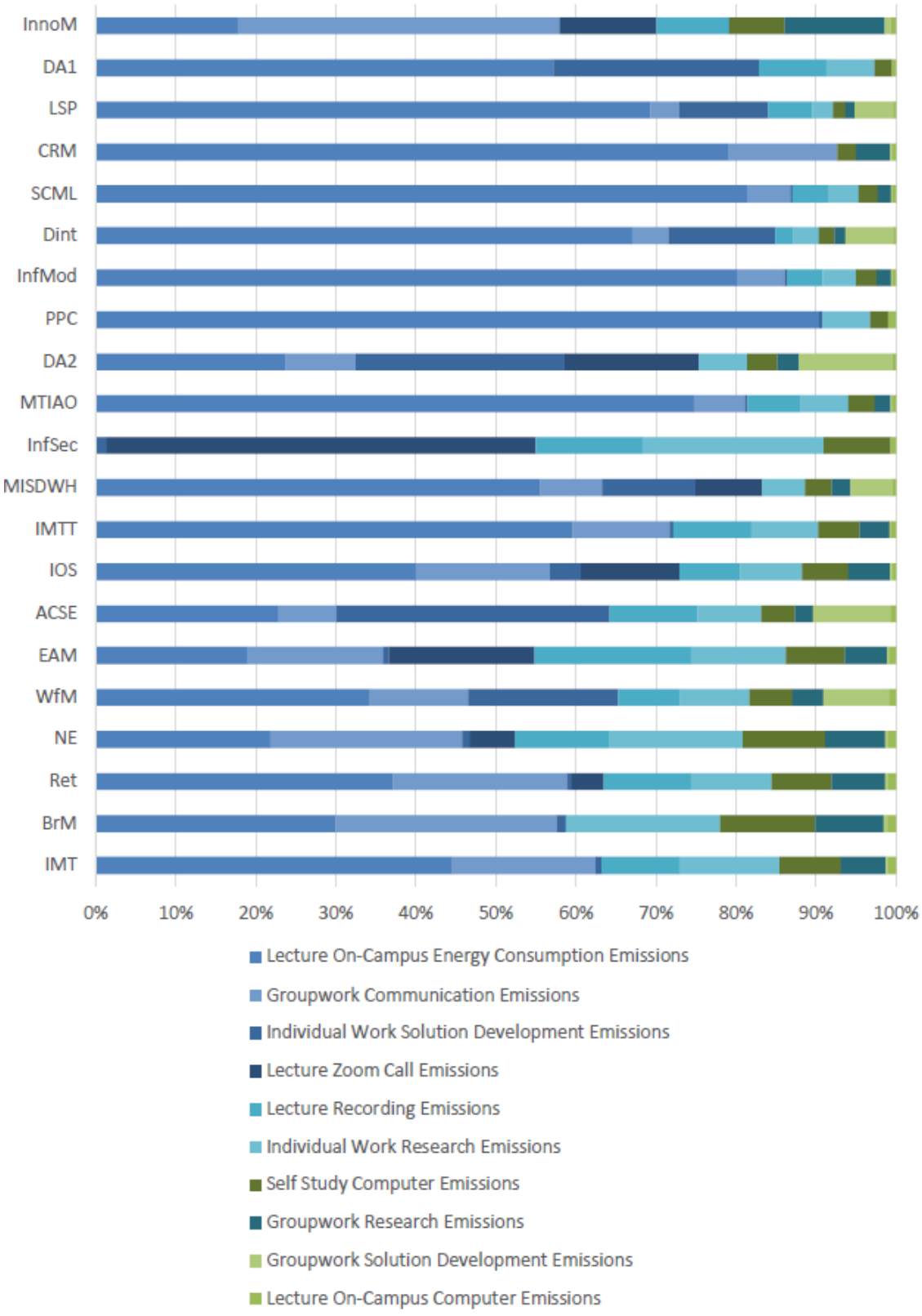

Figure 17: Composition of CF across modules

D Module Calculations

D.a Calculations per Module

Module	Teaching Mode	Calculation
InformationManagement – Managing the Information Age Organization	Total in-class sessions: 21 Total recorded sessions: 14 Recording length: 1:50 h Participants: 32 Selfstudy: 120 h Grading: 66,6% exam, 33,3% groupwork	**Lectures**: **On-Campus Energy Consumption Emissions**: E_{eMTIAO}= 94,38kWh *21*2h * 0,434kg/kWh= 1.720,36 kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = 32/2*202 kg CO_2e *21*2h / (4*365,25*7h) = 13,27 kg CO_2e **Network Data Transfer Emissions of Recordings:** $N_{eRecording}$=32*0,434kg/kWh*0,64kWh/GB*1,5Mbps*25,66h* (3600/8000) = 153,95 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=32*202 kg CO_2e*120h / (4*365,25*7) = 75,85 kg CO_2e **Groupwork:** 33% = 40h **Research Emissions:** R_{eG}=32*13,33h*r_e=32*13,33*0,10643776= 45,40kg CO_2e **Communication Emissions:** Network Data Transfer (Zoom): N_{eGroup}=32*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*13,33/2 *(3600/8000) = 146,62 kg CO_2e **Solution Development Emissions:** (50/50 Microsoft Word & PowerPoint) S_e=32*13,33h*(0,014+0,016) kWh /2 * 0,434kg/kWh = 2,78 kg CO_2e **Individual Work**: 66% = 80h **Research Emissions**: R_{el} =32*40h* r_e =32*40h *0,10643776 kg CO_2e =136,24 kg CO_2e **Applied Learning Emissions:** (50/50 Microsoft Word & PowerPoint): L_e =32*40*(0,014+0,016) kWh /2 * 0,434kg/kWh =8,33 kg CO_2e **Total:** T_{eMTIAO}= E_{eMTIAO}+ $C_{eCampus}$ + $N_{eRecording}$ + C_{eStudy} + R_{eG} + N_{eGroup} + S_e + R_{el} + L_e = 1.720,36 + 13,27 + 153,95 + 75,85 + 45,40 + 146,62 + 2,78 + 136,24 + 8,33= **2.302,8kg CO_2e**

