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Contents

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From the Editors-in-Chief

SENSE OF SECURITY IN THE DIGITAL AGE

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Abstract: In this Editorial, we discuss the sense of security that is one of human's basic needs and closely connected to human well-being. The sense of security among technology users is highlighted in turbulent times. Cybersecurity is a tool that technology developers, society and individuals can use to increase their sense of security.

Keywords: *sense of security, cyber security, vulnerability, technology users*

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NAVIGATING HUMAN VULNERABILITIES AND TECHNOLOGICAL TRUST

A sense of security constitutes a fundamental human need and is intimately tied to overall well-being. It encompasses both subjective feelings of safety and objective conditions that ensure protection from harm. Psychologically, it reflects confidence, peace of mind, and freedom from fear, while materially it relates to stable conditions that guarantee the satisfaction of basic needs and the assurance of a secure future. The sense of security is also inherently relational, closely connected to trust – whether in interpersonal relationships, societal institutions, or technological systems. (Murayama et al., 2009.)

Contemporary societies are increasingly marked by multiple, overlapping crises. The term polycrisis captures this convergence, describing how challenges such as climate change, ecological degradation, global conflict, forced migration, and pandemics intersect and exacerbate one another. These crises generate pervasive uncertainty and, in some cases, a dystopian atmosphere that erodes public optimism and trust in the future (Lawrence, 2024; Teixeira, 2024).

FRAGMENTATION OF SECURITY ACROSS GENERATIONS

In human-technology interaction research, the sense of security frequently emerges as a core concern. There is, for example, widespread distrust in social media and tech companies handling personal data, and the lack of control over data reduces trust and increases anxiety. In Finland, empirical studies focusing on different demographic groups illustrate how security perceptions vary. Among older adults, apprehension often centers on a lack of digital competence and fear of making irreversible mistakes – for instance, accidentally losing savings through online banking (Korjonen-Kuusipuro et al., 2020). Despite the availability of supportive technologies such as emergency alert devices and health monitoring systems, many older users feel overwhelmed and alienated by rapid technological changes. This perceived lack of control contributes to a diminished sense of agency and, by extension, a weakened sense of security.

Conversely, younger users are typically more adept at using digital tools but face other security-related challenges. Research highlights that Finnish youth are increasingly concerned about online bullying, digital surveillance, and breaches of personal data, and these concerns clearly affect their agency, ability to act. These issues reflect a societal fragmentation of security, where the boundaries between online and offline threats are blurred. While older adults may underestimate digital risks – believing themselves too "ordinary" to be targeted – young users are often more aware of the implications of digital visibility and take active measures to protect their privacy, sometimes to the extent of withdrawing from social media altogether. (Tuuva-Hongisto & Korjonen-Kuusipuro, 2025.)

THE VASTAAMO CASE: A TURNING POINT IN DIGITAL TRUST

Finland, often regarded as a leader in digital innovation and cybersecurity, was deeply shaken by the 2020 Vastaamo psychotherapy data breach. Hackers obtained and disseminated the personal and highly sensitive therapy records of over 33,000 clients, accompanied by ransom demands and individualized blackmail attempts. The psychological and emotional damage extended far beyond the direct victims to their families and communities, exposing the profound vulnerability of digital infrastructures (Ghanbari & Koskinen, 2024; Looi et al., 2025). The case not only revealed systemic weaknesses but also exemplified how quickly trust in digital systems can collapse.

The Vastaamo case exemplifies the strong ethical tensions that can emerge in digital environments, revealing both the extreme vulnerabilities of individuals and the capacity for collective response. While the incident demonstrated the profound cruelty of malicious cybercrime, it also mobilized an array of actors committed to restoring justice. Cybersecurity professionals, technology companies, and civic-minded individuals contributed to the investigation, assisting law enforcement in identifying and ultimately apprehending the perpetrator. Despite the successful conviction, the long-term psychological impact on victims and the broader erosion of trust in digital systems underscore the enduring consequences of such breaches.

TOWARD A SHARED RESPONSIBILITY

Cybersecurity has emerged as an essential component of digital literacy and responsible digital citizenship. The concept of cyber hygiene – encompassing practices such as using strong passwords, updating software regularly, and securing home networks – serves as a practical guide for individuals. However, emphasizing individual responsibility alone is insufficient.

Cybersecurity must be understood as a collective endeavor involving individuals, technology providers, and governments. Despite increased public awareness, the roles and responsibilities within this triad remain ambiguously defined. Sociologist Norma Möllers (2021) poses critical questions about the intersection of digital infrastructure and national identity: What role does information infrastructure play in national belonging? How can states encourage civic engagement with such complex, often invisible systems? These questions are particularly pressing in an era where personal data is contested by global actors, from Western social media conglomerates to state-sponsored cyber operations.

The human dimension of cybersecurity must not be overlooked. Individuals are not anonymous "users", good or bad digital citizens as Möllers (2021) points out, but unique persons – children, parents, grandparents – each with varying degrees of knowledge, access, and risks. Policy solutions must therefore be inclusive, attuned to the specific vulnerabilities and needs of diverse populations. In this regard, governments carry a primary responsibility not only to protect digital infrastructure but also to engage meaningfully with citizens' lived realities. Whose voices are being heard in the design of secure digital systems? And who is left unheard? Who are silent voluntarily?

CONCLUSION

The Vastaamo incident stands as one of the most significant cybersecurity failures in mental healthcare globally, with severe repercussions for both individual well-being and public trust. It exemplifies the fragility of the sense of security in digital environments and the profound social costs of its breach. As societies become increasingly dependent on digital infrastructures, the challenge is not only technical but also ethical and societal: to build inclusive, resilient systems that recognize and respond to the complex ways in which technology mediates human security.

There is a call for a broader and deeper understanding of the sense of security among technology users. With this we do not refer only to the technological dimensions of cyber security but also to "the human", more profound need of the sense of security. There are people behind the cybersecurity; and it would be interesting to read their personal impressions of sense of security and safety – how the sense of security has influenced their career choice, for example. It is not an easy subject to deal with and some of the more technical security issues are understandably left under the smoke screen. But still, it would be interesting to see more research articles in Human Technology journal dealing with cybersecurity and sense of security in general.

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RADICAL DIGITAL AGENCY AS A FOUNDATION FOR JUST AND SUSTAINABLE SMART CITIES

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Abstract: *The article examines the relationship between smart city development, socio-digital inequality, and digital literacy. Furthermore, we investigate the link between city residents' digital competence and so-called smart citizenship. Through these theoretical explorations, we aim to demonstrate the importance of a more in-depth understanding of digital inequality in the context of people-centric smart cities. We then use examples from our hybrid ethnographic fieldwork in Barcelona to show how these perspectives might manifest in practical applications. Barcelona aspires to be the capital of 'technological humanism' and, in recent years, has implemented a number of digital inclusion initiatives. Based on the theoretical discussion and empirical results, we present a framework that combines the theoretical framing and empirical findings, highlighting the intersecting factors that policymakers and educators must consider when developing just and sustainable smart cities.*

Keywords: *smart city, digital city, digital inequality, digital literacy, digital divide, socio-digital inequalities.*

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INTRODUCTION

During the first decades of the 21st century, the smart city has emerged as a widely accepted model for urban development that has already impacted tens of millions of people. What exactly is a "smart city" depends on where it is located and the social, political, economic, and environmental arrangements there. Nonetheless, the primary idea of a smart city is to optimize different municipal activities using digital technology (Ylipulli & Luusua, 2020). Artificial intelligence (AI) has emerged as a significant technology behind the smart city movement in recent years, generating both excitement and anxiety and giving rise to new utopian and dystopian visions. The introduction of AI perfectly encapsulates the essence of the smart city agenda, which is to take the latest, most talked-about technology and propose it as a solution to the most serious urban concerns.

The smart city agenda has also received much critical attention from urban scholars over the years. (e.g. Cugurullo, 2021). The critical scholarship has provided empirical insights into the lived and experienced realities, as well as analyzed the numerous discourses that shape our understandings and concrete forms and arrangements of future cities (e.g. Cugurullo, 2021; Zaman & Hertweck, 2022). These lines of research frequently highlight how smart city initiatives often emphasize financial benefits but overlook social and environmental issues. However, given the speed at which AI and other sophisticated technologies are developing along with the acceleration of urbanization, it is likely that urbanism will advance in tandem with technology also in the near future. Therefore, our research contributes to an expanding body of work that aims to forge new routes towards the techno-urban future and critically examine topics that have attracted less attention in the context of smart cities (McFarlane & Söderström, 2017; Monachesi, 2020; Vadiati, 2022).

Many authors have acknowledged *digital equality* as a significant social issue and a critical component in the development of fair and sustainable smart cities (Hatuka et al., 2020; Jang & Gim, 2022; Martin et al., 2018). In this context, ‘digital equality’ refers to having equal access to the Internet and technology tools that serve as a user interface for smart city services. We also define it to include a broad range of digital abilities and the advantages that come from using them (E. Helsper, 2021; Lutz, 2019). For instance, Hatuka et al. (2020) contend that issues brought about by digitalization in the context of smart cities include the safety of individuals' private information, the disparity in digital literacy among various social groups, and the absence of equal opportunities and means of influencing significant issues. Accordingly, we are focusing on a multidimensional perspective on smart cities (Nam & Pardo, 2011; Yigitcanlar, 2021) entailing technology, policy, and community. This view requires that city residents are considered an essential actors in a smart city.

In this article, we scrutinize the relationships between smart city research and studies on socio-digital inequality and digital literacy. The conversations on digital equality in smart cities appear to bear some of the same difficulties that plague the complicated terrain of digital inequality and digital literacy studies. Simply put, the layered nature of digital inequality is usually oversimplified when ideas are disseminated across different areas of research, and the focus remains on the most evident features such as access and accessibility. The exact impact also applies to digital literacy. Our objective is not to diminish the significance of accessible technologies, but to highlight the multifaceted character of digital inequality in smart cities, which includes many other, more abstract dimensions.

Thus, the aim of this article is to explore intersections of 1) socio-digital inequality research; 2) digital literacy research; and 3) critical smart city literature, focusing mainly on digital citizenship and digital agency. Crucially, through an interdisciplinary investigation, we seek to illustrate the necessity for a more multi-layered understanding of digital inequality within the smart city agenda. It is essential to prevent overly simplistic approaches that lack depth and fail to conceptualize citizens as individuals with a wide range of rights and freedoms (Cardullo & Kitchin, 2019b). We strengthen our theoretical work with an empirical study conducted at Barcelona, Spain: The intention is to highlight how the deeper dimensions of digital inequality in smart cities – conceptualized through analyzing the three different theoretical bodies of work together – can be supported in practice.

METHODS

For the most part, this article is a theoretical paper bringing together three bodies of research described in image 1. We explore the central currents of digital inequality and digital literacy research, filtered through our background as smart city scholars. Further, we explore how digital competence of smart city residents – or so-called 'smart citizens' – has been framed in research. We complement some of the central, critical understandings of 'smart citizen' with conceptualizations on 'radical digital citizenship'. Finally, we link these discussions back to socio-digital inequalities and digital literacy with the concept of 'radical digital agency'.

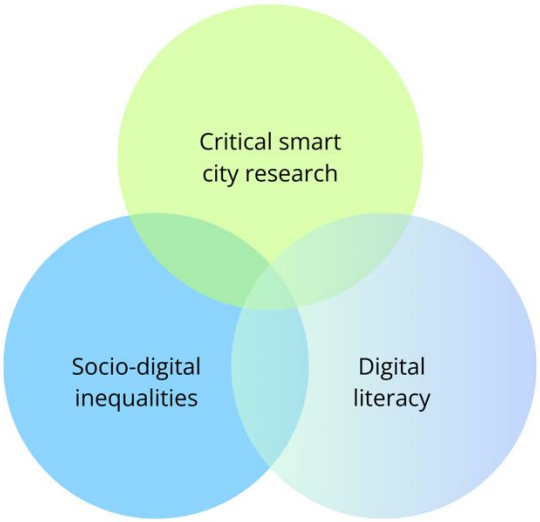

Image 1: The article brings together three bodies of scholarly work.

We combine this theoretical exploration with insights from fieldwork periods conducted in Barcelona, Spain, which focused on investigating how city residents' digital capabilities are supported in the recent policies and practices of this famous 'people-centric' smart city.

The first author of this paper spent 2,5 months in Catalonia in autumn 2022 and conducted brief ethnographic research to understand the general trends of the policies and practices mentioned above. Further, she did a follow-up visit of 1,5 weeks in fall 2023 and arranged several online discussions. Thus, we can consider the fieldwork a *hybrid*: It consisted of off-line and online parts, followed by assembling together notes from in-person interactions and data collected online (Liu, 2022). The fieldwork periods belong to a 5-year research project that scrutinizes relationships between smart city development and digital inequality and explores novel ways to tackle unequal tendencies of techno-urban development.

The goal of the Barcelona-focused research has been to get an overview of relevant public policies and practices by meeting city officials and by visiting different events and public centers. These centers included, for example, *Coboi Lab* (Policy lab) and a center called *Canòdrom* that promotes open technology, digital culture, and democratic participation. The events included the *Smart City Expo and World Congress Barcelona* (x 2) and *Barcelona Conference on Digital Inclusion*. The researcher carried out in-person discussions and meetings with both city officials (n = 6) and with Barcelona-based researchers (agreed individual discussions: n = 4, complemented with a number of informal group discussions). She usually met the key people representing the City several times to establish trust and longer-term collaboration relationships. Two of the individual meetings took the form of a thematic semi-structured interview, and they were recorded and transcribed. Additionally, we gathered key official documents about digital inequality and inclusion.

The visits and online meetings yielded an ample amount of notes and transcriptions that were read alongside official documents and analyzed with thematic content analysis. The aim was to understand the *key concepts* and *central theoretical and practical approaches* that are utilized in Barcelona in conjunction with efforts to enhance digital equality.

We do acknowledge that such an approach to ethnographic fieldwork, entailing short field visits and online follow-ups, has its limitations and does not enable as in-depth understanding as more extended fieldwork would. Nevertheless, we gained interesting insights and perspectives through this type of empirical work; notably, it enables showcasing how some aspects of a people-centric smart city agenda emphasizing radical digital agency can be translated into practical actions. In this paper, we introduce only a couple of specific insights drawn from the empirical study: First, we introduce Barcelona's overall approach to digital inequality, and second, describe one of its practical installations, *Canòdrom*, which intends to act as an interface between the city, technologies, and citizens.

SMART CITY

Urbanization can be considered as one of the current megatrends. According to the UN's 2018 *Revision of World Urbanization Prospects* (Nations, 2018), 2007 marked a significant shift in global population distribution. It was the year when the number of people living in urban regions surpassed those living in rural areas for the first time. Estimates on urban populations differ due to variations in the precise definition of an 'urban area'; however, it is anticipated that by 2050, over two-thirds of the global population will reside in urban areas (Ritchie & Roser, 2018). As urban areas expand and become more complex, also the

challenges they pose for governance, environment, housing, traffic, etc., are likely to grow. Thus, there is a need for new tools, services, and methods to manage urban activities and to meet the needs of the various individuals living in and visiting these cities. The smart city agenda was established in the 1990s as a response to these issues; initially, it was promoted primarily by major technology corporations such as IBM. In the 2020s, several decades after its inception, this model of city-making has gained worldwide popularity and is being increasingly embraced by numerous cities and local administrations (Cugurullo, 2021). The term "smart city" generally refers using information and communication technology (ICT) to enhance the efficiency of urban operations.

The exact meanings of the term may differ, as discussed by Echebarria et al. (2021) and Neirotti et al. (2014) – the definition is highly dependent on the specific context. For example, Albino et al. (2015) argue that variations in local politics and urban development goals and interests lead to significant disparities in the features of smart cities globally. Nevertheless, we may outline general historical trends and identify distinct paths of progress based on the available research: In the early 2000s, the smart city definitions emphasized the simplification of municipal operations and the optimization of infrastructure using digital services, as well as the use of data in decision-making (Hall et al., 2000). By the 2010s, the agenda expanded its scope to encompass policy and community dimensions as well. Echebarria et al. (2021) note that the term was redefined to purposefully dissociate it from the idea of technological determinism commonly associated with smart cities approaches. Nevertheless, they contend that smart cities remain too technocratic, despite this intention to break free from techno-deterministic and techno-solutionist visions.

Many authors have attempted to identify central strands in interpreting the smart city concept. In their comprehensive literature review, Echebarria et al. (2021), for example, identify three primary approaches: The first approach is *techno-centric*, (see also Lee et al., 2014) where smart city infrastructure is built upon digitalization, and development is driven by technology corporations. The second approach is *humanist*, prioritizing the significance of human and social capital. Grassroots actors drive change, based on principles of digital equity, democracy, and local knowledge. The third approach is a *collaborative* one that highlights the connection between city people and the governing body. It aims to foster participatory governance, involving both citizens and companies.

Some scholars present a comparable, yet somewhat distinct perspective, that aligns with the collaborative approach of Echebarria et al. (2021). Yigitcanlar (2021) discusses the drawbacks of the smart city paradigm and argues that these limits are primarily due to the smart city agenda's strong focus on technology. Yigitcanlar's research promotes and applies a *multidimensional perspective on smart cities*, initially developed by Nam and Pardo (2011). This perspective goes beyond the conventional technocratic approach by incorporating technology, policy, and community as interconnected and harmonized factors that ensure sustainable urban futures for everyone. This paradigm utilizes technology to address complexity, policy to reduce uncertainty, and community to facilitate discussions on ambiguity.

These brief definitions are necessarily generalizations; the existing literature on smart cities exhibits a vast range of ideas and opinions derived from many disciplines and research areas, resulting in a multifaceted view. Currently, issues such as privacy, security, socio-digital inequality, and digital citizenship are receiving more attention, as evidenced by the

works of Hintz (2019), Jang and Gim (2022), Martin et al. (2018), and Ylipulli and Luusua (2019). In addition, there is a nascent research line that aims to surpass human-centeredness by investigating approaches to smart cities that recognize the significance of *more-than-human entities*, including animals and nature, and occasionally artificial beings such as robots (e.g. Heitlinger et al., 2024; Luusua et al., 2017; Sheikh et al., 2023; Tomitsch et al., 2021; Yigitcanlar et al., 2019). This strand of research is linked to the promise of ecological sustainability, which is typically included in the smart city agenda. Nevertheless, the existing body of literature on smart cities seems to exhibit a consistent conflict between the technology-focused perspectives and the broader perspectives that aim to tackle cultural, social, and even planetary challenges. According to many researchers, the techno-deterministic and techno-solutionist approach that has influenced the development of smart cities for many years will continue to be present also in the new urban visions revolving around data and artificial intelligence (e.g. Cugurullo, 2021). As a result, it is critical to underline the importance of social and environmental themes in smart urban development to avoid solutionist and fragmented approaches.

Ultimately, there is significant divergence among the various smart city definitions found in the research literature. Significantly, a substantial portion of the literature adopts a *pragmatic viewpoint* and is presented as *non-ideological* (Hatuka et al., 2020; Kitchin, 2015); this increases the appeal to adopt smart city as an approach to tackle the perils of expanding urban areas and worldwide environmental risks, both for policymakers and businesses. Hence, we expect that the proliferation of digitization and digital initiatives will continue thriving in cities worldwide in the foreseeable future.

SOCIO-DIGITAL INEQUALITY AND DIGITAL LITERACY

The concepts of digital inequality and digital literacy are multi-layered and complex, as various individual and societal factors affect and shape them. The majority of research in these fields centers around studying the impact of digital disparities on individuals and society, and analyzing the causes that contribute to these inequalities. Moreover, the fields are examining the methods and instruments that can be employed to diminish these disparities. (Hatuka et al., 2020; Helsper, 2019, 2021). It is also important to note that research on digital inequality and digital literacy are distinct research fields; still, they have also been examined simultaneously, and their focus areas and goals frequently intersect (Helsper & Eynon, 2013).

While traditional forms of social inequality do not specifically relate to digital contexts or smart cities, Robinson et al. (2015) argue that digital inequality is a significant emerging form of inequality. They assert that it has the potential to impact people's lives in various ways. Hence, it is imperative to thoroughly examine the progress of smart city development, which strongly relies on digital technology, by considering the concepts of digital inequalities and digital literacy. In the following, we will introduce some of the main currents of academic conversations around socio-digital inequality and digital literacy and present briefly their central connections with smart cities.

Socio-Digital Inequality

Inequality, which refers to the unjust disparity between various groups of people in society, is a prominent research focus in the social sciences. Traditionally, the social inequalities research has been centered around characteristics such as socioeconomic class, gender, race and ethnicity, age, and education. With the continuous progress and evolution of the information society, new types of inequalities have emerged, collectively known as digital inequality. (Robinson et al., 2015).

Nevertheless, digital inequality is not isolated from other types of inequality. On the contrary, for example, Helsper (2021) argues that digital and social inequalities are frequently interconnected, and disparities that arise in the physical world can easily extend into the digital domain. The relationship between digital technologies and inequalities can also be reciprocal since digital technologies have the potential to expedite and strengthen other types of inequalities, including those connected to age or gender. Therefore Helsper (2021) proposes that to thoroughly investigate the combined effects of social and digital inequalities, it is necessary to recognize them as interconnected and mutually reinforcing disadvantages that align with conventional studies on inequality. The term *socio-digital inequality* describes the overlapping and reciprocal nature of social and digital spheres.

The investigation of digital inequality originates back to the mid-1990s, with the term *digital divide* being coined to delineate the inequalities in computer and Internet access (DiMaggio et al., 2004). After the commodification of computers and digital tools, concerns exclusively pertaining to access lost their significance by the mid-2000s, particularly within Western societies. According to DiMaggio et al. (2004) and Hatuka et al. (2020) the issue of *differentiated use* – which highlights the varying degrees of Internet proficiency and digital literacy – replaced the disparity in physical access to technology.

Today, three levels of digital inequality are often identified in the literature on inequality and digital technology (Helsper, 2019; Lutz, 2019). The first is the previously noted access to technology, which continues to be a problem, particularly for many individuals in precarious socioeconomic situations. The use of digital services becomes difficult without necessary devices or Internet connection. Subtle nuances can also be seen in the first-level digital inequality. For example, there are variations in the *quality of access*, such as whether or not a person has a high-speed connection. Second, having *prospective access* does not guarantee having *access in reality* (Helsper, 2019). For example inadequate skills, individual attitudes, or community norms can prevent the use. Second-level digital inequality is closely linked to digital literacy and usually defined as disparities in ICT competency. According to Helsper, societal elements play a more significant part at this level: Education, gender, and ethnic origin all impact on the disparities in ICT usage and abilities (Helsper, 2019). Finally, the third level of digital inequality is concerned with the advantages, opportunities, and threats that various people face daily. Stated differently, it highlights the positive or unwanted outcomes arising from the preceding two levels, namely access and competences. Positive outcomes include "establishing positive relationships, feeling respected, saving money, finding employment, and having the authority to participate in civic and political life," according to Helsper (2019; see also Van Deursen & Helsper, 2018). Discrimination, cyberbullying, or online hoaxes that cause financial or other issues are examples of adverse outcomes (Helsper & Smahel, 2020).

As briefly highlighted by these examples, socio-digital inequality is a complex and intersectional issue, which renders it a challenging phenomenon to address. Helsper (2019, 2021) has suggested a *location-based approach* as one potential resolution. Rather than focusing on broader digital access, skills, or awareness campaigns, this approach targets particular city districts, local neighborhoods, and social networks. In terms of enhancing technological competence, the significance of social and physical contexts in daily life is likely to be greater than that of society as a whole or at the individual level.

Digital Literacy

Presently, digital literacy is a significant and robust area of study: it typically refers to the digital competencies that allow people to function in a society that is becoming increasingly digital. Prior studies have established a correlation between digital literacy and agency and power. The classic understanding of the *information society* posits that acquiring information is a valuable resource that confers power and enhances productivity (Castells, 1994). This ownership requires access to and proficiency with digital tools and competencies. Digital illiteracy can substantially diminish an individual's agency, defined here as the capacity to act in a sociocultural context.

The last twenty years have seen a significant growth of scholarly debates around digital literacy. As a consequence, there exists a large number of different definitions for digital literacy, and the field has become fragmented and challenging to navigate. The collection of distinct (sub-)literacies required to navigate and engage in the digital society has grown considerably extensive and, at times, perplexing (Ylipulli & Vigren, 2023). Recent studies have addressed, for example, the following types of digital literacy: *coding literacy* (Vee, 2017), *algorithmic literacy* (Cotter & Reisdorf, 2020), *data literacy* (Livingstone et al., 2020) (Pangrazio & Sefton-Green, 2021), and *privacy literacy* (Livingstone et al., 2020), just to mention a few. Marín and Castañeda (2023) profoundly address these complexities and conclude with a somewhat abstract but apt definition: "*DL [digital literacy] emerges as a notion of situated multiple integrated skills and practices (conceptual, attitudinal, procedural, and ethical) that empower people (individuals and groups) to participate and communicate efficiently in society*" (pp. 1093).

Hinrichsen and Coombs (2013) have developed another comprehensive definition of digital literacy through the construction of a model that includes five distinct dimensions. According to this framework, digital skills encompass the following:

1) using: proficiency in utilizing digital tools in a suitable, efficient, and adaptable manner;

2) decoding: understanding of media content, structures, and conventions across various platforms;

3) meaning-making: the ability to derive meaning from digital media;

4) analyzing: the capacity to analyze and make informed judgments and choices in digital domains while taking into account ethical considerations; and

5) persona: the awareness of one's personal reputation, identity work, and online persona, as well as the capacity to actively participate and engage in online communities.

Research does not consistently investigate all of these components. For instance, Helsper (2015) observes that most of studies investigating inequalities in digital literacy mainly concentrate on technical and information-seeking abilities. It is imperative to acknowledge that at a meta-level, the literature on digital literacy frequently emphasizes two separate sets of abilities: 1) technical, functional, and/or design skills and 2) broader theoretical skills that facilitate the critique and evaluation of digital settings. A certain degree of disconnection has existed between these two aspects of digital literacy. According to Pangrazio (2016), this binary opposition has resulted in the fragmentation of critical digital literacy along theoretical lines, which ultimately hinders the framework's ability to effectively cater to the demands of its intended audience, namely the individuals living in increasingly digitalizing societies.

Furthermore, when digital literacy is applied to practice, there is a problematic tendency to lose the critical dimension, as noted by Pangrazio (2016) and more recently by Ylipulli and Vigren (2023). Put in another way, school-based digital literacy initiatives, for instance, seem to focus primarily on technical abilities such as coding. They do not seem to offer tools for challenging current digitalization trends, or for imagining alternatives (see also Williamson, 2015). To phrase our claim a little differently, we can argue that many practical initiatives to improve people's digital literacy emphasize adaptability rather than resistance or change-making abilities. Functional skills do act as an essential condition for engaging in civic life and can also be viewed as a means of gaining greater understanding and wider knowledge of technology. However, we argue that critical thinking skills must be considered a highly significant facet of digital literacy in democratic societies.

Factors Contributing to Digital Inequalities and Digital Literacy in Smart Cities

In the following, we briefly present more detailed examples from past research to show how socioeconomic and sociocultural factors affect digital abilities. The presentation is not exhaustive, but it highlights some of the main causes of digital inequalities that should be considered in techno-urban development. Thus, we claim that the following variables and their interconnections must be addressed in just and socially sustainable smart city development.

Socioeconomic status (SES) can be seen as one of the primary determinants of social inequality. SES is a debated concept that generally refers to the measurement of a person's economic and social standing. It is determined by factors such as work experience, financial resources, and social position in comparison to others. (Baker, 2014). For example, Madden and Rainie (2003) found a correlation between higher household income and the use of the Internet as an informative and work tool, while those with lower income were more likely to focus on entertainment. Further, Peter and Valkenburg (2006)) found that socioeconomic status affects teenage Internet abilities and use. Their findings support Madden's and Rainie’s (2003) observation that lower-class adolescents utilized the Internet for fun and had inferior Internet skills. In general, these findings suggest that digital inequality studies should focus on usage rather than access to the Internet and tools. Digital skills and technology use are influenced by socioeconomic factors like material/non-material wealth, hence digital inequalities generally reflect social inequality inequality (see e.g. Van Dijk, 2005).

One of the leading causes of socio-digital inequality is **educational inequality**, which is largely linked to digital literacy. Deursen and Dijk (2014) found that low-educated Dutch

Internet users spend more time online than higher-status users, yet the latter group uses the Internet more productively. According to Robinson et al. (2015) those with access to higher education and better online skills are more likely to find work and earn more. They (ibid.) add that digital competencies are increasingly vital in job searches. As the economy uses more Internet-based intermediaries and job-searching sites such as LinkedIn, professionals who perform better on these platforms certainly have an advantage in the job market. These findings support SES and digital inequality studies: higher education is associated with more complicated Internet use, which boosts productivity and personal advantages gains (Van Deursen et al., 2011; Van Deursen & Van Dijk, 2009). Overall, the research on digital inequality and education contradicts two common beliefs: first, that time will solve digital skills problems as more people are born 'digital natives'; second, that Internet skills are learned through trial and error experimentation. It can be concluded that these assumptions may apply for operational skills but not for advanced information and strategy abilities, which may require formal education (Hatuka et al., 2020; Van Deursen et al., 2011). Those with access to formal schooling or higher ICT education have a major advantage over those without (Robinson et al., 2015).

Another factor closely linked to inequality and affecting ICT use is **age**. Here we can also find commonly held beliefs on superior capabilities of the younger generations that have been born during the 'digital age'. Lack of digital literacy may, indeed, result in some elderly individuals experiencing a decline in their autonomy and requiring assistance in managing their daily tasks (e.g. Hänninen et al., 2021). Nevertheless, it is essential to acknowledge that the older population should not be regarded as a uniform entity. Their proficiency in digital skills demonstrates considerable variation, influenced by several other variables, as evidenced by the empirical study conducted by Ylipulli and Suopajärvi (2013) within a smart city setting. Motivation, needs, and social context affect technology use as well as skills and digital literacy. Hatuka et al. (2020) emphasize that use and non-use should also be understood as a choice, so older people who refuse to use digital technology or use it only for specific purposes can be understood as having a strong agency, not weak skills. Further, although digital literacy research shows that young people have better functional Internet skills than older people, van Deursen et al. (2011) found that older generations perform better in content-related skills, i.e., they can work and navigate strategically online. Thus, the conventional idea that the digital gap will shrink when the older population retires is false, as ICT competencies might vary in surprising and complex ways between generations.

Robinson et al. (2015) note that while internet access has narrowed between genders in industrialized nations, **gender inequalities** in online behavior still exist. Women use the Internet less often (Wasserman & Richmond-Abbott, 2005), participate less intensely (Hargittai, 2010), and have a narrower range in their online activities (Haight et al., 2014). Robinson et al. (2015) offer three gender-related observations: first, our online activity reflects our societal roles, interests, and expectations. Second, women underestimate their internet capabilities more than men, which may alter research outcomes. Third, males outweigh women in IT development and design, which may affect what kind of services specialists build. *Smart mobility*, a smart city research and development field, illustrates the last point. In urban areas, smart mobility may improve access, safety, convenience, and comfort, however, Singh (2020) claims that women's mobility patterns and travel demands have gotten little attention, despite being considerably different from men's. Her findings

suggest that some smart mobility solutions are widening the gender gap in cities and that only women who travel like most men, can benefit from those services, as they are primarily developed for those who move "*for commuting purposes, have full-time employment with good income, and are moving without children or elderly in tow*" (Singh, 2020).

In a similar vein, studies have demonstrated that Internet proficiency and utilization can be influenced by **ethnic origin** (Mesch & Talmud, 2011). Primarily since digitalization exacerbates pre-existing privileges and amplifies conventional inequalities, ethnic minorities may experience digital disadvantages. In addition to linguistic and cultural obstacles, immigrants may encounter difficulties when attempting to access digitalized public services (Chen et al., 2020). The conventional axes of inequality comprise an intricate spectrum where various factors intersect and have the potential to either magnify or diminish one another. According to Helsper (2021), digital inequalities can be delineated on this intricate landscape. Smart city strategies must not only entail or engage with initiatives designed to improve digital literacy, but also the underlying socioeconomic and sociocultural inequalities need to be addressed.

The last factor we briefly highlight consists of **birthplace and residency**; they affect socioeconomic status and therefore, also ICT use (Arroyo-Menéndez et al., 2022). However, digital inequality research seldom considers geographical aspects and usually prioritizes the person over the local and spatial living environment (Helsper, 2019). Geographical inequalities need additional investigation because digital gaps can exist, for example, between a country's center and periphery and between nearby cities. In addition, there can be significant differences *within a city*: In locations of smart city development, housing often becomes expensive, making these districts exclusive; thus, only the wealthy get to use smart city amenities. Rather than just poor digital skills or infrastructure, geographic inequality is caused by complex socio-spatial actions influenced by political, cultural, and economic factors (Crang et al., 2006). Some researchers (Fernandez et al., 2018; Hatuka & Zur, 2020) have suggested examining the unequal geography of digital technologies in a city and how it may affect social exclusion. The interconnectedness and pervasive integration of ICTs and their diverse applications in daily routines must be considered when analyzing the results from a smart city service perspective and how they affect city residents' mobility, daily tasks, sense of belonging, social cohesion, and quality of life. Therefore, the way individuals utilize digital technologies is influenced not only by socioeconomic status, education, age, gender, and ethnicity but also by their geographic location and how they engage with their immediate environment, various communities, and other pertinent local networks (Silva & Frith, 2012).

TOWARDS 'RADICAL SMART CITIZENSHIP'

The current smart city research clearly recognizes digital inequality or digital divide as a challenge (Martin et al., 2018). For example, Jang & Gim (2022) aptly note that those who benefit from digital innovation in smart cities tend to be affluent, highly skilled, and well-educated; on the contrary, there exists a growing number of people who are in weaker socioeconomic position, and whose basic needs and position in regards to technologies are ignored. The authors (Jang & Gim, 2022) summarize that "*Digital access and digital literacy directly affect levels of knowledge, income, and even democratic rights in smart cities, as*

public service delivery and participation in decision-making are undergoing digital transformations across the board." Based on the points above, one may contend that the smart city agenda has the potential to perpetuate several pre-existing inequalities while also generating new ones. Hence, the advancement of smart cities may contradict the concept of a just city (Rosol et al., 2019). This phenomenon may occur if the smart city innovations focus only on the more privileged rather than addressing all city residents (Shamsuddin & Srinivasan, 2021). Below we first look at how discussions on "smart citizens" and "digital agency" could help us understand digital inequality in smart cities in a more complete and critical way. Then, we look at our real-life example, Barcelona, in light of these theoretical discussions.

Conceptualizations of Smart Citizens and Their Digital Skills

We can identify a few research tracks that address the issue of the digital divide in smart cities. One perspective emphasizes the significance of residents' digital proficiency since only those with a strong understanding of technology can adapt to the rapid changes brought about by urban digitalization. Curiously, there is a similar disparity in arguments over digital literacy, particularly in efforts to promote digital literacy education: The focus is primarily on technical and functional abilities, while critical thinking skills are neglected. For example, Ahad et al. (Ahad et al., 2020) recognize digital divide as one of the central socio-economic challenges in smart city ecosystem, and they underline the significance of functional skills: "*The mindset of the inhabitants plays a very crucial role in realization of a smart city ecosystem. If the people are not ready to accept the digital changes around them, we cannot think of having a smart city in a true sense. For its successful implementation, the users must accept the changes and use the services for their benefits*." This framing of residents' digital skills is connected to *techno-centric* smart city approach, presented in the smart city section (Echebarria et al., 2021).

In addition to this perspective emphasizing the need to address digital inequalities to enable citizens to accept and live with the digital transformation (Williamson, 2015), there exists a strand of smart city research intending to conceptualize 'smart citizen' in an alternative, critical way. This view on smart citizens is more in line with the *humanist* and *collaborative* approaches to smart cities, and it also resonates with the notion that people's critical thinking skills concerning technology should be supported. As an example of this strand, Cardullo & Kitchin (2019a) examine the role of smart citizens by examining their participation. Based on their findings, individuals are provided with many opportunities to engage in smart cities, which might have positive effects on participatory democracy. However, the issue lies in the post-political interpretation of these activities: This implies that people are asked to contribute, negotiate, actively participate, and perhaps even create something – but only to solve practical problems. For example, they can be requested to contribute to the creation of an application or provide input on an urban development plan. However, citizens are not compelled to challenge or resist prevailing social and political conventions but rather to conform to pre-established frameworks. According to Cardullo & Kitchin (2019a), in the smart city, most of inhabitants are "empowered" by technologies that view them as customers or testers. They are treated as individuals who can be guided, controlled, and encouraged to behave in specific ways or as data sources that can be

transformed into goods. Similar arguments have been presented in other studies as well, for example in the works of Williamson (2015) and Vanolo (2014).

Further, Cardullo & Kitchin (2019b) have outlined the necessary modifications to move away from the restrictive role that residents are often assigned in most of smart city programs. They argue for the shift away from "*neoliberal conceptions of citizenship, in which people act as consumers or users within a marketplace of services, and beyond initiatives created through stewardship and civic paternalism (in which elites decide what is best for all).*" Currently, smart city programmes are built mainly to serve the state and the market; instead, they would need to be reoriented to focus on the needs and interests of the people inhabiting the cities. The framing of the citizens' position should be designed to empower them as collaborators, co-producers, creators, and leaders, but also allow them to express resistance. This type of transition necessitates the establishment of human rights as a fundamental basis for smart city development, with a particular emphasis on issues such as democracy and social justice. According to Cardullo & Kitchin (2019b) also the role of public assets would need to be reconsidered, and they "*would form commons to be protected and leveraged for the common good"*.

This alternative form of urban governance can be understood as drawing from Henri Lefebvre's (1996) popular 'right to the city' idea, taking us beyond the non-political, predefined boundaries of participation. 'Right to the city' has been a theoretical starting point for many scholars addressing smart citizens. For example, Anastasiu (2019) explores how the 'right to the city' perspective might facilitate the analysis of the participatory city-making notion. Significantly, Anastasiu (ibid.) highlights that Lefebvre's ideas extend beyond the mere right to access the smart city, information, data, and the right to utilize services or technology. Instead, 'right to the smart city' encompasses the right to actively produce, oversee, and possess all of these elements as a means of political and economic empowerment, primarily aimed at promoting the collective welfare and enhancing social connections.

This brief recap of studies emphasizing the necessity of comprehending the role of smart city residents in a more complete manner and the significance of strengthening citizen involvement and empowering people brings us back to the issues of digital inequality and digital literacy. For instance, Anastasiu (2019) acknowledges the importance of 'media literacy' as a requirement for participating in smart cities, but does not provide any details as her primary emphasis is on other aspects. The significance of digital skills, encompassing technical and functional competencies, is evident for 'smart citizens.' However, to effectively contribute to the development of people-centric smart cities, it is imperative to possess a comprehensive understanding and awareness of the societal, economic, and ecological impacts of technologies. Without a sufficient level of profound comprehension – which will be expanded upon in the subsequent section – it becomes very difficult to grasp the mechanisms that underpin our routine behaviours, such as those associated with the data economy or the use of AI-powered services. Lacking the understanding of how our social media updates and clicks are transformed into large amounts of data and monetized (Zuboff, 2019), or the ability to critically evaluate the limitations of AI and the ethicality of its practices[1], it becomes challenging for citizens to engage as a political entity and actively

[1] https://time.com/6247678/openai-chatgpt-kenya-workers/

participate in society. Hence, one may posit that a comprehensive understanding of technology, encompassing the social, cultural, political, environmental, and economic aspects of digitalization, emerges as an essential requirement for gaining any kind of power and control. This form of digital literacy surpasses most of the current definitions of the term. According to Emejulu & McGregor (2019, 131), the education surrounding digital citizenship suppresses some issues and parts of the concept that are connected to the exploitative character of digital spheres, in addition to failing to center critical understanding of the digital. As the authors point out, many mainstream approaches concentrate on teaching students about cutting-edge technology and how to use it effectively rather than examining political dimensions of digitalization, like "who has power" (Ibid, 2019, p. 133) and the ways in which this power is expressed. In the following section, we deepen our exploration of smart citizenship by exploring the concept of radical digital agency.