Information Management – Information Management Tasks and Techniques	Total in-class sessions: 14 Total recorded sessions: 13 Recording length: 1:50 Participants: 42 Selfstudy: 120 h Grading: 100% exam, groupwork required, 60/40 split assumed	**Lectures**: **On-Campus Energy Consumption Emissions**: E_{elMTT}= 94,38kWh *14*2h * 0,434kg/kWh= 1.146,91 kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = 42/2*202 kg CO_2e *14*2h / (4*365,25*7h) = 11,61 kg CO_2e **Network Data Transfer Emissions of Recordings:** $N_{eRecording}$=42*0,434kg/kWh*0,64kWh/GB*1,5Mbps*13* (110/60)h *(3600/8000) = 187,68 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=42*202 kg CO_2e*120h / (4*365,25*7) = 99,55 kg CO_2e **Groupwork:** 40% = 48h **Research Emissions:** R_{eG}=42*(48h/3)*r_e=42*(48h/3)*0,10643776=71,53kg CO_2e **Communication Emissions:** Network Data Transfer (Zoom): N_{eGroup}=42*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*(48h/3) /2 *(3600/8000) = 230,99 kg CO_2e **Solution Development Emissions:** (50/50 Microsoft Word & PowerPoint) S_e=42*(48h/3)*(0,014+0,016) kWh /2 * 0,434kg/kWh =4,37kg CO_2e **Individual Work**: 66% = 72h **Research Emissions**: R_{el} =42*(72h/2)* r_e =42*(72h/2)*0,10643776 kg CO_2e =160,93 kg CO_2e **Applied Learning Emissions:** (50/50 Microsoft Word & PowerPoint): L_e =42*(72h/2)*(0,014+0,016) kWh /2 * 0,434kg/kWh = 9,84kg CO_2e **Total:** T_{elMTT}= E_{elMTT}+ $C_{eCampus}$ + $N_{eRecording}$ + C_{eStudy} + R_{eG} + N_{eGroup} + S_e + R_{el} + L_e = 1.146,91 + 11,61 + 187,68 + 99,55 + 71,53 + 230,99 + 4,37+ 160,93 + 9,84= **1.923,41kg CO_2e**

Information Management – Information Management Theories	Total in-class sessions: 15 Total recorded sessions: 13 Recording length: varied, total length 15,9h Participants: 25 Selfstudy: 120 h Grading: 60% exam , 40% groupwork	**Lectures**: **On-Campus Energy Consumption Emissions**: E_{elMT}= 26,16kWh *15*2h * 0,434kg/kWh= 340,60 kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = 25/2*202 kg CO_2e *15*2h / (4*365,25*7h) = 7,41 kg CO_2e **Network Data Transfer Emissions of Recordings:** $N_{eRecording=}$25*0,434kg/kWh*0,64kWh/GB*1,5Mbps*15,9h *(3600/8000) = 74,53 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=25*202 kgCO_2e*120h /(4*365,25*7)=59,25 kg CO_2e **Groupwork:** 40% = 48h **Research Emissions:** R_{eG}=25*(48h/3)*r_e=25*(48h/3)*0,10643776=42,58kg CO_2e **Communication Emissions:** Network Data Transfer (Zoom): N_{eGroup}=25*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*(48h/3) /2 *(3600/8000) = 137,49 kg CO_2e **Solution Development Emissions:** (50/50 Microsoft Word & PowerPoint) S_e=25*(48h/3)*(0,014+0,016) kWh /2 * 0,434kg/kWh = 2,6 kg CO_2e **Individual Work**: 66% = 72h **Research Emissions**: R_{el} =25*(72h/2)* r_e = 25*(72h/2)*0,10643776 kg CO_2e =95,79 kg CO_2e **Applied Learning Emissions:** (50/50 Microsoft Word & PowerPoint): L_e =25*(72h/2)*(0,014+0,016) kWh /2 * 0,434kg/kWh =5,86 kg CO_2e **Total:** T_{elMT}= E_{elMT}+ $C_{eCampus}$ + $N_{eRecording}$ + C_{eStudy} + R_{eG} + N_{eGroup} + S_e + R_{el} + L_e = 340,60 + 7,41 + 74,53 + 59,25 + 42,58 + 137,49 + 2,6+ 95,79 + 5,86 = **766,11kg CO_2e**

Process Management – Information Modeling	Total in-class sessions: 24 Total recorded sessions: 12 Recording length: 1:50 h Participants: 27 Selfstudy: 120 h Grading: 100% exam, groupwork required, 60/40 split assumed	**Lectures**: **On-Campus Energy Consumption Emissions**: $E_{eInfMod}$= 94,38kWh *24*2h * 0,434kg/kWh= 1.966,12 kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = 27/2*202 kg CO_2e *24*2h / (4*365,25*7h) = 12,80 kg CO_2e **Network Data Transfer Emissions of Recordings:** $N_{eRecording}$=27*0,434kg/kWh*0,64kWh/GB*1,5Mbps*12* (110/60) *(3600/8000) = 111,37 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=27*202 kgCO_2e*120h /(4*365,25*7)= 64 kg CO_2e **Groupwork:** 40% = 48h **Research Emissions:** R_{eG}=27*(48h/3)*r_e=27*(48h/3)*0,10643776=45,98kg CO_2e **Communication Emissions:** Network Data Transfer (Zoom): N_{eGroup}=27*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*(48h/3) /2 *(3600/8000) = 148,49 kg CO_2e **Solution Development Emissions:** (Modeling Software with energy usage similar to Word & PPT assumed, thus a 50/50 Microsoft Word & PowerPoint taken) S_e=27*(48h/3)*(0,014+0,016) kWh /2 * 0,434kg/kWh = 2,81kg CO_2e **Individual Work**: 66% = 72h **Research Emissions**: R_{el} =27*(72h/2)* r_e = 27*(72h/2)*0,10643776 kg CO_2e =103,46 kg CO_2e **Applied Learning Emissions:** (Modeling Software with energy usage similar to Word & PPT assumed, thus a 50/50 Microsoft Word & PowerPoint taken) L_e =27*(72h/2)*(0,014+0,016) kWh /2 * 0,434kg/kWh = 6,33 kg CO_2e **Total:** $T_{eInfMod}$= $E_{eInfMod}$+ $C_{eCampus}$ + $N_{eRecording}$ + C_{eStudy} + R_{eG} + N_{eGroup} + S_e + R_{el} + L_e = 1.966,12 + 12,80 + 111,37 + 64+ 45,98 + 148,49 + 2,81+ 103,46 + 6,33 = **2.461,36kg CO_2e**

Process Management – Enterprise Architecture Management	Total in-class sessions: 14 Total live streams: 14 Total Zoom calls: 14 Zoom/Stream length: 1:50 h Futher videos: 24x 0,33h=8h Participants: 52 Selfstudy: 120 h Grading: 60% exam , 40% groupwork	**Lectures**: **On-Campus Energy Consumption Emissions**: E_{eEAM}= 26,16kWh *14*2h*0,434kg/kWh=317,9 kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = 52/2*202 kg CO_2e *14*2h / (4*365,25*7h) = 14,38 kg CO_2e **Network Data Transfer Emissions of Recordings:** $N_{eRecording}$=52*0,434kg/kWh*0,64kWh/GB*1,5Mbps*(14* (110/60) +8)*(3600/8000) = 328,23 kg CO_2e N_{eZoom}=52/3*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*(110/60)h*14*(3600/8000) = 305,84kg CO_2e (Assumption: 1/3 of participants is present via zoom) **Selfstudy**: **Computer Emissions:** C_{eStudy}=52*202 kgCO_2e*120h /(4*365,25*7)= 123,25 kg CO_2e **Groupwork:** 40% = 48h **Research Emissions:** R_{eG}=52*(48h/3)*r_e=52*(48h/3)*0,10643776=88,56kg CO_2e **Communication Emissions:** Network Data Transfer (Zoom): N_{eGroup}=52*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*(48h/3) /2 *(3600/8000) = 285,98 kg CO_2e **Solution Development Emissions:** (Modeling Software with energy usage similar to Word & PPT assumed, thus a 50/50 Microsoft Word & PowerPoint taken) S_e=52*(48h/3)*(0,014+0,016) kWh /2 * 0,434kg/kWh = 5,42 kg CO_2e **Individual Work**: 66% = 72h **Research Emissions**: R_{el} =52*(72h/2)* r_e = 52*(72h/2)*0,10643776 kg CO_2e =199,25kg CO_2e **Applied Learning Emissions:** (Modeling Software with energy usage similar to Word & PPT assumed, thus a 50/50 Microsoft Word & PowerPoint taken): L_e =52*(72h/2)*(0,014+0,016) kWh /2 * 0,434kg/kWh =12,19 kg CO_2e **Total:** T_{eEAM}= E_{eEAM}+ $C_{eCampus}$ + $N_{eRecording}$ + N_{eZoom} + C_{eStudy} + R_{eG} + N_{eGroup} + S_e + R_{el} + L_e = 317,9 + 14,38 + 328,23 +305,84+ 123,25 + 88,56 + 285,98 + 5,42 + 199,25 + 12,19 = **1.703,95 kg CO_2e**

Process Management – Workflow Management	Total in-class sessions: 18 Total recordings: 10 Recording length: 1:50 h Participants: 27 Selfstudy: 120 h Grading: 60% exam , 40% groupwork	**Lectures**: **On-Campus Energy Consumption Emissions**: E_{eWfM}= 26,16kWh *18*2h*0,434kg/kWh=408,72kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = 27/2*202 kg CO_2e *18*2h / (4*365,25*7h) = 9,6 kg CO_2e **Network Data Transfer Emissions of Recordings:** $N_{eRecording}$=27*0,434kg/kWh*0,64kWh/GB*1,5Mbps*10* (110/60) *(3600/8000) = 92,81 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=27*202 kgCO_2e*120h /(4*365,25*7)= 64 kg CO_2e **Groupwork:** 40% = 48h **Research Emissions:** R_{eG}=27*(48h/3)*r_e=27*(48h/3)*0,10643776=45,98kg CO_2e **Communication Emissions:** Network Data Transfer (Zoom): N_{eGroup}=27*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*(48h/3) /2 *(3600/8000) = 148,49 kg CO_2e **Solution Development Emissions:** (50/50 split between modeling software & programming assumed) S_e=27*(48h/3)*(0,015+1,051) kWh /2 * 0,434kg/kWh = 99,93 kg CO_2e **Individual Work**: 66% = 72h **Research Emissions**: R_{el} =27*(72h/2)* r_e = 27*(72h/2)*0,10643776 kg CO_2e =103,46 kg CO_2e **Applied Learning Emissions:** (50/50 split between modeling software & programming assumed) L_e =27*(72h/2)*(0,015+1,051) kWh /2 * 0,434kg/kWh = 224,85 kg CO_2e **Total:** T_{eEAM}= E_{eEAM}+ $C_{eCampus}$ + $N_{eRecording}$ + C_{eStudy} + R_{eG} + N_{eGroup} + S_e + R_{el} + L_e = 408,72 + 9,6 + 92,81 + 64+ 45,98 + 148,49+ 99,93 + 103,46 + 224,85 = **1.197,84kg CO_2e**

Business Networks – Interorganizational Systems	Total in-class sessions: 9 Total recorded sessions: 9 Total zoom sessions: 4 Recording length: 1:50h Participants: 45 Selfstudy: 120 h Grading: 50% exam , 50% groupwork	**Lectures**: **On-Campus Energy Consumption Emissions**: E_{eIOS}= 94,38kWh *9*2h * 0,434kg/kWh= 737,3kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = 45/2*202 kg CO_2e *9*2h /(4*365,25*7h)= 8 kg CO_2e **Network Data Transfer Emissions of Recordings:** $N_{eRecording=}$45*0,434kg/kWh*0,64kWh/GB*1,5Mbps*(110/60)*9h *(3600/8000) = 139,21 kg CO_2e N_{eZoom}=45*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*4* (110/60)h *(3600/8000) = 226,86 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=45*202 kgCO_2e*120h /(4*365,25*7)= 106,66 kg CO_2e **Groupwork:** 50% = 60h **Research Emissions:** R_{eG}=45*(60h/3)*r_e=45*(60h/3)*0,10643776=95,79kg CO_2e **Communication Emissions:** Network Data Transfer (Zoom): N_{eGroup}=45*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*(60h/3) /2 *(3600/8000) = 309,36 kg CO_2e **Solution Development Emissions:** (50/50 Microsoft Word & PowerPoint) S_e=45*(60h/3)*(0,014+0,016) kWh /2 * 0,434kg/kWh = 5,86 kg CO_2e **Individual Work**: 50% = 60h **Research Emissions**: R_{el} =45*(60h/2)* r_e = 45*(60h/2)*0,10643776 kg CO_2e =143,69kg CO_2e **Applied Learning Emissions:** (50/50 Microsoft Word & PowerPoint): L_e =79*60h*(0,014+0,016) kWh /2 * 0,434kg/kWh =71,1 kg CO_2e **Total:** T_{eIOS}= E_{eIOS}+ $C_{eCampus}$ + $N_{eRecording}$ + N_{eZoom} + C_{eStudy} + R_{eG} + N_{eGroup} + S_e + R_{el} + L_e = 737,3 + 8 + 139,21 + 226,86 + 106,66 + 95,79 + 309,36 + 5,86 + 143,69 +30,86 = **1.803,59 kg CO_2e**