Radical Digital Agency

- *Radical digital citizenship*, as presented by Emejulu & McGregor (2019), consists of both being able to critically analyze digital technologies and their sociopolitical, environmental, and economic effect, as well as participating in collective action and imagining alternative views for technological developments. The authors (ibid.) contend that digital citizenship needs to be viewed in the context of broader discussions about social justice, bringing an alternative perspective to discussions focusing on issues such as the distribution of wealth, representation, and democratic engagement. This type of digital citizenship is radical in the sense that it challenges the very foundations of digital development. In this context, we can challenge the individualistic, skills-focused and technocentric views on digital society through community and collective digital agency. Choi & Cristol (2021, 366) argue that radical digital citizenship requires reconsidering “previously unchallengeable institutional power structures and systemic oppressions” and acting based on intersectional and inclusionary participation in democracy, primarily focusing on elevating marginalized voices. As a result, digital participation should be examined not only in terms of practical and limiting socio-digital inequalities, but also in terms of the power struggles that residents encounter when contributing to a digitalized society.
- In the light of these conceptualizations, we can investigate the possibilities of *radical digital agency* as a competence to act with digital technologies and/or within digital realms, subjected to critical understandings of digital power struggles and alternative visions for the future (Emejulu & McGregor, 2019; Passey et al., 2018). In general, *agency* can be defined as the socio-culturally defined ability to influence one's surroundings and circumstances (Pangrazio & Sefton-Green, 2021, 22). In the digital environment, the concept of agency expands into the individual's capacity to perceive societal and digital structures and their role within them, safeguarding themselves from harm and recognizing opportunities to act towards meaningful change in these environments, as discussed by Pangrazio and Sefton Green (2021) and Hintz et al. (2017). The ability to act in one's own best interests, as well as an understanding of digital power systems, are thus critical components of digital agency. The agency is a

prerequisite for the conscious and autonomous use of digital media, online civic engagement, and understanding of one's digital rights (Pangrazio & Sefton-Green, 2021).

- Radical digital agency questions the notion of agency being directly linked to digital skills or even digital literacy. Agency can take many different forms, sometimes contradictory, such as refusing to adopt new technologies or participate in digital societies entirely. According to Ylipulli and Vigren (2023), critical analysis of digitally transformed societies and their futures does not require high-level technical proficiency. Resistance and critical reflection should not be restricted to any demographic. Based on arguments of Emejulu and McGregor (2019) and Ylipulli and Vigren (2023), digital citizenship should be built through agency, which not only raises awareness but creates space for resistance, collective action, and possibilities for alternative visions about digital futures. These radical forms of digital agency are critical when discussing digital or smart citizenship, and potential paths to them should be investigated in greater depth.
- Emejulu and McGregor (2019) present a two-fold approach to fostering radical digital citizenship: first, they stress the need to raise awareness and resistance to narratives that portray technology as a neutral societal factor, and second, supplement understanding with collective action, such as independent platforms, grassroot organizing, and mobilization outside of the corporate and neoliberal spheres. Additionally, Emejulu and McGregor (Ibid., p. 143) argue for carving space for citizen-centerd future imaginaries of smart and digital citizenship.
- Incorporating such a vision for building digital citizenship is challenging in the smart city context. As argued by Cardullo and Kitchin (2019a, 825), smart city initiatives are rarely built to increase citizens' digital agency and instead prioritize private interest over citizen perspectives (see Hollands, 2008; Jirón et al., 2021; Zaman and Hertweck, 2022). Following Hintz et al. (2017, 735), digital citizenship should be approached by providing citizens with the tools to exercise self-determination in datafied environments. This could be accomplished by establishing secure infrastructures and regulations, increasing public awareness and discourse about digital citizenship, and facilitating the responsible use of relevant digital platforms and technologies.

Barcelona’s Approach to Smart Cities

This part aims to enhance the core findings of the theoretical part by incorporating insights from praxis. We have drawn the insights below from short-term and hybrid fieldwork conducted in Barcelona, Spain, between 2022–2023. Several scholars, including Cardullo & Kitchin mentioned above, point to Barcelona as an example of a city that has made recent efforts to develop and implement policies that are consistent with the fundamental ideas of a people-centric smart city. Barcelona has been dubbed a 'rebel city' by international media, and its approach has been described as 'radical municipalism', which refers to efforts to build cities from the ground up by 'radically' increasing citizens' power (Rushton, Steve, 2019). This is done, for example, by emphasizing the role of civic movements, social innovation,

and also repurposing digital platform technologies (Aragón et al., 2017; Charnock et al., 2021). The roots of Barcelona's reputation for being an example of global urbanism can be traced back to the 1990s and are out of the scope of this article; however, it is important to note that during the 2000s, the city successfully branded itself as the 'world's leading smart city' (Charnock et al., 2021). In general, this development was initially based on a more techno-centric approach to smart cities, as discussed earlier in this article (e.g. Echebarria et al., 2021).

The smart city vision was steered towards a new direction with political shifts in 2015, during a period when a left-wing, green, social movement coalition governed the city; however, as Charnock et al., (2021) write, the smart city ecosystem of Barcelona has been 'polyphonic' for a long time, and the change is not necessarily as radical as presented in public. Overall, we should not take the current development at face value; we still need to ask, for example "-- *whether they awaken among citizens a sense of their own productive and political subjectivity that runs counter to the reproduction of entrepreneurial, docile and ambividual conceptions of citizenship*" (Charnock et al., 2021, 585). Following these lines of thought, we do not wish to present that Barcelona's approach would be ideal and without any contradictions and pitfalls; however, when analyzed in the light of the presented literature on socio-digital inequalities and digital literacy, we do see a lot of exiting actions and practical initiatives bearing potential for change. The effect of these developments on citizens is another question for which we cannot (yet) offer any answer.

When conducting fieldwork in Barcelona and attending various events hosted by a variety of smart city actors, it became clear that smart city means different things to different stakeholders, and its consequences are interpreted differently. The perspectives presented below focus on the strand of Barcelona's smart city policies and practices that aim to emphasize *digital inclusion* as the core of smart cities. In discussions with various actors, ranging from Barcelona-based smart city scholars to city officials, it was repeatedly stated that the covid-19 pandemic had painfully brought digital inequality to light – for example, some children did not have access to digital environments to study at home during the pandemic restrictions. This awareness is seasoned with a particular urban culture, emphasizing the importance of participation, equality, activism, and even anarchism (Juris, 2010).

When it comes to broader philosophies behind Barcelona's current approach to digital inclusion in smart cities, we can find at least two frameworks, namely *technological humanism* and *digital rights*. Technological humanism is a thinking paradigm recently surfaced in Spanish political debates. Its roots lie in the Spanish philosophy of technology, and it has gained greater popularity than the concept of *digital humanism*, which is frequently employed in English-speaking nations. Its utilization has witnessed a surge among policy documents and media outlets nationwide. Furthermore, the City of Barcelona has declared that it aspires to transform itself into the capital of technological humanism[2] – an approach defined as follows in a document by the City Council: "*A model of technological development centerd on the human being, that reduces social inequalities and protects human rights, and in which technology is at the service of people and the general interests*." (Digital Future Society, 2022). In contrast, *digital rights* primarily pertain to the rights-

[2] https://citiesfordigitalrights.org/city/barcelona

oriented methodology that Barcelona plans to implement to advance its techno-urban environment. The *Manifesto in Favor for Technological Sovereignty and Digital Rights for Cities*[3] defines these rights as follows: "*Citizens' digital rights include the rights of privacy, security, information self-determination and neutrality, giving citizens a choice about what happens to their digital identity, who uses their data online, and for which purposes. Digital democracy enables more citizen participation in design and governance of cities and city services."* Furthermore, the post-2015 'rebel' urbanism is built on top of other broad conceptualizations too, such as *technological sovereignty*, which plays a role in some of the digital inclusion initiatives as well; *technological sovereignty* pertains to the reestablishment of authority over data and information produced by digital technologies, while advocating for the establishment of public digital infrastructures founded upon free and open source software, open standards, and open formats (Bria, 2017).

We find it very interesting that in Barcelona, and throughout Spain, such frameworks have become popular in non-academic, political, and popular contexts. However, the more important question for this article is how they are perceived in relation to citizens and translated into action. During the on-site phase of the fieldwork, the first author of this article attended *Barcelona Conference for Digital Inclusion; Bridging Gaps for a Just Digital Transition* (1st of December 2022). At this conference, high-level city officials from Barcelona but also from several collaborating European Cities, such as Amsterdam, discussed the challenges of digital inclusion. Overall, the discourse focused on *digital access* and *skills*, which were widely assumed to be interconnected. On a few occasions, access was viewed as consisting of two layers: personal devices and public infrastructure such as high-speed Internet access. Furthermore, in a few talks, it was emphasized how digital gaps are inextricably linked to other inequalities; in Catalonia, the most important ones were argued to be economic inequalities, gender disparities, and language barriers (it was noted that there should be a possibility to use digital services and platforms in Catalan).

During this event – and on several other occasions – numerous practical actions and initiatives surfaced, demonstrating the steps Barcelona has taken towards integrating digital rights in the city's decision-making. These approaches include measuring the digital divide regularly (BIT Habitat, 2021). Further, the City has built different kinds of initiatives to enhance citizens' digital competencies: Barcelona Digital City webpages list '46 citizen initiatives for defending digital rights' [i]. For example, the city has an *ICT Agents* program[4] which offers digital assistance for people who need advise in their everyday lives. A training center called *Cibernàrium,* established already for over 20 years ago, provides training to improve technological comptetence of the people, covering everyday skills and professional digital skills (Cibernàrium team, 2020). *Antenes Cibernàrium* program extends the technology training to a larger geographic area, mainly to Barcelona's municipal libraries. Further, there is a pilot project in the city to ensure free and safe access to digital technology for all public primary and secondary schools, carried out in collaboration with Xnet and the Barcelona Education Consortium.

[3] https://www.barcelona.cat/digitalstandards/manifesto/0.2/
[4] https://bithabitat.barcelona/es/proyectos/agents-tic-2/

Canòdrom as a Nest for Radical Digital Agency?

We focus here in more detail on one of the digital rights initiatives, a center called *Canòdrom*[5]. Aims of the center reflect the comprehensive conceptualization of digital literacy and an approach towards radical digital agency that we believe are prerequisites for 'smart citizenship' as defined in the previous sections. In other words, we can see Canòdrom as an example of how these rather abstract ideas could be transformed into an actionable initiative. Since 2020, a former greyhound stadium in Sant Andreu (a low-middle income district) has housed a center that acts as a link between the neighborhood and the city, promoting Barcelona's digital inclusion agenda at the grassroots level. While the center provides workspaces for visiting researchers and the *Decidim* team, who manage Barcelona's famous citizen participation platform, one of its primary objectives is to engage and benefit the public. We connected with the center's managers online and have visited the center four times in total to get a sense of their approach and concrete activities. In addition to several more informal discussions, we interviewed one of the management team members.

Firstly, it is essential to acknowledge that Canòdrom does not solely focus on offering digital training. The center's managers are actively striving to develop a genuine connection with the residents and to involve them in their activities; they stated that this was quite hard at first. All the activities do not revolve around technology; the local community uses the facility for a variety of purposes, including hosting community meetings. When we last visited the center in autumn 2023, the building's terrace was open to everyone in the afternoons and evenings, and games were available to children, young people, and families, which had proven to be a popular activity. The interviewed management team member emphasized that by building connections with the inhabitants of the neighbourhood and acquainting them with the premises, they have taken steps towards a governance framework that would empower the locals to engage in the administration of the space. According to the respondent, the concept of space is perceived as a commons, aligning with the theoretical discussions surrounding the citizens' 'right to the city' (Lefebvre, 1996). However, digital technology is a crucial component in Canòdrom's agenda. Our interviewee explained that "*The space is primarily devoted and focused on offering a place where we can reflect on and delve into technology with a more humanistic approach."* This approach does not just cover problems and challenges, but it also addresses opportunities new technologies bring along.

The facility has provided a diverse range of events tailored to the needs of different urban residents, encompassing workshops, seminars, exhibitions, music performances, book presentations, festivals, and open-air cinema screenings. With the primary objective of the center being to lower the treshold to participate in debates about technology and democracy, the various events focus thematically around digital culture, open-source technology, digital rights, and democratic engagement. In addition, the center provides courses for people who want to enhance their digital skills, and the level of courses ranges from fundamental skills to more advanced ones. Their goal is not only to encourage people to use technology, but also to foster a healthy relationship with digital technologies, as they offer 'digital detox' sessions.

To provide some more specific examples of their activities, we briefly describe two events for very different target groups: During our previous visit, Canòdrom had an ongoing

[5] https://canodrom.barcelona/en/el-canodrom

campaign to collect local memories from when the center was still a greyhound stadium, in the form of photographs. They had about 12 people, all older adults and mostly women, who helped collect historical images and discuss their memories before beginning to digitalize the pictures. The idea was that this activity would teach participants how to use technology to digitalize images, which would be empowering for them. The second example comes from a lecture and workshop on artificial intelligence that we attended in autumn 2023.The event's presenters were from a collective called *Taller Estampa*, which is a group of artists and technologists. They create creative installations revealing how AI works and reflecting its working mechanisms critically. This event had around 12 adult participants. The presentation described AI's history and how it works; notably, they framed the technology as "Not a futuristic technology but a product of sociohistoric processes." The latter part of the event consisted of testing some of the interactive artworks of the collective.

Crucially, Canòdrom stands out from other centers and projects that provide digital training by utilizing open-source technologies for all operations, including programs that teach fundamental digital skills like email usage. The objective is to enhance knowledge regarding alternative tools instead of utilizing common services, platforms and applications provided by major technology corporations. Our interviewee stated that alongside classes or sessions that emphasize fundamental abilities, they also offer additional courses that enhance and elaborate on the critical perspective: "*When you come here to learn about a certain tool, there is no such talk initially; there is just the introduction of the tool. However, in parallel to that, if people wonder why we offer these kinds of tools instead of Google or Microsoft or others, there are certain courses that expand on this critical point of view. There are people who just come here to learn how to use digital tools or software. This is the entry-level. And in this group of people some want to learn more about the alternatives*."

This approach is linked not only to technological humanism and digital rights, but also to digital sovereignty; the goal is to expose the central mechanisms of data capitalism, which operate by collecting, tracking, and analyzing personal data without people's consent. Further, through its different activities, Canòdrom wishes to resist black box algorithms, reproduction of discrimination and inequality, social media bubbles, hate discourses, information manipulation and other threats to democratic societies that powerful technology companies have introduced us.

Canòdrom is a unique physical space, intending to offer a low-threshold forum for techno-political debates. The initiative's main objective is to enhance the agency of urban residents and emphasize the potential of everyday decisions in shaping alternative technology trajectories. The employed approach considers a whole spectrum of digital interests and competencies, starting from learning the basic skills and singular tasks such as digitalizing photographs, extending towards studying emerging technologies' social, political, and environmental impacts through artistic experiments. Furthermore, it is important to note that the center is located in a typical community in which a large proportion of the residents are elderly or economically disadvantaged. This approach aligns with Helsper's (2019) suggestion to prioritize the *meso-social* level when aiming to tackle digital inequalities. In essence, it is imperative to recognize communities and pre-existing networks as pivotal focal points for endeavours aimed at enhancing individuals' digital proficiency. The approach of Canòdrom also resonates with Emejulu's and McGregor's (2019) two-fold approach to fostering radical digital citizenship: they highlight the importance of first creating awareness

and resistance to the narratives of technology as a neutral societal factor, and secondly, they suggest enhancing this awareness by incorporating collaborative efforts, such as autonomous platforms, grassroots mobilization, and organizing beyond the realm of corporate and neoliberal influence.

Despite beautifully embodying some of the central facets of our explorations on digital inequality and radical digital agency as a prerequisite for smart citizenship, the approach and example set by Canòdrom has its challenges. For example, the scale of its activities is quite small, focusing on the quality and depth of the interactions rather than intending to reach large segments of the city inhabitants. To raise awareness, each neighborhood would require its own canòdrom. Creating change through this type of effort is likely to take a long time, and the center's existence is dependent on who governs the city. Furthermore, assessing the impact of such an initiative can be difficult, and the managers did not have a clear answer for how to evaluate the change they may cause. This issue is related to the previous one: without a proven effect, it can be difficult to justify funding these types of projects, particularly for governments that do not share the same values.

DISCUSSION AND CONCLUSIONS

We begin by presenting key findings from the study on socio-digital inequalities and digital literacy, followed by a discussion of how these concepts should be considered when developing citizen-centric smart cities and improving critical smart citizenship.

Through our theoretical exploration, we noted the layered nature of digital inequality and digital literacy; both consist of intersecting factors that can reinforce or diminish the effect of other factors. Furthermore, traditional axes of inequalities are superimposed on digital inequalities, and they have a strong impact on how digital disparencies manifest themselves in society. Moreover, it seems that research on socio-digital inequalities and research on digital literacy form two separate research traditions; however, when dealing with the effects of broad and complex agendas accelerating digital transformation such as smart cities, we should be able to consider issues connected to both areas simultaneously. We also noticed that, while several scholars have emphasized the importance of critical thinking skills in digital literacy frameworks, the majority of the research focuses on technical or functional skills. This tendency is reinforced when digital literacy implemented and taught at schools, for example: the educational programs easily overemphasize the role of technical skills. Following the arguments of Toscano (2011) and Ylipulli & Vigren (2023), we claim that digital literacy should include the dimension of *technological understanding*, which highlights societal, cultural, political, environmental, and economic dimensions of digitalization, and includes the *ability to imagine other kinds of futures.* We believe that these skills, particularly in the context of smart cities, are critical to ensuring democratic urban development. We have collected and combined the central findings from this part of the inquiry into the image 2. The model follows, to some extend, the conceptual framework by Helsper & Eynon (2013) which analyzes connections between digital inclusion and digital skills. Our model differs from their framework (ibid.) because we intend to display the interaction between different socioeconomic and sociocultural factors and digital skills with a vocabulary and in a format that would assist in aligning these insights with the body of work

concerning critical smart citizenship. We also wanted to create a representation that would enable applying the model in practical initiatives.

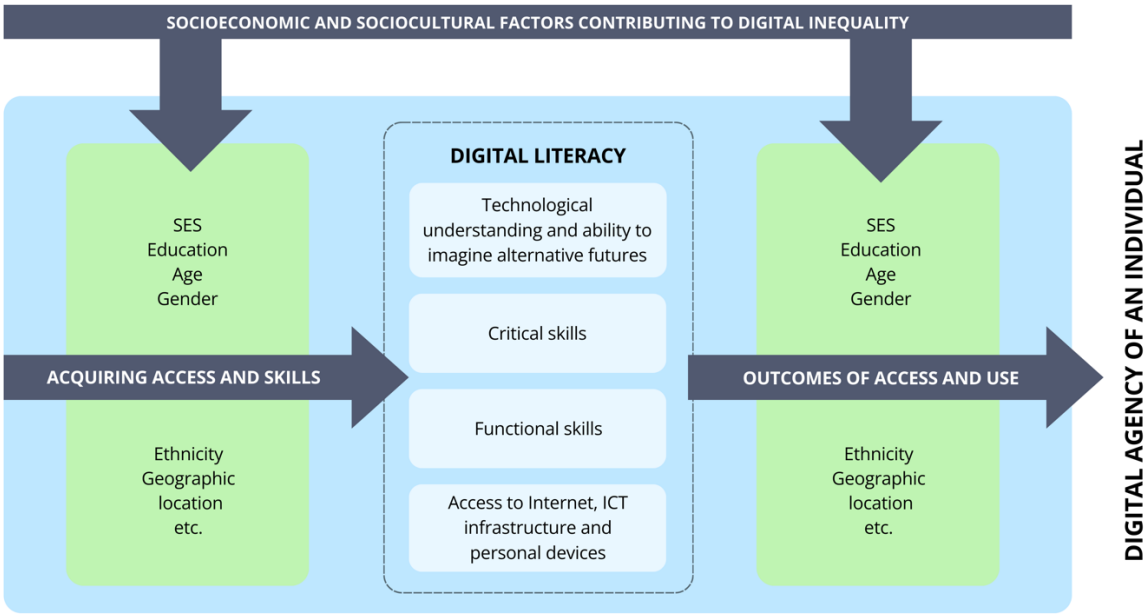

Image 2: The framework combining central findings from theoretical review on digital inequality and digital literacy research. A prior version of the framework was published in Ylipulli & Hämäläinen (2023).

Initially, our model emphasizes how various societal inequities, referred to as socioeconomic and sociocultural factors, affect an individual's ability to obtain Internet access and various digital devices, as well as the individual's chances of acquiring various forms of digital literacy and skills. These are referred to as first and second-level digital inequalities in the literature. The factors above also impact an individual's potential to benefit from diverse skill sets and access positively; this constitutes the third tier of digital inequality. As defined by Helsper & Eynon (2013), this concept may also be called "digital engagement."

The first column of the model explains how a person's ability to acquire ICT or a variety of skills might be impacted by socioeconomic and sociocultural factors. For instance, a person with a limited income might have challenges affording digital devices or a high-speed Internet connection. Likewise, inadequate ICT proficiency is frequently the consequence of a lack of education. The column on the right-hand side serves as a reminder that, even with varying degrees of access and competence, an individual may not be able to benefit from use for various reasons. As previously stated, access and usage are insufficient if one's educational background or social milieu only allows or promotes recreational use, for example. Another example is discrimination based on gender: Even though a person who identifies as female may have (limited) access to and can develop a high level of digital literacy, she may be unable to use these skills to advance her own or society's interests because she is not acknowledged as an expert or because she lacks human rights. Therefore, socioeconomic and sociocultural factors are complex and multi-level variables that require careful consideration when devising policies and interventions to address digital divides.