Buisness Networks – Information Security	Total in-class sessions: 0 Total recorded videos: 19 Total zoom sessions: 12 Recording length: 30 min Participants: 79 Selfstudy: 120 h Grading: 100% exam, no groupwork	**Lectures**: **On-Campus Energy Consumption Emissions**: $E_{eInfSec}$= 0 **Computer Emissions for video lectures & zoom tutorials:** $C_{eCampus}$ = 79*202 kg CO_2e *19*0,5 /(4*365,25*7h)= 14,82 kg CO_2e **Network Data Transfer Emissions of Recordings:** $N_{eRecording}$=79*0,434kg/kWh*0,64kWh/GB*3,17Mbps*0,5h*19*(3600/8000) = 297,37 kg CO_2e N_{eZoom}=79*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*12* (110/60)h *(3600/8000) = 1.194,8 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=79*202 kgCO_2e*120h /(4*365,25*7)= 187,25 kg CO_2e **Individual Work**: 120h **Research Emissions**: R_{el} =79*60h* r_e = 79*60h*0,10643776 kg CO_2e =504,51 kg CO_2e **Applied Learning Emissions:** (50/50 Microsoft Word & PowerPoint): L_e =79*60h*(0,014+0,016) kWh /2 * 0,434kg/kWh =30,86 kg CO_2e **Total:** T_{eIOS}= $E_{eInfSec}$+ $C_{eCampus}$ + $N_{eRecording}$ + N_{eZoom} + C_{eStudy} + R_{el} + L_e = 0 + 14,82 + 297,37 + 1.194,8 + 187,25 + 504,51+ 30,86= **2.229,61 kg CO_2e**
Business Networks – Network Economics	Total in-class sessions: 11 Total zoom calls: 1 (duration 1:50) Total video recordings: 13 chapters, 20 min per chapter Participants: 50 Selfstudy: 120 h Grading: 100% exam, groupwork required, 60/40 split assumed	**Lectures**: **On-Campus Energy Consumption Emissions**: E_{eNE}= 26,16kWh *11*2h * 0,434kg/kWh= 249,78 kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = 50/2*202 kg CO_2e *11*2h /(4*365,25*7h)= 10,86 kg CO_2e **Network Data Transfer Emissions of Recordings:** $N_{eRecording}$=50*0,434kg/kWh*0,64kWh/GB*5Mbps*(20/60)*13 *(3600/8000) = 135,41 kg CO_2e N_{eZoom}=50*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*1* (110/60)h *(3600/8000) = 63,02 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=50*202 kgCO_2e*120h /(4*365,25*7)= 118,51 kg CO_2e **Groupwork:** 40% = 48h **Research Emissions:** R_{eG}=50*(48h/3)*r_e=50*(48h/3)*0,10643776=85,15kgCO_2e **Communication Emissions:** Network Data Transfer (Zoom): N_{eGroup}=50*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*(48h/3) /2 *(3600/8000) = 274,98 kg CO_2e **Solution Development Emissions:** (50/50 Microsoft Word & PowerPoint) S_e=50*(48h/3)*(0,014+0,016) kWh /2 * 0,434kg/kWh = 5,21 kg CO_2e **Individual Work**: 60% = 72h **Research Emissions**: R_{el} =50*(72h/2)* r_e = 50*(72h/2)*0,10643776 kg CO_2e =191,59 kg CO_2e **Applied Learning Emissions:** (50/50 Microsoft Word & PowerPoint): L_e =50*(72/2)h*(0,014+0,016) kWh /2 * 0,434kg/kWh =11,72 kg CO_2e **Total:** T_{eNE}= E_{eNE}+ $C_{eCampus}$ + $N_{eRecording}$ + N_{eZoom} + C_{eStudy} + R_{eG} + N_{eGroup} + S_e + R_{el} + L_e = 249,78 + 10,86 + 135,41 + 63,02 + 118,51 + 85,15 + 274,98 + 5,21 + 191,59 +11,72 = **1.146,23 kg CO_2e**

Business Intelligence – Management Information Systems and Data Warehousing	Total in-class sessions: 14 Total zoom calls: 14 (duration 1:50) Participants: 29 Selfstudy: 120 h Grading: 100% exam, groupwork required, 60/40 split assumed	**Lectures**: **On-Campus Energy Consumption Emissions**: $E_{eMISDWH}$= 94,38kWh *14*2h*0,434kg/kWh=1.146,91kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = (29*2/3)/2*202 kg CO_2e *14*2h / (4*365,25*7h) = 9,6 kg CO_2e **Network Data Transfer Emissions of Stream:** (Assumption: 1/3 of participants is present via zoom) N_{eZoom}=29/3*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*14* (110/60)h *(3600/8000) = 170,57 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=29*202 kgCO_2e*120h /(4*365,25*7)= 68,74 kg CO_2e **Groupwork:** 40% = 48h **Research Emissions:** R_{eG}=29*(48h/3)*r_e=29*(48h/3)*0,10643776=49,39kg CO_2e **Communication Emissions:** Network Data Transfer (Zoom): N_{eGroup}=29*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*(48h/3) /2 *(3600/8000) = 159,49 kg CO_2e **Solution Development Emissions:** (50/50 split between modeling software & programming assumed) S_e=29*(48h/3)*(0,015+1,051) kWh /2 * 0,434kg/kWh = 107,33 kg CO_2e **Individual Work**: 66% = 72h **Research Emissions**: R_{el} =29*(72h/2)* r_e = 29*(72h/2)*0,10643776 kg CO_2e =111,12 kg CO_2e **Applied Learning Emissions:** (50/50 split between modeling software & programming assumed) L_e =29*(72h/2)*(0,015+1,051) kWh /2 * 0,434kg/kWh = 241,50 kg CO_2e **Total:** $T_{eMISDWH}$= $E_{eMISDWH}$+ $C_{eCampus}$ + N_{eZoom} + C_{eStudy} + R_{eG} + N_{eGroup} + S_e + R_{el} + L_e = 1.146,91 + 9,6 + 170,57 + 68,74 + 49,39+ 159,49 + 107,33 + 111,12 + 241,50 = **2.064,65 kg CO_2e**
Business Intelligence – Data Analytics 1	Total in-class sessions: 26 Total recorded sessions: 26 Recording length: 1:50h Participants: 35 Selfstudy: 120 h Grading: 100% exam, no groupwork	**Lectures**: **On-Campus Energy Consumption Emissions**: E_{eDA1}= 94,38kWh *26*2h*0,434kg/kWh=2.129,07 kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = 35/2*202 kg CO_2e *26*2h / (4*365,25*7h) = 17,97 kg CO_2e **Network Data Transfer Emissions of Stream:** $N_{eRecording}$=35*0,434kg/kWh*0,64kWh/GB*1,5Mbps*(110/60)h*26 *(3600/8000) = 312,79 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=35*202 kgCO_2e*120h /(4*365,25*7)= 82,96 kg CO_2e **Individual Work**: 100% - 120h **Research Emissions**: R_{el} =35*120h/2* r_e = 35*(120h/2)*0,10643776 kg CO_2e = 223,52 kg CO_2e **Applied Learning Emissions:** (100% programming assumed) L_e =35*(120h/2)* 1,051 kg CO_2e * 0,434kg/kWh = 957,88 kg CO_2e **Total:** T_{eDA1}= E_{eDA1}+ $C_{eCampus}$ + $N_{eRecording}$ + C_{eStudy} + R_{el} + L_e = 2.129,07 + 17,97 + 312,79 + 82,96 + 223,52 + 957,88 = **3.724,19kg CO_2e**

Business Intelligence – Data Analytics 2	Total in-class sessions: 25 Total zoom calls: 25 Participants: 38 Selfstudy: 120 h Grading: 60% exam, 40% groupwork	**Lectures**: **On-Campus Energy Consumption Emissions**: E_{eDA2}= 26,16kWh *25*2h*0,434kg/kWh= 567,67 kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = (38*2/3)/2*202 kg CO_2e *25*2h / (4*365,25*7h) = 12,51 kg CO_2e **Network Data Transfer Emissions of Stream:** (Assumption: 1/3 of participants is present via zoom) N_{eZoom}=38/3*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*25* (110/60)h *(3600/8000) = 399,11 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=38*202 kgCO_2e*120h /(4*365,25*7)= 90,07 kg CO_2e **Groupwork:** 40% = 48h **Research Emissions:** R_{eG}=38*(48h/3)*r_e=38*(48h/3)*0,10643776=64,71 kg CO_2e **Communication Emissions:** Network Data Transfer (Zoom): N_{eGroup}=38*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*(48h/3) /2 *(3600/8000) = 208,99 kg CO_2e **Solution Development Emissions:** (100% programming assumed) S_e=38*(48h/3)*1,051 kWh * 0,434kg/kWh = 277,33kg CO_2e **Individual Work**: 66% = 72h **Research Emissions**: R_{el} =38*(72h/2)* r_e = 38*(72h/2)*0,10643776 kg CO_2e =145,61 kg CO_2e **Applied Learning Emissions:** (100% programming assumed) L_e =38*(72h/2)*1,051kWh * 0,434kg/kWh = 623,99 kg CO_2e **Total:** T_{eDA2}= E_{eDA2}+ C_{eDA2} + N_{eZoom} + C_{eStudy} + R_{eG} + N_{eGroup} + S_e + R_{el} + L_e = 567,67 + 12,51 + 399,11 + 90,07 + 64,71 + 208,99 + 277,33 + 145,61 + 623,99 = **2.389,99kg CO_2e**

Information Systems Development – Logic Specification and Programming	Total in-class sessions: 24 Total recorded sessions: 24 Recording length: 1:50h Participants: 19 Selfstudy: 120 h Grading: 100% exam, groupwork required, 40/60 split assumed	**On-Campus Energy Consumption Emissions**: E_{eLSP}= 94,38kWh *24*2h*0,434kg/kWh= 1.966,12 kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = 19/2*202 kg CO_2e *24*2h / (4*365,25*7h) = 9 kg CO_2e **Network Data Transfer Emissions of Recording:** $N_{eRecording}$=19*0,434kg/kWh*0,64kWh/GB*1,5Mbps*(110/60)*24 *(3600/8000) = 156,74 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=19*202 kgCO_2e*120h /(4*365,25*7)= 45,03 kg CO_2e **Groupwork:** 40% = 48h **Research Emissions:** R_{eG}=19*(48h/3)*r_e=19*(48h/3)*0,10643776=32,36 kg CO_2e **Communication Emissions:** Network Data Transfer (Zoom): N_{eGroup}=19*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*(48h/3) /2 *(3600/8000) = 104,49 kg CO_2e **Solution Development Emissions:** (100% programming assumed) S_e=19*(48h/3)*1,051 kWh * 0,434kg/kWh = 138,66 kg CO_2e **Individual Work**: 66% = 72h **Research Emissions**: R_{el} =19 *(72h/2)* r_e = 19*(72h/2)*0,10643776 kg CO_2e =72,8 kg CO_2e **Applied Learning Emissions:** (100% programming assumed) L_e =19*(72h/2)*1,051kWh * 0,434kg/kWh = 312 kg CO_2e **Total:** T_{eLSP}= E_{eLSP}+ $C_{eCampus}$ + $N_{eRecording}$ + C_{eStudy} + R_{eG} + N_{eGroup} + S_e + R_{el} + L_e = 1.966,12 + 9 + 156,74 + 45,03 + 32,36 + 104,49 + 138,66 + 72,8 + 312= **2.837,2 kg CO_2e**
Information Systems Development – Data Integration	Total in-class sessions: 23 Total recorded sessions: 8 Recording length: 1:50h Participants: 23 Selfstudy: 120 h Grading: 60% exam, 40% groupwork	**On-Campus Energy Consumption Emissions**: E_{eDInt}= 94,38kWh *23*2h*0,434kg/kWh= 1.884,20 kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = 23/2*202 kg CO_2e *23*2h / (4*365,25*7h) = 10,44 kg CO_2e **Network Data Transfer Emissions of Recording:** $N_{eRecording}$=23*0,434kg/kWh*0,64kWh/GB*1,5Mbps*(110/60)*8 *(3600/8000) = 63,25 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=23*202 kgCO_2e*120h /(4*365,25*7)= 54,51 kg CO_2e **Groupwork:** 40% = 48h **Research Emissions:** R_{eG}=23*(48h/3)*r_e=23*(48h/3)*0,10643776=39,17 kg CO_2e **Communication Emissions:** Network Data Transfer (Zoom): N_{eGroup}=23*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*(48h/3) /2 *(3600/8000) = 126,49 kg CO_2e **Solution Development Emissions:** (100% programming assumed) S_e=23*(48h/3)*1,051 kWh * 0,434kg/kWh = 167,86 kg CO_2e **Individual Work**: 66% = 72h **Research Emissions**: R_{el} =123*(72h/2)* r_e = 23*(72h/2)*0,10643776 kg CO_2e =88,13 kg CO_2e **Applied Learning Emissions:** (100% programming assumed) L_e =23*(72h/2)*1,051kWh * 0,434kg/kWh = 377,68 kg CO_2e **Total:** T_{eDInt}= E_{eDInt}+ $C_{eCampus}$ + $N_{eRecording}$ + C_{eStudy} + R_{eG} + N_{eGroup} + S_e + R_{el} + L_e = 1.884,20 + 10,44 + 63,25 + 54,51 + 39,17 + 126,49 + 167,86 + 88,13 + 377,68 = **2.811,73 kg CO_2e**