In addition, our approach identifies four categories of digital literacy. Since access is still a problem, it needs to be covered in any framework that aims to explain the various issues related to digital inequality and smart cities. Furthermore, it is essential to consider multilayered digital skills. Digital literacy studies frequently mention two skill sets: critical skills and functional skills. Most definitions of critical skills seem to revolve around the ability to critically examine and produce digital material as well as the capacity to critically assess one's own place within digital domains (e.g. Hinrichsen & Coombs, 2013). Thus, these criteria focus on the immediate digital context and an individual's capacity to comprehend, reflect, and create digital content. We have included the *level of understanding* in our framework because of the importance of competencies related to understanding societal roles and the societal embeddedness of technologies. We could view the proposed level of understanding as a unique set of skills, complementing the standard categories of functional and critical skills.

When it comes to digital inequality in smart cities, it is recognized as a challenge in literature, but it is framed in many ways. Mapping and analyzing these different framings would probably constitute a study of its own; still, in this paper, we highlighted two different types of framings: a) A smart citizen needs digital skills to adapt to inevitable digital transformation and to act as a user and customer for private and public sector actors providing the increasingly digitalized services; b) a smart citizen needs digital skills to participate, to co-create, and to act as a leader; and also to express resistance. We are more interested in this latter type of smart citizenship, which is aligned with the humanist and collaborative smart city models and intends to distribute power in more equal ways within the digitalizing urban context. However, we also noted that investigating digital competence as a prerequisite for the critical 'smart citizenship' has not received significant attention in research.

We take the first steps towards targeting this research gap in two ways: We draw from Emejulu's and McGregor's (2019) notion of radical digital citizenship and from the practical example offered by Barcelona's Canòdrom center. According to Emejulu and McGregor (2019), the ability to critically analyze digital technologies and their effects on the economy, society, and environment is a requirement for radical digital citizenship. It also means crafting alternatives for technology development and participating in cooperative projects. They (ibid.) stress that we should view digital citizenship within the larger context of social justice discourses. The 'radicality' of the approach lies in the fact that it underlines citizens' possibilities to investigate and question the very fundamentals of digital development. To advance radical digital citizenship, Emejulu and McGregor (2019) propose two strategies: first, dispelling the myths that view technology as an objective social force, and second, advancing understanding through collective action such as independent platforms, grassroots organizing, and mobilization outside of the corporate and neoliberal spheres. Both Ylipulli & Vigren (2023) and Emejulu and McGregor (2019) point out the need for carving out space for alternative future imaginaries. In our comprehensive (yet tentative) model, we suggest that radical digital citizenship is achieved by strengthening digital agency. This means having the skills to interact with digital technologies and/or in digital spaces while being aware of digital power struggles and other possible futures.

To present a practical example, we introduced *Canòdrom* in Barcelona, a community and digital training hub functioning under the local smart city agenda. It provides access to

technology and digital training covering different skill levels and targeted for different groups of people, and intends to enhance citizens' awareness of technologies' societal, cultural, political, environmental, and economic dimensions. As part of their agenda, they also stress the potential of alternative technologies that might lead us towards alternative futures. Canòdrom demonstrates that supporting radical digital agency in a smart city context in practice is possible. We identified the small scale of Canodròm's activities and its dependency on prevailing city policies as challenges.

Finally, we emphasize that even though we have explored and highlighted the interconnectedness of socio-digital inequality, digital literacy, and agency, a radical digital agency cannot be understood as a result of all the components presented in image 2. being in perfect configuration. A professional programmer, for example, might be highly educated and wealthy and has exceptionally high functional and technical skills; a YouTuber, on the other hand, might have excellent production skills, a superior understanding of the subtleties of video content, and the ability to manage their online persona with extreme skill (i.e. critical skills). The outcomes these imagined individuals get from being in a favorable socioeconomic and sociocultural position and possessing advanced digital skills in some areas can be highly rewarding on a personal level. This does not imply that they have technological understanding, though, in the sense that we have defined it. Possessing strong critical and functional skill sets does not guarantee that one can understand how one's activities fit into the larger political and economic structures of the world. Beyond the practical and personal advantages made possible by digital technology, radical critical agency critiques unfavorable societal and environmental trends and consequences.

IMPLICATIONS FOR SMART CITY POLICIES

Based on the empirical and theoretical research presented in this article, we can formulate a few practical guidelines for people-centric smart city policies. Before anything else, it is critical to emphasize the importance of addressing socio-digital inequalities and digital agency in the development of just and sustainable smart cities. We also need to think in terms of *citizenship* which shifts the focus from an individual and their digital competence to the relationship between society and the individual. In the case of 'smart citizenship', this means acknowledging that the digital abilities of people living in digitalizing cities are also on the responsibility of urban decision-makers, policymakers and urban planners.

Furthermore, it is imperative that smart city strategies not only incorporate or collaborate with endeavors aimed at enhancing digital literacy but also address the fundamental socioeconomic and sociocultural inequalities. Hence, in addition to socioeconomic status, education, age, gender, and ethnicity, geographic location and how individuals interact with their immediate surroundings, diverse communities, and other relevant local networks also impact how individuals employ digital technologies (e Silva & Frith, 2012). We propose an evolving and progressively intersectional strategy for tackling socio-digital disparities within the smart city. As stated by Helsper (2021) and Robinson et al. (2018), we must view the digital capabilities of city residents from a multidimensional perspective that avoids generalizations. For example, when it comes to digital assistance for older adults, it is crucial to cater to their unique requirements without employing a homogeneous categorization

approach. As technologies and societies evolve, we should frequently question notions of socio-digital inequality.

Additionally, we suggest that the interdependence between socio-digital inequalities and digital agency should be considered: improving digital equality and augmenting the digital competencies of the general public do not not inherently result in robust digital agency. Ylipulli and Vigren (2023) contend that a diminished capacity to envision alternatives can result in a decreased sense of agency; understanding and awareness of complex relations between technology and society alone are often not sufficient. Resources should be directed towards initiatives which draw, for example, from future studies or design fields in which diversity of futures is recognized and addressed through practical methods and tools.

To support collective action and alternative platforms, smart cities will need to start creatively building connections between their residents, technologies, innovation, and democracy – in a manner that reaches also those who are not at all interested in 'smart experiments' touted by the cities and companies. The Canòdrom center in Barcelona sets one example, but these initiatives should always pay attention to local conditions on many levels and take into account spatial arrangements of different cities, the role of pre-existing local communities, and, naturally, the digital needs of urban inhabitants living in a particular area.

AUTHORS' NOTES ON PRIOR PUBLICATIONS AND ON THE USE OF AI TOOLS

An earlier version of the study by Ylipulli & Hämäläinen was published in the *Proceedings of Communities and Technologies Conference* 2023 (C&T'23). The newer version differs from the prior publication in following ways: We have included in this article results from a second fieldwork period in Barcelona, which was conducted after the publication of the prior paper. Due to these additions, we rewrote a large part of the empirical section and extended the empirical analysis. Further, we strengthened the theoretical part by adding a new section on radical digital citizenship and agency. These changes affected the discussion and conclusion which were modified and complemented with new insights. In addition, we wrote a new section focusing primarily on implications for smart city policies. AI-powered text editor (Quillbot) was used to shorten and rephrase some sections of the article. The original text is written by the authors.

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SOCIAL PERCEPTION OF MOBILE NETWORK DEVELOPMENT IN POLAND: THE ROLE OF TRUST, BENEFITS AND RISKS

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Abstract: *This paper aims to explore the intricate relationships between general trust in technology, perceived benefits, perceived threats, and future intentions to use wireless technology. The study employs Structural Equation Modelling (SEM) to analyse data collected from a representative sample of 1010 Polish respondents. The methodology is rooted in the Technology Acceptance Model (TAM), incorporating modifications to accommodate the specifics of wireless technology acceptance. The results affirm significant positive relationships between general trust in technology and perceived benefits, as well as a negative association between general trust and perceived threats. Interestingly, while perceived threats were expected to negatively impact future usage intentions, this study finds that the positive perceptions of benefits substantially outweigh the concerns related to threats, leading to a strong intention to use future technologies. This study extends the TAM by incorporating trust and perceived threats into the model, providing a more comprehensive understanding of the factors that drive technology acceptance, particularly in the context of next-generation wireless networks. This highlights the pivotal role of trust in moderating the perceived risks associated with new technologies. Demonstrating the importance of enhancing public trust and accurately communicating the benefits of new technologies, this research suggests strategies that could mitigate public apprehension and enhance the adoption rates of new technological systems.*

Keywords: *5G, wireless technology, social acceptance, trust in technology, TAM model*

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INTRODUCTION

5G is neither the first nor the last generation of mobile networks. It is merely an update of the technological solutions from the early 1980s, when it was analogue mobile telephony (1G), transformed in 1991 into digital mobile telephony (2G) with an additional short message service (SMS) function. In the early 21st century, the third-generation mobile telephony (3G) emerged, offering (by the standards of that time) fast data transmission and internet access (from 14 to 28 Mbps). In 2009, the 4G version emerged and allowed data transmission at speeds up to 300 Mbps. Many countries are currently implementing 5G, which will not only accelerate data transmission up to 60 times (up to 20 Gbps) but also support more devices per square kilometre (up to 1 million compared to 100,000 for 4G) and reduce transmission delays in the radio network (from 50 ms in 4G to 1 ms in 5G) (ITU, 2015). 5G represents regular technological evolution, but it is referred to as a breakthrough technology. The reason for that is both the qualitative change 5G brings and the role it can play in the ecosystem of connected devices. The strategic nature of the 5G network is likely one of the reasons why this technology has become the cause of the so-called technology cold war (Segal, 2019). For the first time in the history of the telecommunications sector, communication technology has become the subject of trade wars and geopolitical games conducted on such a wide scale (Soler, 2021).

The "fifth generation" (5G) of telecommunication systems, currently being implemented, and the development of the "sixth generation" is expected to become one of the main drivers of the development of the global economy and the digital society of the next decade. When presenting them, attention is often focused on technological and business benefits, while the benefits from other perspectives (such as social benefits) are rarely presented clearly. This could contribute to arousing wider interest among citizens, increasing social awareness, and mitigating the effects of distrust (Soler, 2022). In particular, the development and implementation of 5G technology have brought about many social discussions, leading even to nationwide protests against its implementation, inspired by misinformation (La, 2020; Destiny 2020; Eliassen & Pena 2020). Protesters demand a full ban on 5G technology. Their actions are not limited to verbal objections, but extend to destroying critical infrastructure, e.g. setting fire to cellular masts.

Despite social concerns, in 2017, 93% of European citizens had a personal mobile phone (European Commission, 2018) and in 2019, 73% of European citizens used a mobile device to connect to the Internet (Eurostat, 2020) and this number is constantly growing - close to 90% in 2023 (Eurostat, 2023). These data contradict the observed concerns expressed by users of wireless technology.

Based on current reports and literature, it is possible to determine what is the approach to this technology of adopted by government agencies and what practices they apply in implementing the proposed strategies for regulation of wireless connectivity in the context of the 5G technology. However the majority of existing literature predominantly delves into technical aspects, such as network deployment, compatibility, and related technical considerations of 5G technology (Asif, 2018; Rao et al., 2020; David & Berndt, 2018)

Transition from 4G LTE to 5G is an archetypal example of technological change (Oughton, et al. 2018). Many countries have already developed strategies for the growth of mobile traffic and the potential development of the Internet of Things (IoT), Smart Cities, or

other technological achievements (services) based on digital connectivity infrastructure, leveraging 5G technology (Weerakkody & Dhillon 2008; Oughton et al., 2018).

According to Fettweis and Alamouti (2014) the 5G technology is a critical step in the development of the wireless sphere. The authors argue that 5G cellular communication will be another paradigm shift that will redefine our future, impacting out societies in ways which cannot be foreseen, A Qualcomm report describes the benefits of 5G and focuses on the commercial benefits achieved by implementing this technology (Qualcomm, 2020). As noted by the authors of the report, this network will significantly extend the capabilities of various spectra, and its high band indicators will help to increase capacity in various spheres.

Deeper research on the adaptation of mobile networks and mobile Internet has been intensively conducted since the second decade of the 21st century. Researchers have examined the adoption of mobile internet in the context of the transition from 3G to 4G (D'Alessandro & Winzar 2014) and 4G to 5G (Čaušević & Medić, 2021). This transition has also been examined from a business perspective, addressing issues like industry (Tilson & Lyytinen 2006; Attaran 2023), banking (Luyao et al., 2022; Mukong & Nanziri, 2021), Internet of Things (IoT) (Rosa et al., 2021) or societies' development (Cumiskey & Humphreys, 2023), as well as their application in clinical research (Jurek-Matusiak et al., 2021; Steć et al., 2022). Governments of individual countries have also attempted to familiarize their societies with wireless technologies by publishing educational materials dedicated to 5G technology (Ajmone et al., 2018; Żurek, 2018).

Taking the above into consideration, the aim of the research was to explore the relationships between four research construct: general trust to technology, perceived benefits, perceived threats and future intention to use of wireless technology.

The first part of the article provides a review of the existing literature on the factors determining acceptance wireless technology. The conducted literature reviews formed the basis for the development of research hypotheses and a theoretical model. In the subsequent section of the article, the research methodology was presented, defining the research sample, research tool, data collection methods, and data analysis techniques. Subsequently, the results of the conducted studies were discussed, which were further subjected to discussion in the following section. The final part of the article includes conclusions, research limitations, and directions for future research.

LITERATURE REVIEW AND THEORETICAL MODEL

The development and adoption of wireless technologies are influenced by a variety of factors, including technological, economic, social, and regulatory considerations. On one hand, the dynamics of the development of wireless technologies and their applications must align with market demand and stem from consumer expectations (Plohl & Čuš Babič, 2024).

Socio-psychological, economic, and personal factors have a substantial influence on human behaviour. However, their impact on shaping consumer behaviour with respect to 5G remains largely uncharted (Mustafa et al., 2022).

When analysing the issues posed in the topic of this article, it is worth referring to the Technology Acceptance Model by Davis (1985). His concept was based on the assumption that the decision to use a new information technology by the user is a reaction that can be explained

or even predicted based on the user's motivation, which in turn is directly influenced by external stimuli resulting from the current features and capabilities of the technology. Davis deduced that the user's attitude is influenced by two main beliefs: perceived usability and perceived ease of use, the latter having a direct impact on the former. During further experiments, Davis refined his model by introducing other variables and modifying the originally formulated relations. The model was also applied by other researchers who introduced their modifications (usually new variables), making the TAM the primary model used for explaining and predicting the use of information technology systems. Recent studies have extended TAM applications to telecommunications contexts, examining how technology acceptance varies across different geographic and socio-economic contexts (Aderibigbe, 2023). It has gained immense popularity - it is quoted by the majority of authors examining the issues of acceptance of information technologies, despite the fact that it is sometimes criticized (Chen et al., 2012). In numerous technology acceptance models, trust plays a pivotal role. The notion of trust has been extensively examined in online studies (Kim & Peterson, 2017; Kunst et al., 2024; Leonov et al., 2024).

On one hand, trust can act as a determinant of technology usage; on the other hand, experiences associated with using technology can enhance trust levels toward it. Two categories of trust in technology can be distinguished: a) general trust in technology, reflecting a societal belief and confidence that technological development generally has a positive impact on society, which is expressed in openness to new solutions; b) trust in specific technologies, stemming from the experience of using them, the benefits experienced, or the threats posed by the technology (Figure 1).

Figure 1. Two types of trust in technology [Source: Own study]

The issue of trust in wireless technologies has traditionally been approached from a research perspective related to technical aspects, both in terms of internal and external network attacks leading to information theft and network destruction (Zhu, 2018). Currently, there is an increasing concern about ensuring the security of telecommunications networks and, consequently, building trust in them (ITU, 2020; Haque et al., 2024).

The benefits of technology are often discussed in the literature primarily from the perspective of the usefulness of a particular technology and its impact on usage intentions (Shin, 2010). In the case of telecommunications technologies, the importance of social impact, users' environmental awareness, and ensuring the safety of its usage are also emphasized (Shahzad et al., 2023; Soler, 2022).

Interesting studies concerning trust and intention to use 5G were conducted by researchers from China (Shahzad et al., 2023). Their results confirm that trust and intention to use 5G significantly mediate the relationship between social influence, environmental awareness, and security availability in actual use of 5G among Chinese students. Moreover, they also discovered that supportive facilitating conditions strengthen the relationship between trust and intention to use 5G. In earlier studies as well (Lee & Song, 2013), trust and perceived risk have been demonstrated as direct predictors of intention to use wireless technologies, with trust also playing an indirect role. Nuntasunti and Bernold (2006) confirmed that success of wireless technology in the long run depends on trust. Also research conducted by Lu et al., (2003) confirmed that wireless trust environment wireless trust environment influenced long-term and near term usefulness, perceived as benefits perceived. Thus, authors propose the following hypothesis 1.

H1: General trust to technology determine the perceived benefits of wireless technology development

In the process of technology adoption, the relationship between trust and perceived risk is especially significant because trust can diminish perceptions of risk. Research on organizational technology adoption has shown that resistance to technological change often stems from factors such as skepticism about the need for change, fear of the unknown, and mistrust of change initiators (Kuzhda, 2016). The crucial role of trust in online research stems from its capacity to mitigate associated risks during initial and subsequent interactions (Gefen et al., 2003). Factors influencing technological acceptance, especially within the health context, underscore the importance of two psychological factors in the adoption process: trust and perceived risk (Kuen, Westmattelmann et al., 2023; Walter et al., 2024). According to Lu, Yao and Yu (2005) trust has significant negative effects on risk perception. Trust serves as a mechanism to manage uncertainties. Trust in technology aids in overcoming perceived uncertainties, thereby enhancing the intention to use it (Kuen, Westmattelmann et al., 2023). The importance of trust is grounded in situations marked by uncertainty, as it assists in overcoming these challenges (Lewicki et al., 2006). Sousa and Beltrão (2021) also risk perception identified as the most problematic construct in the context of trust. The aforementioned assumptions have facilitated the formulation of a hypothesis 2:

H2: General trust in technology is related to the perceived threats connected with wireless technology applications

In many technology acceptance models, benefits are an element of a construct called usefulness. Numerous studies confirm a significant correlation between the perceived usefulness of technological solutions and the inclination to adopt them in the future. Regardless of the type and area of application, such relationships are significant and positive.

Our third and fourth hypothesis are confirmed by the previous research of Setterstrom et al. (2013). The conclusions they made suggest that regardless of whether individuals decided to adopt or continue using a mobile phone with internet access, perceived usefulness, enjoyment, and perceived cost influenced perceived value. And from the other side, perceived value influenced the decision to adopt or continue usage. Their results also suggest a shift in the significance of benefits in shaping perceived value.

Examples of studies examining the relationship between usefulness (perceived through the lens of expected benefits) and future intentions to use solutions related with using wireless technology from various areas include: virtual assistant with children (Wald et al., 2023);

mobility technology (Altay & Okumus, 2022; Lopez-Carreiro et al., 2024); virtual communication (Gupta & Mathur, 2023); digital wallets (Shetu et al., 2022); energy-saving appliances (Karunarathna et al., 2023).

The conducted studies allowed for the formulation of a hypothesis.

H3: The level of perceived benefits of wireless technology influences future intention to use of new advanced wireless technology

Past studies on perceived risk (threats) have emphasized its multidimensional nature and the impact of various perceived risks on the intention to use (Kuen, Schuermann et al., 2023). For example various studies in the telemedicine context have confirmed the negative relationship between perceived risk and the intention to use (Yang et al., 2022). In relation to medical technologies based on IT solutions, Kuen and his team confirmed the hypothesis that performance risk is negatively related to intention to use (Kuen, Westmattelmann, et al., 2023). Also, in the context of IT technology applications based on wireless technology in the mobility sector (autonomous cars, buses) (Cai et al., 2023; de Blanes Sebastian et al., 2023), the issue of the impact of perceived risks on user intentions plays a crucial role. Considering the importance of perceived risk (threats) in future intention to use of new advanced wireless technology the following hypotheses were formulated:

H4: The level of perceived threats connected with wireless technology development and adaptation influences the future intention to use of new advanced wireless technology

The conducted literature reviews relating to the four analyzed constructs: trust in technology, perceived benefits and risks, and intentions regarding the use of wireless technology, allowed for the proposal of the theoretical model presented in Figure 2.

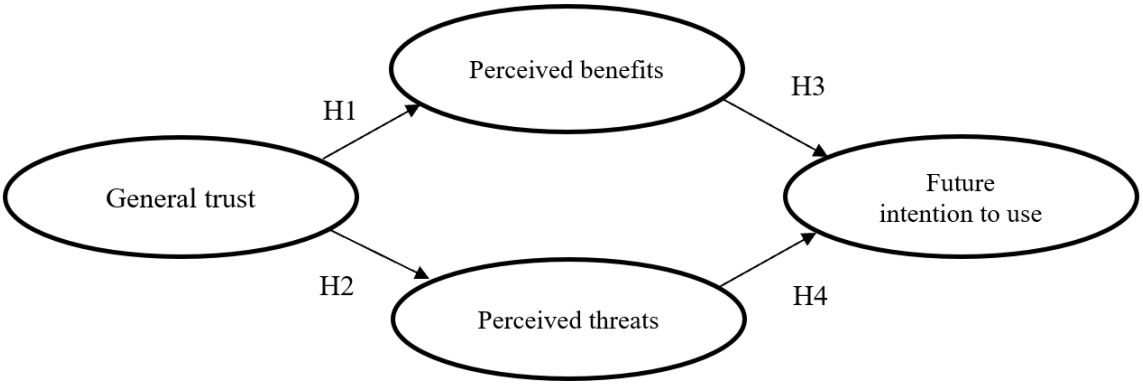


Figure 2. Theoretical model [Source: Own study]

RESEARCH METHODOLOGY

Research sample

The research was conducted in 2023 on a representative sample of 1010 Poles in the age group above 15 years old. Data was collected using the CATI (Computer-Assisted Telephone

Interviewing) technique. The research sample was diverse in terms of age, education, and gender of the respondents and corresponded to the structure of the general population. The respondents' demographic structure based on gender, age, and education is presented in Table 1.

Table 1. Respondents' demographic structure based on gender, age, and education [Source: Own study]

	Frequency	Percentage
Gender		
Female	485	48.0
Male	525	52.0
Total	1010	100.0
Age		
15-24 years old	111	11.0
25-34 years old	162	16.0
35-44 years old	202	20.0
45-54 years old	192	19.0
55-64 years old	161	15.9
over 65 years	182	18.0
Education level		
Primary or lower secondary education	172	17.0
Basic vocational education	232	23.0
Secondary (high school/ post-secondary	333	33.0
Higher education (University level)	273	27.0

Research measurements

The developed theoretical model considered relationships between four constructs: General trust (GT), Perceived benefits (PB), Perceived threats (PT) and Future intention to use (FI). To investigate the relationships between the unobservable constructs, measurement scales were proposed for each of the constructs based on a literature review. A 5-point Likert scale was used to assess the measurement variables, where: 1 - indicated "strongly agree," and 5 - indicated "strongly disagree."

To verify the developed measurement scales for the three constructs: General trust (GT), Perceived benefits (PB), Perceived threats (PT) a confirmatory Factor Analysis (CFA) was conducted. Subsequently, the validity of the CFA measurement model was assessed. The model estimation was conducted using GLS (Generalized Least Squares) method. In the process of assessing individual measurement models, modifications were made related to the standardized residual covariances and regression coefficients. From the original set of observable variables, variables were removed if their regression coefficient value was less than 0.6 and if the absolute values of the covariances for standardized residuals were greater than 2 (Table 2).

Table 2. Standardized regression weights before and after CFA [Source: Own study]

Constructs and items	Standardized regression weights before and after CFA		Variable symbol
	Before	After	
General trust (GT)			
Due to science and technology, the world is a better place	0.735	0.686	GT1
Science and technology make our lives easier and more comfortable	0.755	0.759	GT2
Science and technology make our lives healthier	0.519		Removed
Science and technology create more opportunities for the development of future generations	0.796	0.799	GT3
Perceived benefits (PB)			
The development of mobile networks is an essential component of socio-economic development	0.771	0.747	PB1
Due to the mobile network coverage, I feel safer	0.695	0.698	PB2
Wireless communication improves the quality of my life.	0.749	0.775	PB3
Perceived threats (PT)			
Using wireless communication is a source of risk	0.328		Removed
The development of technologies utilizing mobile networks makes us increasingly dependent on them	0.827	0.839	PT1
Wireless technologies are causing our lives to change too quickly	0.599	0.575	PT2

* Variable removed due to regression coefficient value was less than 0.6 and if the absolute values of the covariances for standardized residuals were greater than 2.

The reliability of the developed measurement scales for all constructs was assessed using the Cronbach's alpha coefficient ranging from 0.648 to 0.784. It is assumed that Cronbach's alpha coefficient above 0.6 is acceptable. Table 3 displays the descriptive statistics and Cronbach's alpha values for both the constructs and individual items.

Table 3. Descriptive statistics and Cronbach's α for all constructs [Source: Own study]

Constructs and items	**Factor Loading**	**Cronbach's α**
General trust (GT)		
GT1. Due to science and technology, the world is a better place	0.686	0.784
GT2. Science and technology make our lives easier and more comfortable	0.759	
GT3. Science and technology create more opportunities for the development of future generations	0.799	
Perceived benefits (PB)		
PB1. The development of mobile networks is an essential component of socio-economic development	0.747	0.779
PB2. Due to the mobile network coverage, I feel safer	0.698	
PB3. Wireless communication improves the quality of my life.	0.775	
Perceived threats (PT)		
PT1.The development of technologies utilizing mobile networks makes us increasingly dependent on them	0.839	0.648
PT2. Wireless technologies are causing our lives to change too quickly	0.575	
Future intention to use (FI)		
FI1. I intent to use next-generation mobile networks [5G, 6G, etc.].	0.863	0.682
FI2. I intent to encourage others to use mobile networks [5G, 6G, etc.].	0.595	

The exclusion of selected variables led to an enhancement in the fit measures of the CFA model. The fit indices of the CFA model after variable reduction are presented in table 4.

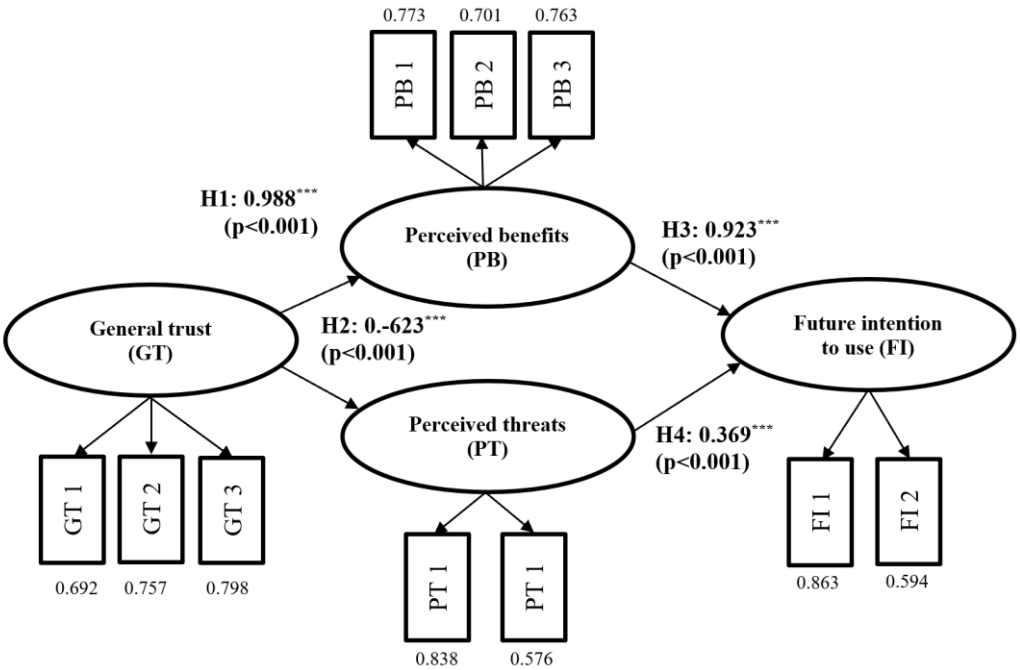
Table 4. The fit indices of the CFA model [Source: Own study]

Model	NPAR	CMIN Chi-kwadrat		DF	P	CMIN/DF
Default model	26		62.247	29	0.000	2.146
	RMR	**GFI**	**AGFI**	**PGFI**		
Default model	0.022	0.988	0.977	0.521		
	NFI Delta1	**RFI rho1**	**IFI Delta2**	**TLI rho2**	**CFI**	
Default model	0.903	0.849	0.945	0.913	0.944	
	RMSEA	**LO 90**	**HI 90**	**PCLOSE**		
Default model	0.034	0.022	0.045	0.991		
	HOELTER 05	**HOELTER 01**				
Default model	690	804				

The developed measurement scales and the assessment of their reliability facilitated the examination of relationships between constructs.

RESEARCH RESULTS

To test research hypotheses, Structural Equation Modelling (SEM) was employed, allowing for the analysis of causal relationships between variables. The verification of the four hypotheses was conducted based on the structural path coefficients. The figure 3 presents structural path estimates between constructs and variables.



Values on paths between latent variables are standardised regression coefficients and values at observable variable are factor loads.

Figure 3. Measurement model [Source: Own study]

The analysis of factor loadings of paths and the p-value indicate that all four hypotheses have been confirmed (table 5). The obtained model fit indices confirm that the model fits well. Among researchers, there is a consensus on the fundamental model fit measures. According to Iacobucci(Iacobucci 2010), the Chi-square test (CMIN) should be indicated first, along with degrees of freedom and p-value. An ideal model fit is confirmed by a Chi-square statistic indicating no statistically significant relationship ($p>0.05$). However, the Chi-square statistic has significant limitations as it is sensitive to sample size. With large samples, the Chi-square statistic will almost always indicate poor model fit ($p<0.05$). A solution used in such situations is the Chi-square statistic divided by degrees of freedom (CMIN/DF), and its value should not exceed 3, with an acceptable level being 5. Commonly used model fit measures include RMSEA, CFI, GFI, AGFI. The measurement model exhibits a high level of fit, as confirmed by the RMSEA (Root Mean Square Error of Approximation) with a value of 0.033. For the RMSEA, values within the range <0; 0.05> indicate good model quality, with 0.08 being the upper limit for satisfactory estimation and 0.1 as the threshold for model rejection. Regarding the GFI (Goodness of Fit Index) and AGFI (Adjusted Goodness of Fit Index), values above 0.9 indicate acceptable model fit.

Table 5. The results of hypothesis statistical verification

Relationship between Constructs	Estimate	Standard Error	Capability Ratio	p	Hypothesis Testing
H1: GT→PB	0.988	0.041	23.972	***	Support
H2: GT→PT	-0.623	0.044	-14,262	***	Support
H3: PB→FI	0.923	0.083	11.187	***	Support
H4: PT→FI	0.369	0.088	4.177	***	Support

$\chi^2 = 63.13$; degrees of freedom (df) = 30; $\chi^2/df = 2.104$; $p < 0.001$; RMSEA = 0.033; GFI = 0.988; CFI=0.944; AGFI=0.977; *** the adopted level of statistical significance was 0.001

DISCUSSION

Throughout human history, technology has consistently propelled civilization forward. This phenomenon extends beyond telecommunications to other emerging technologies such as autonomous vehicles, where similar patterns of social acceptance and resistance are observed (Razavi & Sierpinski, 2024). However, this development has also been accompanied by apprehension and fear due to its novelty and the potential unknown consequences it may bring. The conviction that technological progress can enhance human life on one hand, but may pose dangers, especially when the long-term consequences are unknown, has led to the division of societies and highlighted differences among people. This phenomenon has been observed in the past, such as when people were wary of inventions by figures like Leonardo Da Vinci, and it persists in the 21st century. An evident change is the accelerated pace at which both technologies and societies undergo transformations. In the 20th and 21st centuries, researchers have sought to understand what factors influence people to adopt technologies, exemplified by this research.

The connection between a positive attitude toward technology and a favourable stance towards 5G technology is rooted in the evolution and societal understanding that technological advancements signify progress and enhance individuals' lives. The pace at which people adapt to changes varies, and the acceptance of a specific change, like the dynamic technological developments observed in the 21st century, indicates an acknowledgment of the benefits it brings. The willingness to embrace and utilize new technologies is driven by the recognition that these innovations significantly improve life, fostering greater openness to emerging technologies. Contemporary research affirms this thesis (Parasuraman, 2000; Shah et al., 2021; DigitalPoland, 2020).

The conducted research and obtained results have confirmed that statistically significant relationships exist between the examined constructs. The hypotheses 1 and 2 reflected the relationships between general societal trust (GT) in technology and the perceived benefits (H1) of accessing wireless networks, as well as the perceived threats (H2) associated with unrestricted access to wired networks. Both hypotheses have been supported ($p<0.001$).

A higher level of general trust in technology, manifested by society recognizing the positive impact of technology on socio-economic development, making life easier and more comfortable, leads to society rating the perceived benefits of wireless network access higher. At the same time, it results in a lower perception of associated risks. Belief in the positive impact of technology on society (GT) leads to a lower perception of the risks (mark minus) associated with becoming increasingly dependent on technology and with the fact, that life is changing too quickly. The obtained results are consistent with the findings of other authors concerning various technologies that utilize wireless networks (Kuen, Schuermann et al., 2023).

Hypotheses 3 and 4 pertained to the relationships between the perceived benefits (H3) and threats (H4) associated with using wireless networks and society's future intentions regarding the use of 5G, 6G networks. Hypothesis H3 has been supported ($p<0.001$). A higher level of perceived benefits (PB) contributes to a higher declared intention to use 5G and 6G networks in the future (FI) (Hypothesis 3). The results also align with those of other researchers (Gupta & Mathur, 2023; Lopez-Carreiro et al., 2024).

Surprising results were related to the fact that a higher level of perceived threats associated with wireless network access does not limit the level of declared future use of 5G and 6G networks (Hypothesis 4). Despite the perceived threats (PT), respondents declare future intentions to use wireless networks, which can be explained only by the expected higher net benefits. This alignment is also mirrored in other social studies, like those conducted by the Digital Poland Foundation. They found that the benefits arising from the convenience of wireless internet access outweigh concerns about its impact on health (DigitalPoland, 2020; PIIT, 2024).

Conditions that maintain a balance between trust in technology and reasonable skepticism are still considered important (Melberg & Gressgard, 2023)

In reference to the residents of Poland, one can observe a relatively high level of trust in technology in general. This is also confirmed by international studies. Research conducted as part of the Global Value Survey confirmed that despite the general low propensity of Poles to trust (social trust), their faith and belief in the positive impact of technology on life are very high. This is confirmed by the percentage of responses between 8-10 to the aforementioned question. Over 61% of respondents agree with the statement that "science and technology make

our world healthier, life easier, and more comfortable," indicating responses between 8-10 (WVS, 2018).

CONCLUSIONS

The study examined the relationships between general trust in technology, perceived benefits, perceived threats, and future intentions to use wireless technology. Our findings validate the hypotheses suggesting a strong positive correlation between general trust in technology and perceived benefits, and a significant inverse relationship between general trust and perceived threats. This reflects broader societal attitudes that technological advancement is fundamentally beneficial, enhancing socio-economic development and improving quality of life. Moreover, despite the presence of perceived threats, a high level of perceived benefits strongly influences future intentions to adopt advanced wireless technologies like 5G and 6G.

The research has several limitations that should be considered. Firstly, the study was geographically confined to Poland, which might limit the generalizability of the findings to other contexts with different cultural, economic, and technological backgrounds. Additionally, the study's reliance on self-reported data may introduce response biases, potentially affecting the accuracy of the findings. Finally, the dynamic nature of technology and societal values may mean that the perceptions and intentions captured are subject to change as new information and technologies emerge.

Future research could expand on this study by incorporating a more diverse international sample to enhance the generalizability of the findings across different cultural and technological contexts. Longitudinal studies could also be conducted to observe how perceptions and intentions evolve with the ongoing advancements in wireless technology. Furthermore, qualitative studies could provide deeper insights into the reasons behind trust enhancing the understanding of underlying psychological and socio-cultural factors. Finally, exploring the role of educational interventions in shaping perceptions and mitigating perceived threats could offer practical implications for policy and communication strategies in technology adoption.

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DIGITAL INCLUSION AMONG OLDER ADULTS: IDENTIFYING POTENTIAL SOLUTIONS

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Abstract: *Technology could assist older adults in managing their lives independently, yet many face challenges in using it. This article explores solutions from the perspective of older adults to address the challenges. A qualitative research approach was used, featuring 15 semi-structured interviews with individuals aged 65 or above. Data was analysed thematically. Findings indicated the effective role of education in supporting older adults' digital inclusion by supporting their digital skills, self-efficacy, and fostering positive emotions toward technology. Real-time support provided by assistive technology like chatbots for non-critical online tasks emerged as useful for maintaining older adults' engagement with technology. Additionally, user-friendly designs of smart devices and e-services with clear instructions were identified as essential. Furthermore, our findings underscore the need to identify different motivational factors to encourage a broad range of older adults and realign fair social norms to foster technology use within this demographic.*

Keywords: *smart devices and e-services, older adults, digital divide, digital inclusion.*

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INTRODUCTION

The global population age structure is undergoing a significant shift, with older adults, individuals aged 65 and above, representing an increasingly large share of the total population (Coco, Kangasniemi, & Rantanen, 2018; Valkama & Oulasvirta, 2021). In Europe, the proportion of older adults will reach 25% of the total population by 2030 and 30% by 2070 (European Commission, 2021). This rapid increase is because of different factors, such as declining fertility rates and rising life expectancy (Welsh, Matthews, & Jagger, 2023).

Population aging is a prominent socioeconomic trend with many implications (Bloom & Luca, 2016; Coco, Kangasniemi, & Rantanen, 2018; Valkama & Oulasvirta, 2021). The shift in demographics toward aging leads to a lower rate of participation in the labor force while it increases healthcare costs and strains pension and health schemes leading to slow economic growth (Bloom & Luca, 2016). In addition, older adults face many age-related health difficulties, such as physical disabilities or cognitive issues, that undermine their independence and autonomy in managing self-care (Huisman, Kunst, & Mackenbach, 2003; Kontos, Blake, Chou, & Prestin, 2014). An example is facing challenges in using the healthcare system to manage their health issues independently (Bertolazzi, Quaglia, & Bongelli, 2024; Van Het Bolscher-Niehuis, Den Ouden, De Vocht, & Francke, 2016). Therefore, older adults need to be taken care of by others (Pulkki & Tynkkynen, 2016). This means that the number of people requiring extended care will likely increase. Given the shortage of carers and nurses, it is necessary to find solutions to assist older adults (European Parliament Technology Assessment, 2019).

One solution to mitigate the effects of population aging could be the use of technology, which can support and streamline many day-to-day activities and assist older adults in managing their daily tasks, thus improving their quality of life (Bloom & Luca, 2016; Pal, Funilkul, Vanijja, & Papasratorn, 2018; Rosenberg & Taipale, 2022; Vaportzis, Giatsi Clausen, & Gow, 2017). The usefulness of technology for older adults has been studied in different contexts. For example, Thangavel, Memedi, and Hedström (2022) showed that using information and communication technology can facilitate older adults' communication and reduce their loneliness, for example, via social media. Furthermore, Huvila et al. (2018) discussed the role of technology in enhancing older adults' access to information.

Lefler et al. (2018) studied the usefulness of technology for older adults in the health domain. They showed that *mHealth*, defined as using mobile phones and other wireless tools for medical purposes (Istepanian & Lacal, 2003), supported older adults in maintaining their health and adhering to their treatment regimens. Additionally, Wang et al. (2019) found that technology supported aging in place, staying in one's home, and having an independent lifestyle. This was possible because technology facilitated older adults' home-based tasks, such as cooking and cleaning, and satisfied their critical needs, such as maintaining social connections and personal health (Pal et al., 2018).

Despite these benefits, some older adults face difficulties restricting their use of smart devices and e-services. A *smart device* can be variously defined. According to Silverio-Fernández, Renukappa, and Suresh (2018, p.8), it is "a context-aware electronic device capable of performing autonomous computing and connecting to other devices through wires or wirelessly for data exchange". Two examples are smartphones and computers.

For older adults, then, one difficulty could be related to the lack of *digital literacy*—that is, individuals' awareness of, attitudes toward, and ability to use technology (Reddy, Sharma, & Chaudhary, 2020). This lack makes it difficult for them to gain experience and comfort from technology (Schreurs, Quan-Haase, & Martin, 2017). Additionally, Wildenbos, Peute, and Jaspers (2018) showed that the design of smart devices and e-services is not always suitable for older adults; the design guidelines often do not consider their functional limitations. For instance, a complex design makes it difficult for some older adults to navigate e-services, such as returning to the previous interface (Ejdys & Gulc, 2022; Hoehle, Aljafari, & Venkatesh, 2016; Schreurs et al., 2017). They might face privacy and security concerns (Spann & Stewart, 2018; Turner, Turner, & Van De Walle, 2007). Certain e-services require the provision of personal information, and in some cases, older adults are wary of sharing such information (Lie, Lindsay, & Brittain, 2016).