Information Systems DEvelopment – Advanced Concepts in Software Engineering	Total in-class sessions: 18 Total recorded sessions: 18 Recording length: 1:50h Participants: 32 Selfstudy: 120 h Grading: 70% exam, 30% groupwork	**On-Campus Energy Consumption Emissions**: E_{eACSE}= 26,16kWh *18*2h*0,434kg/kWh= 408,72 kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = 32/2*202 kg CO_2e *18*2h / (4*365,25*7h) = 11,37 kg CO_2e **Network Data Transfer Emissions of Recording:** $N_{eRecording}$=32*0,434kg/kWh*0,64kWh/GB*1,5Mbps*(110/60)*18 *(3600/8000) = 197,99 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=32*202 kgCO_2e*120h /(4*365,25*7)= 75,85 kg CO_2e **Groupwork:** 30% = 36h **Research Emissions:** R_{eG}=32*(36h/3)*r_e=32*(36h/3)*0,10643776=40,87 kg CO_2e **Communication Emissions:** Network Data Transfer (Zoom): N_{eGroup}=32*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*(36h/3) /2 *(3600/8000) = 131,99 kg CO_2e **Solution Development Emissions:** (100% programming assumed) S_e=32*(36h/3)*1,051 kWh * 0,434kg/kWh = 175,16 kg CO_2e **Individual Work**: 70% = 84h **Research Emissions**: R_{el} =32*(84h/2)* r_e = 32*(84h/2)*0,10643776 kg CO_2e =143,05kg CO_2e **Applied Learning Emissions:** (100% programming assumed) L_e =32*(84h/2)*1,051kWh * 0,434kg/kWh = 613,04 kg CO_2e **Total:** T_{eACSE}= E_{eACSE}+ $C_{eCampus}$ + $N_{eRecording}$ + C_{eStudy} + R_{eG} + N_{eGroup} + S_e + R_{el} + L_e = 408,72 + 11,37 + 197,99 + 75,85 + 40,87 + 131,99 + 175,16 + 143,05+ 613,04 = **1.798,04 kg CO_2e**

Logistics, Production and Retail – Supply Chain Management and Logistics	Total in-class sessions: 28 Total recorded sessions: 13 Recording length: 1:50 h Participants: 28 Selfstudy: 120 h Grading: 100% exam, groupwork required, 60/40 split assumed	**Lectures**: **On-Campus Energy Consumption Emissions**: E_{eSCML}= 94,38kWh *28*2h * 0,434kg/kWh= 2.293,81 kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = 28/2*202 kg CO_2e *28*2h / (4*365,25*7h) = 15,49 kg CO_2e **Network Data Transfer Emissions of Recordings:** $N_{eRecording}$=28*0,434kg/kWh*0,64kWh/GB*1,5Mbps*13* (110/60) *(3600/8000) = 125,12 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=28*202 kg CO_2e*120h /(4*365,25*7)= 66,37 kg CO_2e **Groupwork:** 40% = 48h **Research Emissions:** R_{eG}=28*(48h/3)*r_e=28*(48h/3)*0,10643776=47,68 kg CO_2e **Communication Emissions:** Network Data Transfer (Zoom): N_{eGroup}=28*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*(48h/3) /2 *(3600/8000) = 153,99 kg CO_2e **Solution Development Emissions:** (Modeling Software with energy usage similar to Word & PPT assumed, thus a 50/50 Microsoft Word & PowerPoint taken) S_e=28*(48h/3)*(0,014+0,016) kWh /2 * 0,434kg/kWh = 2,92 kg CO_2e **Individual Work**: 66% = 72h **Research Emissions**: R_{el} =28*(72h/2)* r_e = 28*(72h/2)*0,10643776 kg CO_2e =107,29 kg CO_2e **Applied Learning Emissions:** (Modeling Software with energy usage similar to Word & PPT assumed, thus a 50/50 Microsoft Word & PowerPoint taken) L_e =28*(72h/2)*(0,014+0,016) kWh /2 * 0,434kg/kWh = 6,56 kg CO_2e **Total:** T_{eSCML}= E_{eSCML}+ $C_{eCampus}$ + $N_{eRecording}$ + C_{eStudy} + R_{eG} + N_{eGroup} + S_e + R_{el} + L_e = 2.293,81 + 15,49 + 125,12 + 66,37 + 47,68 + 153,99 + 2,92 + 107,29 + 6,56 = **2.819,23 kg CO_2e**
Logistics, Production and Retail – Production Planning and Control	Total in-class sessions: 27 Total recorded videos: 0 Participants: 23 Selfstudy: 120 h Grading: 100% exam, no groupwork	**Lectures**: **On-Campus Energy Consumption Emissions**: E_{ePPC}= 94,38kWh *27*2h * 0,434kg/kWh= 2.211,89 kg CO_2e **Computer Emissions on Campus** $C_{eCampus}$ = 23*202 kg CO_2e *27*2 /(4*365,25*7h)= 24,53kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=23*202 kgCO_2e*120h /(4*365,25*7)= 54,51 kg CO_2e **Individual Work**: 120h **Research Emissions**: R_{el} =23*60h* r_e = 23*60h*0,10643776 kg CO_2e = 146,88 kg CO_2e **Applied Learning Emissions:** (50/50 Microsoft Word & PowerPoint or similar): L_e =23*60h*(0,014+0,016) kWh /2 * 0,434kg/kWh =8,98 kg CO_2e **Total:** T_{eIOS}= E_{ePPC}+ $C_{eCampus}$ + C_{eStudy} + R_{el} + L_e = 2.211,89 + 24,53+ 54,51 + 146,88 + 8,98 = **2.446,79 kg CO_2e**