Furthermore, some older adults might not be motivated to use technology for various reasons, such as difficulties in achieving personal goals or being uncomfortable with a shift in responsibilities from experts to individuals (Airola, 2021). In addition, Suopajärvi (2015) found that some older adults did not perceive technology as sufficiently useful or worthwhile to justify investing their time in learning and using it.

These challenges can disconnect some older adults from digital life, leading to a *digital divide* (Tacken, Marcellini, Mollenkopf, Ruoppila, & Széman, 2005), where there are significant inequities between a person's access to and ability to use and benefit from technology (Fuchs & Horak, 2008). As technology is increasingly present in public and private life, some older adults might become isolated from the rest of society (Tirado-Morueta, Rodríguez-Martín, Álvarez-Arregui, Ortíz-Sobrino, & Aguaded-Gómez, 2023). For example, they might not be able to rely on *eHealth services* (Mannheim et al., 2019), which is "the use of information and communication technologies for health" (World Health Organization, 2018), leading to unequal use of available healthcare services.

In a transition toward a sustainable society where everyone has an equal chance to use technology, it is necessary to find solutions that support older adults' digital inclusion. The concept of *digital inclusion* can be understood from various perspectives. In this study, this concept refers to the degree to which older adults can engage with a digitalizing society using smart devices and e-services (Hänninen et al., 2021). Digital inclusion varies in non-linear ways across lifespans (Taipale, Wilska, & Gilleard, 2017). To support digital inclusion among older adults, scholars have identified several solutions. For example, Mannheim et al. (2019) showed the usefulness of considering older adults' needs, characteristics, expectations, and experiences in the design of smart devices and e-services. The design should be tailored to address the situated and dynamic needs and interests of older adults (Righi, Sayago, & Blat, 2017). In addition, Righi et al. (2017) noted the importance of improving the *usability* of smart devices and e-services, the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" (ISO-9241-11, 2022), to support older adults' digital inclusion.

Providing older adults with the necessary support services, such as digital skills, has been identified as effective in supporting their digital inclusion and use of smart devices and e-services in many studies (Jokisch, Schmidt, Doh, Marquard, & Wahl, 2020; Kärnä et al., 2022; Pihlainen, Korjonen-Kuusipuro, & Kärnä, 2021; Tirado-Morueta et al., 2023). Despite

the availability of multiple solutions, some older adults still face many challenges in interacting with smart devices and e-services and might remain non-users. Therefore, there is a need to find other practical solutions from the perspective of older adults, specifically where technological development is progressing quickly (De Santis et al., 2023; Gomez-Hernandez, Ferre, Moral, Villalba-Mora, 2023; Hoehle et al., 2016; Fang et al., 2018; Li & Luximon, 2016; Wildenbos et al., 2018; Zhou, Qian, & Kaner, 2024).

This study aimed to identify potential solutions to tackle the challenges hindering older adults' sustained use of smart devices and e-services. Fifteen semi-structured interviews were conducted with adults aged 65 or above who had previous experiences using smart devices or e-services. This approach allowed us to obtain practical results. The study sought to answer one main research question: *What suggestions do older adults recommend to address their challenges with smart devices and e-services?*

Older Adults and Digital Inclusion

Digital inclusion has the potential to bridge the digital divide and mitigate the social exclusion experienced by disadvantaged segments of society, such as older adults (Hill, Betts, & Gardner, 2015; Wong, Law, Fung, & Lam, 2009). Promoting digital inclusion among older adults is a key objective in many European countries. To achieve this goal successfully, it is essential to emphasize that digital inclusion involves more than merely increasing access to smart devices and the Internet. It also requires ensuring that individuals possess the necessary digital skills and feel confident and empowered to use smart devices and e-services effectively (Tirado-Morueta et al., 2021; Wynia Baluk, Detlor, La Rose, & Alfaro-Laganse, 2023). In addition, these tools should provide valuable and relevant content tailored to specific disadvantaged groups to enhance their motivation and incentives to learn and use it (Wong et al., 2009). Furthermore, according to Rasi-Heikkinen and Doh (2023), to support digital inclusion among older adults, policies, practices, and research projects should be implemented to promote, examine, and assess older adults' participation in a digitalized society.

Hanson (2011) showed that older adults interact with technology only if their multifaceted needs, including physiological, societal, and personal ones, are satisfied by it. Various factors were identified as useful in influencing older adults' digital inclusion, including demographics, perceived difficulty, cost of access, privacy concerns, trust, and others. While these factors are often considered significant, there is no consensus on the list of factors that influence older adults' digital inclusion (Guner & Acarturk, 2020).

Several frameworks and theories have been used to understand potential factors that support individuals' digital inclusion, for instance, the technology acceptance model (TAM) proposed by Davis (1989). This theory suggests that technology use is driven by behavioral intention, which is shaped by an individual's attitude toward the technology. It further explains that both attitude and behavioral intention are influenced by perceived usefulness and perceived ease of use, alongside external factors. Based on TAM, if individuals perceive a technology as both useful and easy to use, they are more likely to use it.

Moreover, the Unified Theory of Acceptance and Use of Technology (UTAUT) aims to provide a unified understanding of digital inclusion and shows that use behavior could be an outcome of the relationship between background characteristics and behavioral intention

(Venkatesh, Morris, Davis, & Davis, 2003). UTAUT identifies four key factors: individual's belief that technology will assist them in completing tasks, their perceived ease of learning, their perception of societal value placed on learning technology, and the availability of genuine support during the learning process. In addition, UTAUT considers the four moderators of age, gender, experience, and voluntariness which are related to predicting behavioral intention to use technology (Venkatesh, Thong, & Xu, 2016). The extended version of UTAUT, known as UTAUT2, adapts the original model from an organizational context to consumer use. This development involves adding three additional constructs—hedonic motivation, price value, and habit—to the core framework (Plohl & Babič, 2024; Venkatesh, Thong, & Xu, 2012). Hedonic motivation is defined as enjoyment or pleasure gained from using technology. Price value represents the consumer's cognitive evaluation of the tradeoff between the perceived benefits of using the technology and its monetary cost. Habit reflects the degree to which an individual perceives their technology use behaviour as automatic (Venkatesh et al., 2012). Various studies have used this framework in the field of digital inclusion among older adults (e.g. Palas, Sorwar, Hoque, & Sivabalan, 2022; Tiainen, Kaapu, & Ellman, 2013).

METHODS

This study sought to find solutions to facilitate the sustained use of smart devices and e-services by older adults with prior experience with these tools. It applied a qualitative, exploratory approach based on in-depth, semi-structured, face-to-face interviews with individuals aged 65 years or above.

Recruitment of Participants

People were eligible to participate if they were aged 65 years or older and had experience using at least one smart device or e-service. The participants were restricted to experienced older adults to ensure that they had initial familiarity with the topic, had encountered challenges related to the technology in question, and could suggest practical solutions. We excluded individuals with dementia and those who were too frail or ill to take part.

Participants were recruited through convenience sampling at the main public library in Turku, southwest Finland. The researchers advertised the study and explained its aims to older adults visiting the library from June to August 2022. In addition, we used flyers to advertise the study to the target group. Individuals interested in participating shared their contact details with the researchers. Later, the first author contacted them to inquire about their interest in participating and choose an interview time and place. Two individuals who were initially interested in participating did not answer their phones, and another one refused to take part for personal reasons.

The study followed the procedures and codes of conduct of the Finnish National Board for Research Integrity TENK guidelines (2019). Participation was completely voluntary, and the researchers obtained informed consent from all the participants before the interviews took place. This study did not collect any personal or sensitive information and did not endanger the health and safety of the participants. The data were stored following the EU’s General

Data Protection Regulation (2019). The participants were not reimbursed for their participation.

Data Collection

The researchers developed a semi-structured interview guide to collect data (Additional file 1). Before the interviews, we provided the participants with an oral introduction to the study, including its aims, data collection process, and security and privacy aspects of the collected data. In addition, the participants were told about the definition of smart devices and e-services and given concrete examples. To ensure clarity, the participants were provided with a written information sheet.

We collected information about the participants' backgrounds, including their gender, education, and the smart devices they used. We also asked them what kind of experiences they had concerning the use of smart devices and e-services, what could prevent them from benefiting from smart devices and e-services, and what suggestions they had to be able to benefit more from these tools. To ensure the interview guide's effectiveness, we conducted pilot interviews with two older adults. Since no major revisions were necessary, with the participants' consent, we included the pilot interviews in the study.

All the interviews were carried out in person, and they took place in Turku's main public library from June to August 2022. The interviews were conducted in Finnish. With the permission of the participants, they were audio-recorded. After each interview, the audio files were transcribed and translated into English by a transcription company; then, the files were deleted. Any identifying information was removed. The text files were used solely for research purposes and were not shared with other parties.

The average duration of the interviews was about 45 minutes (range 25–75 minutes). We continued interviewing until we reached saturation—that is, sufficient data to answer the study's research questions (Saunders et al., 2018).

Data Analysis

Thematic analysis involves a series of steps aiming to identify recurring themes or patterns within a textual dataset. To analyse the data, we applied the six steps of the thematic analysis framework introduced by Braun and Clarke (2006):

Step one is familiarizing oneself with the data by transcribing, reading the transcripts repeatedly, and noting the initial list of ideas. To follow the framework, we transcribed interviews and read the transcripts several times, each reading circle led us to note down our initial ideas.

Step two is generating initial codes. Getting familiar with the data makes it possible to identify initial codes. The initial codes should identify interesting features of the data systematically. This step can have either theory-driven or data-driven approaches. We selected the data-driven approach and worked systematically through the entire dataset paying full and equal attention to each data item. Then we identified as many possible interesting aspects in the data items, and codes, that may form the basis of potential themes across the dataset.

Step three is searching for themes. After finalizing the initial coding process, the analysis proceeds to search for potential themes and sub-themes. This step focuses on considering how different codes may combine into potential themes and sub-themes and have a sense of the significance of individual themes. In this step, visual representations, such as tables or mind maps (drawings) can be used to sort the different codes into the potential themes and sub-themes. We combined the identified codes into the potential themes and sub-themes. For visual representation, we used tables.

Step four is to review and refine the potential themes. This process might lead to the understanding that some potential themes are not relevant to the research questions, some could be combined into broader ideas, or some need to be divided into separate themes. In this step, it is necessary to ensure that there is a clear coherence of data within themes and equally distinct boundaries between themes. At this level, two processes of evaluating whether the identified codes make up a particular theme fit together and assessing whether the themes as a whole capture the entire dataset. We reviewed and refined the identified potential themes resulting in having relevant and suitable themes that capture the entire dataset.

Step fifth is defining and naming themes. At this step, we defined and further refined the themes that we presented and analyzed the data within them. The main job in this step was to identify the central idea in each theme and name them in a way that concisely captures that idea.

Step six is producing a scholarly report of the analysis when themes and their interrelationships are fully identified. The analysis must provide a concise, coherent, logical, non-repetitive and interesting story of data, within and across themes. At this step, we ensured the analysis was relevant to the research questions and literature, and we reported the findings in the results sections.

RESULTS

Demographic Information

The ages of the participants ranged from 67 to 94, with an average age of 83. The participants' characteristics are summarized in Table 1.

Table 1. Respondents' Characteristics (N = 15)

Characteristic		N (%)
Gender	Male	6 (40)
	Female	9 (60)
Educational background	Elementary education	3 (20)
	Upper secondary education	3 (20)
	Bachelor's degree	2 (13,33)
	Master's degree or higher	7 (46,66)
Smart devices used by the participants	Smartphone	13 (86,66)
	Simple phone	2 (13,33)
	Tablet	8 (53,33)
	Computer/ laptop	9 (60)
	Other devices	10 (66,66)
	Internet connection	13 (86,66)

Reasons for using smart devices and e-services	Communication	15 (100)
	Entertainment	9 (60)
	Information seeking	8 (53,33)
	Daily tasks (e.g. banking affairs or online shopping)	7 (46,66)

Solutions to Address the Challenges of Using Smart Devices and E-services.

This study identified several solutions to address the challenges that older adults might face while using smart devices and e-services. These solutions are categorized in Table 2 and explained in the following section.

Table 2: Solutions, Suggested by Older Adults, to Address Their Challenges with Smart Devices and E-services.

Solutions	Potential Challenges to Address
Providing support services	Lack of digital skills or insufficient digital skills
	Lack of familiarity with the available support services
	Lack of proper support services
	Negative attitudes
	The belief that smart devices and e-services are not designed for older adults
Supporting self-efficacy	The concern about damaging advanced smart devices.
	The belief that smart devices and e-services are not designed for older adults
	Stress or anxiety
	Negative attitudes
Providing proper instruction	Lack of instruction
	Complexity of the available instructions
Providing assistive technologies	Lack of real-time support
	Cognitive issues (e.g. memory issues)
	Fear of making serious mistakes
	Stress or anxiety
Providing user-friendly smart devices and e-services	Complexity of the smart devices or e-services
	Lack of proper English language skills
	Frequent updates
	Health issues
Supporting motivation	Personal perceptions and mindsets
	Missing in-person interactions
Setting fair social expectations	The belief that smart devices and e-services are not designed for older adults

Providing Support Services

Several participants, regardless of their educational backgrounds, acknowledged that deficiencies in their digital skills limited their digital inclusion. These interviewees said that their digital skills allowed them to use simple smart devices and e-services and only for basic tasks, such as making a phone call or being active on social media, but not for more advanced functions (e.g. file compression) or important tasks (e.g. managing health or financial issues).

"I have experience working with computers, but I would say that I can't do many things. An easy example is that I can write an email, but I don't know how to upload big files" (P12). Differences in participants' digital skills were noticed. Some participants said that they were able to use smart devices and e-services completely fluently and without the need for external help.

Lack of sufficient digital skills was identified as a source of negative emotions for some participants. They shared that their insufficient digital skills led to negative emotions regarding technology or themselves. They felt incapable and stupid. These feelings were said to discourage them from using smart devices and e-services. "*I don't have enough knowledge to use computers, and it makes me have bad feelings about myself when I have to use these tools."* (P8)

Some participants talked about their challenges when they wanted to gain digital skills or update their knowledge. Some of these interviewees noted they were not aware of the available support services and could not find any relevant information. Some noted that there was no support services close to their living area so they had to travel to get help. Some others said that even though they had a chance to use the support services; the services were not proper for their age group or tailored to their needs.

> *There was a course in the main library in Turku on how to use computers. I was there, and I learned some things, but the course could have been better. The teacher was very young, and she was teaching quickly. Maybe she had no idea how hard it was for us to follow her. She shared too much information, which was hard to learn and remember.* (P13)

One solution, suggested by most participants to address the above-mentioned issues, was providing older adults with proper education. The education, it was said, could be provided in groups or individually; however, most participants, especially those with low educational backgrounds or less experience with technology, expressed a preference for personalized tutoring in their homes using their own smart devices. The interviewees believed that learning in a familiar environment with familiar smart devices facilitates their learning and helps them retain information better. These participants described that memory issues make it difficult to recall details or apply the lessons learned with other tools to their own. "*I don't know how to use my computer. I wish someone just comes and teaches me at home. If I learn with my computer, I will remember for the next time.*" (P12)

The same participants noted also the potential benefits of repeating the training more than two times to ensure they had learned the important knowledge. In addition, they talked about the importance of having a teacher of a similar age, as they believed that peer tutoring could foster mutual understanding, be more reliable and trustworthy, and enhance the quality of the training. "*I trust a teacher more when they are my age; we understand each other better*." (P12)

Some participants emphasized the importance of support from compassionate experts, such as family members. For example, three individuals talked about using certain e-services, such as My Kanta, the nationwide e-health record system, just because their spouse or children taught them to use the services. "*My wife said I should use My Kanta to check my health records. I was not so sure if I could do it. But she helped me."* (P8)

Supporting Self-efficacy

The results of the current study identified several problems stemming from a lack of self-efficacy. For example, some participants, especially females and those with low educational backgrounds were afraid of touching smart devices and causing damage to them, especially when the devices were unfamiliar and seemed very advanced or fragile. Therefore, they preferred to minimize their interaction with the devices to reduce the likelihood of causing damage and embarrassing themselves. In addition, some noted that the complexity of the smart devices or e-services made them believe that these tools were not designed for people of their generation, and they were not supposed to use such tools. Thus, they were reluctant to use those smart devices and e-services.

> *These computers are so hard to work with them. I know young people love these devices, but I think that these devices are not for people of my age. I only have a simple phone and use it to call people.* (P4)

Most participants suggested that supporting older adults' self-efficacy would help them believe in their abilities and create the mindset that they can and should use smart devices and e-services even if the tools initially seemed so hard to learn and use. The interviewees recommended several solutions, for example, they believed supporting digital skills via education could increase older adults' confidence in using smart devices and e-services and cultivate positive attitudes toward technology and themselves. For example, one participant stated, "*My son taught me to use mobile banking. I was able to pay my bills, and I felt good about myself.*" (P3)

In addition, it was noted that the availability of support services could promote the idea that people with different backgrounds (e.g. age, education, etc.) could learn and use such tools. Some participants saw peer tutoring as useful in supporting their self-efficacy. They believed that seeing people at their age who mastered using smart devices or e-services gives them the courage to use these tools.

Moreover, providing feedback was recommended by some participants as another solution supporting older adults' self-efficacy. The interviewees said that they would feel happy to receive feedback either automatically or from specific people. For example, an automatic positive message appears on the page when an online task is completed successfully. *"Imagine a bank application that knows the age of its users. For instance, if I, a user over 65, complete a task, like paying a bill, the app could display a message saying, 'Well done! This message could encourage me to use this app again or try other apps."* Moreover, some participants said that positive feedback from real people could emotionally support their self-efficacy. "*I paid all the bills online by myself and my son said that you have done a great job; I was encouraged to do other online tasks."* (P)

Providing Proper Instructions

Some participants highlighted challenges related to the instructions provided for smart devices and e-services. Some interviewees noted the complete absence of clear, accessible instructions, which increased their sense of complexity and frustration when using smart devices and e-services. Others pointed out that even when instructions were available, they were often riddled with technical jargon or presented in formats unsuitable for individuals

with physical disabilities, for instance, small fonts that posed significant difficulties for those with vision impairments.

These barriers were said to impede the participants from setting up and navigating smart devices or e-services independently. Moreover, they found it challenging to rely on such instructions to troubleshoot problems during use, further exacerbating their difficulties.

> *I have a blood pressure issue, and sometimes I need to measure my blood pressure at home. When I need to use the device, I often forget which button to press. My device has three buttons. The instructions are written with small characters, which is difficult for me to read. So, I have to ask others to read it for me.* (P10)

To address the challenges associated with instructions, some participants shared several valuable insights. The interviewees emphasized the importance of simple, step-by-step guidance that could serve as a clear roadmap for older adults when they want to complete online tasks or operate smart devices. The interviewee highlighted that the guidance should be free of charge, as most smart devices are already expensive, and charging extra for instructions would be unreasonable.

Participants also stressed that the instructions should use plain, easy-to-understand language, avoiding technical jargon to ensure its usefulness for all user groups. Additionally, they suggested that the instructions be available in multiple languages, enabling users to access them in their native language. For more complex smart devices or sensitive e-services, such as those related to health or financial matters, participants preferred to have instructions in visual or audio formats. Examples included videos, audio recordings, and illustrative figures accompanying text-based instructions. These multimedia formats were seen as particularly helpful for older adults, as they provide reassurance, reduce stress, and ensure tasks are performed correctly.

> *The printer broke. I found the instructions and was able to install what was necessary. It was less stressful to fix it by following the instructions. I believe the instructions should be simpler and follow a road map*. (P13).

Providing Assistive Technology

Some participants raised the issue of lacking real-time support while using smart devices or e-services. These participants noted that forgetting certain details caused them to feel stressed or nervous when using a smart device or completing an online task, and they could not get any real-time support. Their anxiety stemmed from a fear of making irreversible mistakes with potentially serious and long-term consequences. They said that this challenge mostly stopped them from completing their online tasks or using smart devices.

> *Many times, I was in the middle of completing an online task and forgot what to do as the next step. So, I had to stop before finalizing my task."* (P6)
>
> *It was a couple of days ago. I wanted to check something on a bank account. I clicked on a link, but then I was on a different page. I did not know what this page was, and I was afraid of clicking on anything. I could have done something wrong. I just closed the web page.* (P5)

Some interviewees, regardless of their educational backgrounds, spoke of the importance of receiving real-time support for their sustained use of smart devices and e-services. These interviewees suggested several options, such as phone support, voice commands, and

chatbots. They found chatbots useful for mitigating their stress and fear and helping them recall details and complete their online task. However, they mentioned trusting chatbots only for nonserious issues. In case of serious or complicated issues, such as health or financial-related topics they prefer to have at least a phone call with a real person. These participants, in addition, highlighted the value of visual tours as a form of real-time support for explaining new e-service features and functionalities.

> *I was booking a hotel for my trip, and then I forgot what I needed to do next. I was so nervous. I wished there was a button I could press to get help from a chatbot. I could tell the chatbot what I needed or why I was stuck, and it could guide me. I think a chatbot wouldn't hurt, as long as it doesn't have access to my bank account*. (P10)

Providing User-friendly Smart Devices and E-services

The complexity of the available smart devices and e-services and their constant updates were raised by some participants as one of their primary concerns, regardless of their educational backgrounds. They felt that most smart devices and e-services had inappropriate and intricate interface designs, resulting in challenging and time-consuming interactions. The most frequently mentioned issue was related to navigation difficulties, and the participants shared many problems they faced. For example, they said that many web pages were overloaded with information, making it challenging to locate what they needed. They also found it difficult to distinguish clickable elements from non-clickable ones, and even when they found the clickable element, it often opened a new page full of text, further complicating the search process.

Furthermore, some interviewees reported that the development of smart devices and e-services was so fast that keeping up with the changes was difficult. They considered themselves slow adopters of new technologies and mentioned getting bored easily or forgetting the details fast when they aim to learn updates. Some interviewees said their unfamiliarity with the English language or technical terminologies added to their perceived difficulty with smart devices and e-services.

Some participants shared several ideas for supporting the usability of smart devices and e-services. For example, they suggested producing lighter versions of smart devices. Older adults might not be strong enough to carry heavy gadgets, or their shaky hands cause them problems holding normal gadgets. "*Using a tablet is more comfortable than a computer or a phone, but if the tablets were lighter, I could hold them longer and use them more.*" (P6).

Some interviewees suggested increasing the size of some buttons on phones' keyboards, such as the microphone button. The participants said that their main reason for using smart devices was communication, this function could facilitate it, especially for those with physical difficulties, such as shaky hands and visual impairments. Moreover, some participants suggested using facial recognition as a password mechanism for social media apps instead of traditional text-based passwords, as it was so hard for some of our interviewees to remember passwords due to their cognitive issues.

> *I created an Instagram account a couple of years ago, but I deleted the app. Later, when I decided to use it again, it asked for my password, and I couldn't remember it. It would be better if social media accounts used facial recognition as a password [mechanism]. It would be easier and safer.* (P11)

Regarding e-services, some interviewees recommended using bright colors for the backgrounds of web pages, noting that text is easier to read when the background has white or other light colors. Moreover, some participants suggested developing and following a color code for national important online platforms, such as patient portals or bank applications to facilitate the search process. For example, they recommended that clickable items be bolded with green color.

Supporting Motivation

Lack of motivation could stop older adults from using smart devices and e-services. Some interviewees said that using these tools was difficult, and they felt disappointed after spending many hours struggling with them. The sense of imbalance between the effort expended and the results achieved discouraged them from continuing to use smart devices or e-services.

> *I used computers for a while and managed to send emails and pay my bills. But I couldn't do many things even after spending so much time and energy. I was so disappointed in myself and didn't see enough reasons for my struggles. One day, I woke up and said, "No more computers." Since that day, I have only used my phone to call people.* (P15)

In addition, the participants shared their worries that digital-based communication, such as video calls, might replace human-based interaction. This worry had many negative consequences. First, the interviewees believed that if people met virtually, they would not be motivated to meet in person, especially young people. This perception generated negative feelings and reduced the interviewees' motivation to continue using smart devices and e-services because they wanted to continue meeting their children or relatives in person. Second, the interviewees assumed that when everything is online, many roles might shift, and they have to take on many responsibilities. For example, if they have to manage their finance online and there is no real person to guide them, it causes stress and discouragement.

Some interviewees spoke of the importance of motivation in supporting older adults' willingness to continue using smart devices or e-services. We found that the meaning of "motivation" varied from one person to another. For example, some participants with low educational backgrounds believed that they needed reminders concerning the benefits of smart devices and e-services, while some reported their need for emotional and digital support.

Furthermore, some interviewees, especially those with high educational backgrounds, shared the role of peers in encouraging their use of smart devices and e-services. It was noted by some interviewees that they might continue to use a smart device or an e-service if their friends were also using it. "*I have a Facebook account, which I used years ago. Then, I stopped. When a couple of friends said that they were using the app and texting each other, I started using it again*" (P1).

Setting Fair Social Expectations

Our findings showed that social expectations could have both positive and negative effects on older adults' use of smart devices and e-services. Social expectations could act as either a

barrier or a motivator, depending on how they are perceived and managed. On the one hand, according to some participants, social expectations served as a hindrance. The participants shared experiences of feeling pressured to learn new technologies quickly. Such unrealistic expectations discouraged them and made the learning process stressful.

> *"When I asked my kids to teach me how to use mobile banking, they were teaching me and kept asking, 'Don't you get it?' They expected me to learn it immediately. It doesn't work that way for me—we [older adults] need more time, practice, and a patient teacher."*

In addition, some participants shared the social impression of being underestimated. *"If you can't do it, let it be, I will do it for you"* (C12). This behavior shamed and demotivated older people and made them feel that they had to give up before trying enough.

On the other hand, some participants saw that social expectations acted as a motivator. Several participants highlighted how these expectations supported their digital inclusion. They noted that feeling expected to perform online tasks independently, such as managing bills created a sense of responsibility and drive to learn. In these cases, the desire to meet expectations from close or extended social networks provided a meaningful push toward digital inclusion. *"I knew my kids expected me to pay my bills online, so making them happy was one reason I learned"* (P5).

Furthermore, interviewees believed that reasonable social expectations could convey a message that these services are designed for everyone and encourage them to use these tools. This expectation could address common stereotypes, such as "Not designed for me", or "I am too old to learn and use smart devices and e-services."

Our participants believed that fostering digital inclusion among older adults requires setting fair and realistic expectations that account for their learning capabilities. Support, guidance and encouragement were suggested to help transform these expectations into positive motivators for successful digital inclusion.

DISCUSSION

This article presents findings from a qualitative study involving 15 semi-structured interviews with individuals aged 65 years and above who had experience using smart devices and e-services. We identified practical solutions to address the challenges some older adults often face when using these tools to support their sustained use. Implementing the identified solutions in practice requires collaboration among various parties, including societal stakeholders, authorities, service developers, caregivers, and others.

One significant useful solution identified in the analysis, is providing older adults with support services to use the available smart devices and e-services. The services should aim to support older adults' digital skills and help them understand smart devices and e-services as well as the relevant updates. The usefulness of education has been identified in many other studies (Berkowsky & Czaja, 2018; Jokisch et al., 2020; Rantanen, Järveläinen, & Leppälahti, 2022). Suopajärvi (2015) argued that supporting older adults' digital skills, among other citizens, is essential especially when the technology is aimed at the public. We add to these findings that personalized tutoring delivered at home with tools owned by older adults could have better learning outcomes than public courses with borrowed tools.

Possessing sufficient digital skills was also found useful in supporting older adults' self-efficacy and mitigating their negative attitudes toward technology or themselves when interacting with technology. Similarly, Wynia Baluk et al. (2023) showed that older adults need training that is adaptable to their needs, to promote their confidence to use smart devices and e-services effectively. In addition, the results of the quantitative study by Ha and Park (2020) found that positive attitudes toward technology represented a relatively more important factor than perceived ease of use or perceived usefulness in explaining the relationship with technology among a group of older adults. Therefore, as indicated by the present findings, it is necessary to build positive attitudes among older adults via proper support services.

Our findings also add to the body of the literature that some older adults regardless of their educational backgrounds are ready to welcome the real-time support provided by assistive technologies, such as chatbots when the task is not very complex or related to critical issues. Providing real-time support could help them control their stress and fear while using a smart device or completing an online task. Chatbots could also aid older adults with cognitive issues in recalling details while performing tasks online. For example, a bot could be installed on smart devices and operated through voice commands. When individuals need assistance, they can activate the bot and request help. Several studies have confirmed the usefulness of chatbots for older adults in different contexts. For example, Gudala, Ross, Mogalla, Lyons, Ramaswamy, and Roberts (2022) showed that the acceptance of voice-based chatbots could lead to various benefits for older adults and help them overcome visual and dexterity impediments while using smart devices and e-services. Similarly, Aggarwal, Tam, Wu, Li, and Qiao (2023) revealed that Artificial intelligence (AI) chatbots could offer a nonjudgmental space for communicating sensitive information. Furthermore, other forms of real-time support were suggested by the participants, such as hotlines operated by humans for important subjects, or visual tours for the public e-services.

In addition to providing older adults with different types of support services, our findings emphasized the significance of user-friendly designs in supporting older adults' use of smart devices and e-services. This design approach was suggested as useful in mitigating the perceived feeling of complexity regarding smart devices and e-services as a significant issue hindering older adults' sustained use of smart devices and e-services, similar to other research works (Ejdys & Gulc, 2022; Hänninen et al., 2021; Schreurs et al., 2017; Suopajärvi, 2015). We confirm previous findings that involving older adults, their needs or experiences in the design process could improve digital inclusion, as people find the tools easy to interact with and relevant to their needs (Holthe, Halvorsrud, & Lund, 2022; Ma, Chan, & Teh, 2021). The suggested usability improvements, in this study, were primarily related to improving communication functions. This is not surprising, considering that the participants mainly used smart devices and e-services for communication reasons. For example, a larger microphone button on smartphones was suggested to make sending audio messages easier. Larger buttons are more easily recognizable by older adults and accommodate physical challenges such as impaired vision and hand tremors.

We found that when the user-friendly tools come with proper instructions in multi-media forms, such as short videos, audio files, road maps, and easy-to-read texts with pictures, older adults feel more supported to use. Suitable instructions and a user-friendly design were identified as useful in mitigating problems related to the complexity of smart devices and e-

services and the negative attitudes toward them. Although the need for proper instructions has been discussed frequently in previous studies (Harris, Blocker, & Rogers, 2022; Kaihlanen et al., 2022; Mahroo, Greci, Mondellini, & Sacco, 2023; Tang et al., 2022; Xie et al., 2020), it seems that the available support and instructions are still not adequate or appropriate for all groups of users. Therefore, service designers should focus more on finding solutions to make the instruction more practical and efficient. We suggest using older people's direct insights in the design process of instructions.

Moreover, our findings confirm previous studies that to ensure older adults' sustained use of smart devices and e-services, it is essential to support their motivation (van Velsen, Broekhuis, Jansen-Kosterink, & Op den Akker, 2019). We added to this finding that motivational factors might differ for older adults with different backgrounds. Older adults with low education backgrounds might feel motivated to use the tools when they receive information regarding the tools, their benefits, and their functionalities. For example, when they know how to manage their health issues online independently, they will be motivated to use such tools. Friends were, on the other hand, identified as an effective factor in maintaining motivation among older adults with high educational backgrounds, to use smart devices or e-services.

Moreover, our findings showed that social expectations can influence older adults' relationship with technology in both positive and negative ways. When older adults are expected to use technology without being pressured to learn it too quickly or being underestimated due to their slow learning and use process, they are more likely to feel encouraged to engage with smart devices and e-services. Similarly, other studies showed that older adults often develop strategies to adapt and fit in when societal norms emphasize being capable users of new technologies (Jaschinski, Ben Allouch, Peters, Cachucho, & van Dijk, 2021). Therefore, we recommend realigning social norms and expectations to foster technology use within this demographic. To do so, it is necessary to accept that older adults need specific types of education and longer periods to learn to handle smart devices and e-services. The responsibility of realigning social norms and providing older adults with proper education is on various societal sectors, including authorities (e.g. governments, local community centres), educational institutions, and tech companies. Adequate funding and policy support are essential to scale these efforts.

CONCLUSIONS

The findings of this study suggest that while there is no concrete answer to enhancing digital inclusion for older adults, a combination of practical solutions could effectively support their inclusion. Our findings suggest that future designs or updates of smart devices and e-services should have user-friendly interfaces that address the needs, expectations, and emotions of older adults. By being mindful of older adults' needs, manufacturers, service providers and developers can make more informed design decisions. We suggest that these tools should also be accompanied by additional support services, such as clear instructions in multimedia formats and real-time assistance features, such as chatbots and hotlines.

Moreover, to bridge the digital divide between generations, public decision-makers and authorities should take several actions. First, offering older adults personalized education

concerning their digital skills, self-efficacy and emotions toward technology, as well as themselves when interacting with the available technology. Second, identifying and implementing factors that support older adults' motivations. The motivational factors vary widely within this demographic based on their background, necessitating the identification and implementation of diverse strategies tailored to individual needs. Lastly, social norms should be adjusted to foster a more supportive environment for technology use among older adults.

However, this study identified the potential solutions to address the challenges, but it did not address practical implementation strategies. For example, we found that multiple factors could support older adults' motivation to use smart devices and e-services, but for inquiring into those factors in detail, additional studies are needed. This gap underscores the need for further research. This study faced other obvious limitations. For example, the participants did not represent the entire population of older adults. The interviewees were people who had previous experience of using at least one smart device or e-service, and they were recruited at the main public library in Turku. Therefore, only relatively healthy and active older adults were included in the study. Those who were unable to leave their homes or care facilities and those without previous experience using smart devices and e-services were excluded. A study with a larger sample of older adults from a broader variety of backgrounds is needed to identify population-level trends concerning the issues discussed in this article. Another limitation is the lack of focus on a specific smart device or e-service. We allowed participants to discuss the most important challenges and potential solutions related to any type of smart device or e-service. Future studies should focus on specific tools to collect more specified data.

IMPLICATIONS FOR THEORY, APPLICATION, OR POLICY

This study highlights the importance of considering vulnerable users' viewpoints regarding the solutions supporting their sustained interaction with technology. The findings reveal that incorporating users' contributions goes beyond integrating their experiences into the design of technology; it also involves addressing their feelings, motivational factors and needs for support to use various tools. We underline the importance of real-time support provided by assistive technologies, like chatbots in older adults' sustained use of technology and addressing challenges for non-critical issues. It is anticipated that tools with bot assistants will support older adults in managing real-time issues that cause stress or fear and help them recall details needed to complete online tasks. Moreover, the dual effect of social expectations on older adults' digital inclusion underscores the importance of realigning fair social norms. Achieving these goals requires the collaboration of multiple parties in society, such as societal stakeholders, service designers, service providers, and families.

Declaration of interest statement

The authors declare that they have no conflicting interests.

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IMPACTS OF INTERSECTIONAL DUAL-PERSPECTIVE VR EXPERIENCES ON EMPATHY AND UNDERSTANDING OF MICROAGGRESSIONS

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Abstract: *This study advances our understanding of virtual reality (VR) as a tool for increasing both empathy and comprehension of microaggressions, using a unique intersectional dual-perspective approach. Through immersive VR video experiences, participants simultaneously experience and witness microaggressions focusing on racial assumptions about academic abilities. The VR video, developed and scripted by two undergraduate students of color, was recorded from two distinct perspectives: a Black student and an Asian American student, providing viewers an opportunity to witness differential treatment based on racial bias. We conducted a mixed-methods survey of 83 students who viewed the VR experience, focusing on self-reported affective and cognitive reactions. Findings indicate that the VR experience heightened participants' understanding and empathy toward microaggressions. Notably, one perspective (the Asian American student), led to greater impact, suggesting the necessity for further exploration of VR experiences' differential impacts and its implications for the intersection of VR and social justice.*

Keywords: *virtual reality, 360-degree video, microaggressions, racism, intersectionality.*

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INTRODUCTION

As virtual reality (VR) technology has increased in popularity with the widespread use of the Oculus/Meta Quest, PlayStation VR, and others, emerging research examines whether such technology can be leveraged to increase empathy for a variety of social issues. Because VR offers the opportunity to have first-person experiences from another person's perspective, it seems well suited to the development of such empathy. These research questions grew in part out of early VR-style documentaries that sought to create empathy for others, such as Chris Milk's *Clouds Over Sidra*, which portrayed the experiences of a Syrian refugee. Projects such as this one have shown significant potential to evoke strong emotional responses and a deeper understanding of others' experiences.

However, moving from anecdotal experiences to academic research has raised numerous ethical challenges. A growing body of academic research aims to evaluate the effectiveness of these approaches, with a particular emphasis on its ability to foster empathy. Such research is vital, because organizations are already adopting VR for training related to diversity, equity, and inclusivity training sessions, with firms like Praxis Labs creating these experiences as a form of employee training for major companies (Brown, 2021). Yet, the results of such programs aren't always documented or reported in an academic manner, complicating their analysis.

Emerging research has largely focused on assessing the impact of VR experiences on empathy and understanding using both first-person and third-person perspectives and by comparing the impact to that of traditional training videos. However, a significant gap in this research exists, as it fails to assess whether the same scene, witnessed from a different perspective (such as that of a Black student versus an Asian American student) can have different impacts. Our project aims to utilize an intersectional research approach by considering whether assuming different identities can impact one's experience in VR. From this, two major research questions evolved:

- RQ1: How does viewing a VR experience from different perspectives (e.g., the perspective of a Black student vs. an Asian American student) impact the viewers' empathy and understanding?

- RQ2: Do participants' demographics and prior knowledge or experiences (e.g., race, age, prior experience with VR) influence their engagement with and the effectiveness of VR in promoting empathy and understanding?

Overall, prior research on the impacts of VR on empathy have yielded mixed results, though many results suggest that role-taking through media like VR can increase empathy by reducing self-other boundaries. This connects to a longer history of research that explores the power of older media to invoke empathy, going so far as to link the rise of universal human rights to the literary explosion in the 18th and 19th centuries (Farmer & Maister, 2017). While VR holds potential for amplifying this effect due to its immersive nature, evaluating its impact is challenging. Racial bias served as a major lens of analysis for many early studies. Banakou et al. (2016) analyzed whether implicit racial bias against Black people can be decreased using VR experiences. They found that implicit bias is decreased, though it

decreases more when the participants are represented by a Black body rather than a White body within the experience. On the other hand, Groom et al. (2009, p. 224) found that "automatic racial bias is not reduced by embodying a person of a disfavored racial group." Roswell et al. (2020) collected survey data based on a 60-minute large group activity about racial microaggressions, followed by a 20-minute VR module. They found that "most respondents (90.8%) reported feeling engaged in the VR experience. Additionally, the majority agreed that VR was an effective tool for enhancing empathy (94.7%), that the session enhanced their own empathy for racial minorities (85.5%), and that their approach to communication would change (67.1%)" (2020, p. 3). Though mixed, VR's potential to increase empathy and reduce bias appears promising.

Raposo et al. (2023) conducted a pilot study simulating the experiences of marginalized individuals, including pregnant women, elderly individuals, wheelchair users, and those with visual impairments to determine if VR would increase empathy among university students. Their results indicated that students had both increased awareness and empathy, suggesting the possibility for using such a tool for pedagogical purposes. Bacca-Acoasta et al. (2023) found that compassion and attitudes toward migrants positively influence emotional empathy in virtual reality experiences, while engagement, attitudes toward migrants, compassion, and immersion enhance cognitive empathy. Pinto-Coelho et al. (2023) found that VR experiences of those with disabilities generates empathy that promotes both inclusion and understanding. van Loon et al. (2018) measured empathy through a behavior game after a VR experience and found that the experience increases empathy for specific others, but only if the partner in the game is the same person whose perspective they assumed in the virtual reality simulation, suggesting that the impact of such experiences may be limited. Sora-Domenjó (2022) conducted an interdisciplinary literature review which found little evidence of any correlation between VR exposure and empathy that was able to evoke changes in prosocial behavior. Overall, evidence of the impact of VR on empathy for marginalized individuals is quite mixed.