Logistics, Production and Retail - Retail	Total in-class sessions: 15 Total Zoom Sessions: 1 Total video recordings: 10 Participants: 29 Selfstudy: 120 h Grading: 100% exam, groupwork required, 50/50 split according to lecture	**Lectures**: **On-Campus Energy Consumption Emissions**: E_{eNE}= 26,16kWh *15*2h * 0,434kg/kWh= 340,60 kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = 29/2*202 kg CO_2e *15*2h /(4*365,25*7h)= 8,59 kg CO_2e **Network Data Transfer Emissions of Recordings:** $N_{eRecording}$=29*0,434kg/kWh*0,64kWh/GB*1,5Mbps*(110/60)*10*(3600/8000) = 99,68 kg CO_2e N_{eZoom}=29*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*1* (110/60)h *(3600/8000) = 36,55 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=29*202 kgCO_2e*120h /(4*365,25*7)= 68,74 kg CO_2e **Groupwork:** 50% = 60h **Research Emissions:** R_{eG}=29*(60h/3)*r_e=29*(60h/3)*0,10643776=61,73 kg CO_2e **Communication Emissions:** Network Data Transfer (Zoom): N_{eGroup}=29*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*(60h/3) /2 *(3600/8000) = 199,36 kg CO_2e **Solution Development Emissions:** (50/50 Microsoft Word & PowerPoint) S_e=29*(60h/3)*(0,014+0,016) kWh /2 * 0,434kg/kWh = 3,78 kg CO_2e **Individual Work**: 60% = 72h **Research Emissions**: R_{el} =29*(60h/2)* r_e = 29*(60h/2)*0,10643776 kg CO_2e =92,6 kg CO_2e **Applied Learning Emissions:** (50/50 Microsoft Word & PowerPoint): L_e =29*(60/2)h*(0,014+0,016) kWh /2 * 0,434kg/kWh =5,66kg CO_2e **Total:** T_{eNE}= E_{eNE}+ $C_{eCampus}$ + $N_{eRecording}$ + N_{eZoom} + C_{eStudy} + R_{eG} + N_{eGroup} + S_e + R_{el} + L_e = 340,60 + 8,59 + 99,68 + 36,55 + 68,74 + 61,73 + 199,36 + 3,78 + 92,6 +5,66 = **917,29kg CO_2e**
Marketing – Innovation Management	Total in-class sessions: 6 Duration: 4h Total Zoom Sessions: 3 Duration: 2h Total video recordings: Multiple short ones, overall duration 5h Participants: 162 Selfstudy: 120 h Grading: 100% groupwork	**Lectures**: **On-Campus Energy Consumption Emissions**: E_{eInnoM}= 94,38kWh *6*4h * 0,434kg/kWh= 983,06kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = 162/2*202 kg CO_2e *6*4h /(4*365,25*7h)= 38,4 kg CO_2e **Network Data Transfer Emissions of Recordings:** $N_{eRecording}$=162*0,434kg/kWh*0,64kWh/GB*5Mbps*5*(3600/8000) = 506,22 kg CO_2e N_{eZoom}=162*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*3* (120/60)h *(3600/8000) = 668,21 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=162*202 kgCO_2e*120h /(4*365,25*7)= 383,97kg CO_2e **Groupwork:** 100% - 120h **Research Emissions:** R_{eG}=162*(120h/3)*r_e=162*(120h/3)*0,10643776= 689,72 kg CO_2e **Communication Emissions:** Network Data Transfer (Zoom): N_{eGroup}=162*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*(120h/3) /2 *(3600/8000) = 2.227,35kg CO_2e **Solution Development Emissions:** (50/50 Microsoft Word & PowerPoint) S_e=162*(120h/3)*(0,014+0,016) kWh /2 * 0,434kg/kWh = 42,18 kg CO_2e **Total:** T_{eNE}= E_{eInnoM}+ $C_{eCampus}$ + $N_{eRecording}$ + N_{eZoom} + C_{eStudy} + R_{eG} + N_{eGroup} + S_e + R_{el} + L_e = 983,06 + 506,22 + 668,21 + 383,97 + 689,72 + 2.227,35 + 42,18= **5.500,71 kg CO_2e**

Marketing – Customer Relationship Management	Total in-class sessions: 54:30h, Recordings: none Participants: 28 Grading: 100% Groupwork	**Lectures**: **On-Campus Energy Consumption Emissions**: E_{eInnoM}= 94,38kWh *54,5h* 0,434kg/kWh= 2.232,37 kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = 28/2*202 kg CO_2e *54,5h /(4*365,25*7h)= 15,07 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=28*202 kgCO_2e*120h /(4*365,25*7)= 66,37 kg CO_2e **Groupwork:** 100% - 120h **Research Emissions:** R_{eG}=28*(120h/3)*r_e=28*(120h/3)*0,10643776= 119,21 kg CO_2e **Communication Emissions:** Network Data Transfer (Zoom): N_{eGroup}=128*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*(120h/3) /2 *(3600/8000) = 384,98 kg CO_2e **Solution Development Emissions:** (50/50 Microsoft Word & PowerPoint) S_e=28*(120h/3)*(0,014+0,016) kWh /2 * 0,434kg/kWh = 7,29 kg CO_2e **Total:** T_{eNE}= E_{eInnoM}+ $C_{eCampus}$ + $N_{eRecording}$ + N_{eZoom} + C_{eStudy} + R_{eG} + N_{eGroup} + S_e + R_{el} + L_e = 2.232,37 + 15,07 + 66,37 + 119,21 + 384,98 + 7,29 = **2.825,29 kg CO_2e**
Marketing – Brand Management	Total in-class sessions: 7 Duration: 3h Recordings: none Participants: 40 Selfstudy: 120 h Grading: 100% exam, groupwork required, 40/60 split assumed	**Lectures**: **On-Campus Energy Consumption Emissions**: E_{eInnoM}= 26,16kWh *7*3h* 0,434kg/kWh= 238,42 kg CO_2e **On-Campus Computer Emissions:** $C_{eCampus}$ = 40/2*202 kg CO_2e *7*3h /(4*365,25*7h)= 8,3 kg CO_2e **Selfstudy**: **Computer Emissions:** C_{eStudy}=40*202 kg CO_2e*120h /(4*365,25*7)= 94,81 kg CO_2e **Groupwork:** 40% = 48h **Research Emissions:** R_{eG}=40*(48h/3)*r_e=40*(48h/3)*0,10643776=68,12 kg CO_2e **Communication Emissions:** Network Data Transfer (Zoom): N_{eGroup}=40*0,434 kg/kWh*0,64kWh/GB*5,5Mbps*(48h/3) /2 *(3600/8000) = 219,99 kg CO_2e **Solution Development Emissions:** (Modeling Software with energy usage similar to Word & PPT assumed, thus a 50/50 Microsoft Word & PowerPoint taken) S_e=40*(48h/3)*(0,014+0,016) kWh /2 * 0,434kg/kWh = 4,17kg CO_2e **Individual Work**: 66% = 72h **Research Emissions**: R_{el} =40*(72h/2)* r_e = 40*(72h/2)*0,10643776 kg CO_2e =153,27kg CO_2e **Applied Learning Emissions:** (50/50 Microsoft Word & PowerPoint) L_e =40*(72h/2)*(0,014+0,016) kWh /2 * 0,434kg/kWh = 9,37 kg CO_2e **Total:** T_{eSCML}= E_{eSCML}+ $C_{eCampus}$ + $N_{eRecording}$ + C_{eStudy} + R_{eG} + N_{eGroup} + S_e + R_{el} + L_e = 238,42 + 8,3 + 94,81 + 68,12 + 219,99 + 4,17 + 153,27 + 107,29 + 9,37 = **903,74 kg CO_2e**

Table 10: Climate Footprint Calculations per Module

D.b Underlying Calculations

Leo 18.3 Occupancy and Energy Consumption

Summer Semester: 46hours/week in SuSe 2022 during the lecture time (16 weeks), 2h/week plus 1 block 5x8h (11 weeks) = 46 * 16 + 2*11 + 1* 40 = 798 h
Energy Consumption per hour usage: 20.879 kWh/ 798h = **26,16kWh**

Winter Semester: 54 h /week * 17 weeks (lecture time) + 7*8h (blockseminars on Saturdays) = 974
Energy Consumption per hour usage: 91.923/974= **94,38 kWh**

Self-Study Time Calculations

Software Development

Runtime following Pereira et al. (2021) and using a 50/50 mix of object oriented and scripting languages (Python and Java): 50% java at 198 j per 1.89ms, and python 75.88j per 71.90 runtime = 1,055j/ms = 1,055 kWh/h

Office Products

Following Struharová et al. (n.d.): PowerPoint at 14 watt, Excel at 12.5 Watt, Word at 16 watt = 0,014kwh/h

Research Emissions r_e

15 search queries per hour -> 15*0.2g = 3g CO_2e = 0,002kg CO_2e (Faber, 2021)

- Downloads 1 paper every 2 hours, approx. size of 1MB: File size * Energy intensity*electricity emissions = 0,001GB* 0,64 kWh/GB *0,434 kg/kWh = 0.00064*0,434=0.00027776 kg CO_2e
- Watches 1 YouTube video of average 10 min every hour at 5mbps (Google, n.d.-b, n.d.-a) = 0,434*0,64*5*(1/6)*(3600/8000)= 0.10416 kg CO_2e
- Total: 0,10643776 kg CO_2e

Working Papers, ERCIS

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No. 2 Teubner, R. A.: The IT21 Checkup for IT Fitness: Experiences and Empirical Evidence from 4 Years of Evaluation Practice. March 2005.

No. 3 Teubner, R. A.; Mocker, M.: Strategic Information Planning – Insights from an Action Research Project in the Financial Services Industry. June 2005.

No. 4 Vossen, G.; Hagemann, S.: From Version 1.0 to Version 2.0: A Brief History Of the Web. January 2007.

No. 5 Hagemann, S.; Letz, C.; Vossen, G.: Web Service Discovery – Reality Check 2.0. July 2007.

No. 7 Ciechanowicz, P.; Poldner, M.; Kuchen, H.: The Münster Skeleton Library Muesli – A Comprehensive Overview. January 2009.

No. 8 Hagemann, S.; Vossen, G.: Web-Wide Application Customization: The Case of Mashups. April 2010.

No. 9 Majchrzak, T. A.; Jakubiec, A.; Lablans, M.; Ückert, F.: Evaluating Mobile Ambient Assisted Living Devices and Web 2.0 Technology for a Better Social Integration. January 2011.

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No. 11 Becker, J.; Beverungen, D.; Delfmann, P.; Räckers, M.: Network e-Volution. November 2011.

No. 12 Teubner R.; Pellengahr A.; Mocker M.: The IT Strategy Divide: Professional Practice and Academic Debate. February 2012.

No. 13 Niehaves B.; Köffer S.; Ortbach K.; Katschewitz S.: Towards an IT Consumerization Theory – A Theory and Practice Review. July 2012.

No. 14 Stahl, F.; Schromm, F.; Vossen, G.: Marketplaces for Data: An Initial Survey. July 2012.

No. 15 Becker, J.; Matzner, M. (Eds.): Promoting Business Process Management Excellence in Russia. March 2013.

No. 16 Teubner, R. A.; Pellengahr, A. R.: State of and Perspectives for IS Strategy Research. A Discussion Paper. April 2013.

No. 17 Teubner, A.; Klein, S.: Münster Information Management Framework. 2014

No. 18 Stahl, F.; Schomm, F.; Vossen, G.: The Data Marketplace Survey Revisited. January 2014.

No. 19 Dillon, S.; Vossen, G.: SaaS Cloud Computing in Small and Medium Enterprises: A Comparison between Germany and New Zealand. April 2014.

No. 20 Stahl, F.; Godde, A.; Hagedorn, B.; Köpcke, B.; Rehberger, M.; Vossen, G.: Implementing the WiPo Architecture. June 2014.

No. 21 Pflanzl, N.; Bergener, K.; Stein, A.; Vossen, G.: Information Systems Freshmen Teaching: Case Experience from Day One. September 2014.

No. 22 Teubner, A.; Diederich, S.: Managerial Challenges in IT Programmes: Evidence from Multiple Case Study Research. 2015.

No. 23 Vomfell, L.; Stahl, F.; Schomm, F.; Vossen, G.: A Classification Framework for Data Marketplaces. 2015.

No. 24 Stahl, F.; Schomm, F.; Vomfell, L.; Vossen, G.: Marketplaces for Digital Data: Quo Vadis? 2015.

No. 25 Caballero, R.; von Hof, V.; Montenegro, M.; Kuchen, H.: A Program Transformation for Converting Java Assertions into Control-flow Statements. 2016.

No. 26 Foegen, K.; von Hof, V.; Kuchen, H.: Attributed Grammars for Detecting Spring Configuration Errors. 2015.

No. 27 Lehmann, D.; Fekete, D.; Vossen, G.: Technology Selection for Big Data and Analytical Applications. 2016.

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No. 32 Dageförde, J.; Kuchen, H.: Free Objects in Constraint-logic Object-oriented Programming. 2020

No. 33 Plattfaut, R.; Coners, A.; Becker, J.; Vollenberg, C.; Koch, J.; Godefroid, M.; Halbach-Türscherl, D: Patient Portals in German Hospitals – Status Quo and Quo Vadis. 2020

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No. 37 Lechtenberg, S.; Hellingrath, B.: Applications of Artificial Intelligence in Supply Chain Management: Identification of main Research Fields and greatest Industry Interests. 2021

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