Additional research explored whether VR experiences were more effective for bystander training than those presented in a two-dimensional (2D) video format. Rawksi et al. (2022) were surprised to find that VR participants were more likely to use indirect and non-confrontational approaches in VR than in 2D experiences. They hypothesize that "the high presence of VR … may have represented a more true-to-life psychophysiological and emotional experience for trainees and motivated them to prefer less socially risky or more generally applicable Interventions" (2022, p. 29). Notably, this suggests that although participants were less willing to take risks, this may be because the VR platform feels much more real, and thus more risky, than interacting with a 2D experience. Wang et al. (2022) found that while all media interventions increased positive attitudes toward a target population, the effect was largest with the use of VR. Similarly, Hargrove et al. (2020) found that VR and an embodied in-person experience were equally effective in eliciting empathy and behavior change. Schutte and Stilinović (2017) found greater empathy was generated by virtual reality than a 2D video format. Huang and Pan (2023) found that first-person perspectives elicited more emotions and empathy than third-person perspectives. Herrera et al. (2018) found that participants who took on the perspective of a character involved in the narrative, as opposed to being a bystander, reported increased feelings of empathy and connectedness to others in the scene. Finally, in a review of 111 papers, Lee et al. (2024)

found that although VR was not better at generating emotional empathy, it did enhance cognitive empathy, comparatively. Collectively, this body of research suggests that there are some additional benefits to the use of VR technology over 2D video formats.

Literature raises ethical questions about the impact of empathy-focused VR research and whether or not such experiences should be created. Andrejevic and Volcic (2020) argue that empathy relies on a sense of otherness, hence VR's attempt to promote empathy through perspective-taking may be ineffective or even counterproductive. Ramirez (2020) highlights how our intersectional identities shape our experiences, so a White man experiencing a VR simulation in the role of a Black woman may not be truly representative, as a White man and Black woman would experience the exact same situation differently due to their unique identities. Barreda-Ángeles et al. (2020) found that enjoyment in VR can conflict with empathy. Short scenes often miss out on contextual information about a particular crisis or the larger history of systemic oppression (Daily, 2021). This suggests that empathy may not be the most important measure or outcome to consider when using VR, especially as there is no general agreement on how to even define the concept (Bollmer, 2017; Foxman et al., 2021). Instead, we might consider sympathy, radical compassion, or the VR's impact on one's understanding or behavior instead (Aitamurto et al., 2021; Bollmer, 2017; Ramirez, 2020).

VR creators and academic researchers, therefore, need to be careful in making claims about what the technology can do, while also mitigating two extreme reactions viewers may experience: downplaying their own suffering in comparison or over-empathizing in a way that makes them feel as if they completely understand the problems or suffering of someone else (Thatcher, 2019). Ramirez (2020) believes that it could be more impactful to use VR to build sympathy, rather than empathy, allowing the viewer to *witness* rather than *experience* suffering, though other results suggest that it may be difficult to disentangle affective and cognitive outcomes (Chen et al., 2021). Nakamura (2020) critiques projects that equate immersive VR viewing with the genuine experiences of others, suggesting they serve to assuage societal guilt rather than address real issues. While powerful imagery can influence public opinion, as seen in the Civil Rights Movement (Baird, 2010), an ethical tension arises between exploiting others' suffering and fostering empathy that can lead to social change. VR further complicates this by enabling the viewer to assume the role of another person in the scene. Lara and Rueda (2021) argue that framing VR as "being in someone else's shoes" instead of "being someone else" overcomes the need to switch to a sympathy framework rather than one of empathy.

Overall, emerging work on how VR can be leveraged to help combat social struggles suggests that the technology can potentially be helpful, at least in limited contexts, but it is extremely important to consider how to do so ethically. Doing so involves being conscientious about how the media is created, how it is promoted, who uses it, and the types of claims that are made about what it is able to do. Additionally, within the broad umbrella of virtual reality, experiences can vary significantly in terms of how interactive and immersive they are, based on whether the experience consists of 360-degree video or fully virtual environments that allow for movement and interaction with the scene.

METHODS

This project develops a VR experience about microaggressions filmed from two different perspectives and analyzes how identity impacts self-reported affective and cognitive reactions. It uses a mixed-methods survey approach to collect data from participants after they view the VR experience.

Research Ethics Approval

This study was approved by Fitchburg State University's Institutional Review Board, IRB #202223-03. This approval included but was not limited to COVID-19 precautions, the survey instrument, the use of VR headsets, advertising materials, and informed consent for all participants.

Creation of VR Media

Grant funding allowed for the purchase of equipment for filming a 360-degree video project that was then viewed on Oculus Quest 2 VR headsets. Two undergraduate students of color were hired and paid to develop and then write a script for the VR video project during the summer of 2022. Notably, the students opted to create a dual-perspective scene, which would be filmed twice, once from the perspective of each character, one of whom was Black and the other of whom was Asian American (See Figures 1 and 2). One character experiences a professor overestimating their class performance based on race, while the other character has their class performance underestimated based on race. The major difference between the two videos is that the viewer hears internal dialogue from the character whose point of view they are seeing. In light of ethical concerns related to intersectionality noted above, this is important because it makes clear that the participant – with their own racial identity – is not actually taking the place of someone else in the video, and it offers additional observational insight into the impact of the events as they occur.

Figure 1. Scene from the perspective of Karim, a Black student.

Figure 2. Scene from the perspective of Duy, an Asian American student.

While previous research has noted some differences between the impact of 2D video and 360-degree video for impact on empathy, comparatively little research is available on differences in impact between 360-degree video and interactive virtual reality scenes, though theoretical reflections have suggested an interactive experience may have greater impact.

Rather than adding another comparison of 2D versus 360-degree video, we opted instead to create a 360-degree only project, introducing the technological complexity of dual perspectives. Our research focused on 360-degree video specifically because it is now feasible to create projects using the medium at a consumer level. The cameras, editing software, and VR headsets needed to record, edit, and view such a video are priced such that they are reasonably accessible to the general public. The creation of interactive VR content, on the other hand, would be substantially more expensive and require a much higher level of specialized knowledge and skill. We were interested in exploring the potential of more accessible tools. Relatedly, there is little existing experimental research that suggests interactive VR is significantly more or less impactful than 360-degree video. The element of realism was also particularly important for our approach – we wanted our participants to experience this happening with real humans and not simulated characters.

There are several ethical considerations related to this approach. First, because 360-degree video was used, the participants are not visually embodied; there is no avatar with a skin color represented in the video. They meet the character they are taking the place of at the beginning of the video, and then view the scene from that character's perspective, without a body being visible. Research suggests that the presence or absence of an avatar makes little difference in outcomes (Herrera & Bailenson, 2021). Additionally, the dual-perspective approach means the participant not only experiences microaggressions against their character but also witnesses them happening to someone else. This opens up the possibility to experience both empathy and sympathy (Ramirez, 2020).

Additionally, we hope that fictional examples of microaggressions are less susceptible to making people "feel good about feeling bad" in ethically problematic ways (Nakamura, 2020). Much of the VR content that has been critiqued is either documentary footage or shows extreme circumstances that are usually almost immediately recognized as problematic (e.g., refugee camps, extreme poverty, or even war zones) without the need for VR to evoke embodied sympathy. Microaggressions, in contrast, are everyday occurrences that may not be obvious to those who don't regularly experience them.

After the script was complete, a casting call was issued at the beginning of the fall 2022 semester. Several auditions were held throughout September and October in order to complete casting. Rehearsals occurred in November and final filming occurred in December. All student actors were paid for both their time rehearsing and performing. A GoPro Fusion was used to capture video and audio during filming. The camera was placed approximately in the location where the student would be sitting in the classroom in order to mimic their perspective. Some audio, including the internal dialogue noted above, was recorded afterward using a Shure SM7B microphone connected to a laptop and using Audacity. Of note, we sought faculty or student support for those with prior work in 360-degree video and audio production; however, despite a vibrant and regionally well-known film/video concentration at the university, we were not able to find anyone with such experience. A graduate student at our university was hired to produce an original score for the opening and closing segments of the video.

Editing was completed in January 2023 by the researchers using Adobe Premiere Pro. The footage was stitched together using GoPro software before being imported into Adobe. Although the researchers had extensive past experience with video editing, this was their first time editing 360-degree footage. Subtitles were added to the video during this process also

using Adobe Premiere Pro. Each line was added 4 times, equally spaced around the video, so the script could be seen no matter where the viewer might be looking. All students involved in the project were invited to participate in writing this manuscript, but all declined.

Each video was then exported as a movie file that was uploaded as a YouTube 360-degree unlisted video. These videos were then able to be viewed on the Oculus headset using the YouTube application. Participants only ever viewed the videos using an Oculus headset. Unlike interactive, rendered VR environments, 360-degree video did not allow participants to physically interact with the scene or embody an avatar. This decision, as noted, was grounded in accessibility concerns, as interactive VR requires more advanced hardware and software. Future research might compare similar scenes recorded as 360-degree video and interactive rendered content to determine if there is an impact on levels of immersion or emotional and cognitive empathy. The two videos were made publicly available via YouTube in the summer of 2023 after all data collection was complete. They can currently be accessed here and are viewable in 2D via a screen or in 3D via the YouTube VR app:

- https://youtu.be/38kzWaa0cJk
- https://youtu.be/RKJXLIT1cQY

Experiment Design

In the spring 2023 semester, we began the process of recruiting participants for the research. We sought undergraduate participants who were as diverse as possible in terms of traditional demographically important variables such as age, gender, sexual orientation, race, ethnicity, educational attainment, political orientation and income. The purpose of prioritizing diversity at this stage was to try as much as possible to avoid bias, and – given the lack of a dominant hypothesis in the literature as to what groups are most likely to have any particular reaction to the video – we aimed to keep an open mind and seek respondents with as many different attributes as possible, in case some specific subgroup produced meaningful results.

To achieve this level of diversity we sought permission from the IRB to utilize a wide range of recruitment techniques. These included more traditional methods – postering, and sending emails – as well as methods that are less common on our campus – social media posts, and via creating and promoting an on-campus event for the exclusive purpose of providing attendees with the chance to volunteer to become respondents.

The method via which we did the majority of successful recruiting was by contacting faculty and arranging for the research team to visit their classroom in person to recruit for the project, and have the interested students participate right then. Professors typically arranged for us to do our recruitment on days when they had scheduled individual work on research projects, self–guided work on an assignment, or some kind of work that did not require the entire class period to finish. In this way, the students who participated did not miss classroom instruction time, and those students who chose not to participate were not negatively affected.

When we arrived in the classroom, the professor would typically describe the events planned for class that day, and then introduce us. The two PIs took turns in different classes reading a project overview from a prepared script (to help maintain uniformity across sessions) and interested participants were then given access to an informed consent page hosted on Google Docs via a QR code (with paper copies available). Students who completed the informed consent were then invited to view the VR experience in a separate room, two at

a time. Each researcher had a headset preloaded with the VR experience filmed from a different perspective, as a way to roughly evenly divide up the number of participants who would experience each perspective. Participants then completed a paper-based safety screening survey about potential physical discomfort while using VR. Participants who were likely to experience discomfort were not permitted to proceed. The headset was cleaned between each use and participants wore VR eye masks in order to prevent bacterial spread (Creel et al., 2020). Immediately after the participant completed the video, researchers asked two separate questions ("Are you feeling okay after the VR experience?" [wait for response] "Are you experiencing a headache, dizziness, nausea, vision problems, or sudden fatigue?" [wait for response]) designed to assess whether the participant was experiencing motion sickness. The IRB required the researchers not only to ask these questions, but also to have emesis bags on hand, as well as crackers and ginger ale for those who might feel ill, and also to review an approved first-aid video regarding treatment of motion sickness. While it is entirely reasonable to pre-screen for a history of motion sickness, and inquire generally about the participants' well-being following the VR experience, the extent of the focus on respondents' medical health felt quite strong, and at times – such as asking about a long list of specific medical symptoms to a participant who has just verbally stated that they feel fine – put the researchers in a position of seeming to insist that participating in their research is dangerous.

Participants completed a survey after viewing the VR video. We collected a total of 87 responses. Four responses were removed from the results because they indicated that the respondents were not current students, leaving 83 responses that were analyzed.

Measures

For our measures, we adapted and expanded a survey instrument by Roswell et al. (2020). We collected information about participants' demographics, their previous use of VR technology, and whether or not they experienced any physical discomfort. Additionally, we used a 5-point Likert scale to collect information about the following measures:

- *Engagement:* Because the success of VR is closely related to a sense of presence, we wanted to understand how present users were in the video, opting to measure their sense of engagement to achieve this (Souza et al., 2021).
- *Empathy:* Because so much research on VR is linked to the concept of empathy, we believe it is important to include this measure. We also wanted to better understand its potential connection to demographics and other, potentially alternative, cognitive measures.
- *Understanding:* Here we are interested in assessing people's understanding and cognition of both the experiences of others and microaggressions in particular (Aitamurto et al., 2021). To measure this, we asked three related questions about understanding the experience of others, understanding what microaggressions are, and understanding the negative impact of microaggressions.

Limitations

The majority of this research was collected by visiting classes and soliciting volunteers. This process might produce a halo effect for students and lead to their rating the project higher than they otherwise would.

Also, in the area of recruitment, one potential limitation emerged as a result of the researchers incorrectly assuming that a larger percentage of students would be interested in participating in the research because it would be their first opportunity to try out a VR headset. In fact, just 8 of 83 participants reported that this was their first VR experience, indicating that the technology is fairly commonplace. As a result, participation rates may have been adversely affected because we did not anticipate the need to "sell" respondents on participation.

Another assumption that could have affected the quality of the data was the assumption that our participants were familiar with the term "microaggressions." While the term itself was coined in 1969 (Johnson & Johnson, 2019), its popularity really began to rise only in 2014-2015, and its use was still increasing in 2022 when the script was being written for this project. So, it is entirely possible that at least some participants did not enter the research with a clear definition of that key term, which may have limited their understanding of the scenarios in the video as part of a larger trend experienced by members of racial minority groups.

Additionally, because of IRB requirements to closely monitor subjects for safety, the researcher was seated near participants when they filled out the survey. There is a potential that this could affect the participant's ability to report honestly. On the other hand, this proximity allowed participants to report issues or ask questions while completing the survey, which gave the researchers further insight into potential limitations.

A small number of students apparently initially misinterpreted the demographic questions about age, race, etc. as being about the character whose role they assumed. We amended the wording partway through data gathering for clarity. This might indicate they feared the survey was a "test," or an extension of the research rather than a way of gathering data about their experience.

Two participants mentioned they almost submitted negatively-skewed survey responses because the 5-item Likert scale on phones needed scrolling to view all options. Although these respondents corrected their responses, others might not have. For instance, a participant who reported strong disagreement with all questions on VR effectiveness and understanding microaggressions praised the VR in an open-ended question, potentially skewing the overall Likert scale results.

One final limitation can be seen in the case of one participant who spoke with a researcher after the experience. They gave feedback that having other students whom they know as actors in the video made it feel not real – "like a cartoon" – and so they found it wasn't helpful to learn from. Therefore, it is possible that knowing the actors outside of their role in the video decreased overall engagement.

RESULTS

Quantitative Results

Demographics

When looking at the race/ethnicity of our sample versus official university statistics (Office of Institutional Research and Planning, 2023) (see Table 1), our sample is generally representative of the makeup of the student body with two exceptions – an underrepresentation of Hispanic / Latinx respondents (7.2% vs. 15.6%) and an overrepresentation of respondents of two or more races (8.4% vs. 2.3%).

Table 1. Comparative Demographics

Demographic	Sample Population	University Population
Hispanic/Latinx	7.2%	15.6%
Two or more races	8.4%	2.3%
18-24 years old	90.4%	78.4%
25-34 years old	7.2%	10.5%
35+	2.4%	11.1%
Men	60.2%	45.6%
Women	31.3%	54.4%
Non-binary	3.6%	N/A
Transgender or gender non-conforming	2.4%	N/A
Other gender	2.4%	N/A

While the modal age category (18-24) is the same in our sample and university data, 90.4% of our sample was found in this group, whereas just 78.4% of the student population is in that age range. Our sample also showed an underrepresentation of those who are 35 years of age and older (2.4% vs. 11.1%).

The gender demographics results also indicate that our sample differs from the student population as a whole. In all, 60.2% reported as men, 31.3% reported as women, 3.6% reported as non-binary, and 2.4% reported as other. This is different from the university population (54.4% male vs. 45.6% female), although some of this difference can potentially be attributed to the lack of "non-binary" and "other" options in the university's instrument.

Experience with VR

Most respondents were not new to VR, with just 24% reporting that this was their first experience. Still, most people reported just a small number of previous VR experiences, with 29% saying they had 1-2 experiences, and 29% saying they had 3-10 experiences. Still, 5% reported moderately heavy use (10-20 previous) and 13% reported high levels of use (21+ experiences).

The vast majority of respondents (92%) reported experiencing no physical discomfort during the VR experience (See Table 2). A total of 5% reported experiencing problems, and 4% reported that they were unsure. More than a majority (55%) reported feeling "very engaged" with the VR experience, with another 36% reporting feeling "somewhat engaged," and just 8% reported feeling neutral.

Table 2. VR Experiences

First VR experience	24.1%
1-2 previous experiences	28.9%
3-10 experiences	28.9%
10-20 experiences	4.8%
21+ experiences	13.3%
No physical discomfort	91.6%
Experienced some problems	4.8%
Unsure if experienced problems	3.6%
Neutral engagement	8.4%
Somewhat engaged	36.1%
Very engaged	55.4%

Microaggressions

Overall, 78% of participants reported being familiar with what microaggressions are, 14% were unfamiliar, and 7% were unsure. Most respondents (63%) also reported that they had experienced microaggressions during their lifetime. Of those who reported experiencing microaggressions, 7% reported that it happened "very often," 18% responded "often," 40% responded "sometimes," and 36% responded "seldom."

VR Experience Perceptions

More than three-quarters of respondents had positive things to say about the nature and potential of VR technology for understanding others' perspectives, aligning with existing

literature on the benefits of 360 video and taking the perspective of a character for increasing empathy. In particular, 85% either strongly (49%) or somewhat (36%) agreed that the experience was an effective tool for understanding the experiences of other people. In all, 79% either strongly agreed (43%) or somewhat agreed (36%) that participating in the VR session allowed them to better empathize with people who experience microaggressions. And 77% also reported that they either strongly (49%) or somewhat (28%) agreed that they could better understand the negative impacts of microaggressions after viewing the VR experience.

Multivariate Analysis

We used SPSS to analyze the data and seek trends by race, by which VR experience participants saw, and also by their responses to various attitudinal questions. Most of these comparisons produced no statistically significant results, but there were a few key interactions that emerged from the data.

The first such result appeared when addressing our first research question, comparing those who watched the video from the Asian American student's perspective with those who watched the video from the Black student's perspective. Based on responses to the question, "I better understand what microaggressions are after this experience," those who watched the Asian American student's perspective were significantly more likely to report being better able to understand the effects of microaggressions (Pearson's chi-square = 9.973, df = 4, Cramér's V = .346, p = 0.041).

Across perspectives, we also saw consistent evidence of an empathy effect in our data. Those who responded most positively to the question "After participating in this VR session, I feel that I can better empathize with people who experience microaggressions" were more likely to respond positively to the statements, "This VR session is an effective tool for understanding the experiences of other people" (Pearson's chi-square = 136.095, df = 16, p < 0.001, Cramér's V = .640, p < 0.001), "I better understand what microaggressions are after this experience" (Pearson's chi-square = 104.536, df = 16, p < 0.001, Cramér's V = .561, p < 0.001), and "I better understand the negative impacts of microaggressions after this experience" (Pearson's chi-square = 127.720, df = 16, p < 0.001, Cramér's V = .620, p < 0.001).

However, not all respondents reported identical gains in empathy. Specifically, people who were unfamiliar with the term "microaggressions" were more likely to respond "not effective" to the questions: "This VR session is an effective tool for understanding the experiences of other people" (Pearson's chi-square = 25.023, df = 8, standardized residual = 3.2, Cramér's V = 0.388, p = 0.002) and "I better understand the negative impacts of microaggressions after this experience" **(**Pearson's chi-square = 15.736, df = 8, standardized residual of 2.7, Cramér's V = 0.308, p = 0.046).

Table 3. Significant Results

Variable 1	Variable 2	N	χ2	df	p	Cramer's V
What character were you in the video?	How much do you agree that you better understand what microaggressions are after this experience?	83	9.973	4	0.041	0.347
How engaged were you with the VR scene you watched?	What is your ethnicity?	83	33.847	18	0.013	0.452
	How much do you agree that VR is an effective tool for understanding the experiences of other people?	83	25.023	8	0.002	0.388
Before participating in this experience, were you familiar with the term "microaggression"?	How much do you agree that you better understand what microaggressions are after this experience?	83	15.736	8	0.046	0.308
	How much do you agree that you better understand the negative impacts of microaggressions after this experience?	83	15.736	8	0.053	0.308
Which character were you in this video?	How much do you agree that you better understand the negative impacts of microaggressions after this experience?	83	9.973	4	0.041	0.347
	How much do you agree that VR is an effective tool for understanding the experiences of other people?	83	136.095	16	0	0.640
How much do you agree that after participating in this VR session, you feel you can better empathize with people who experience microaggressions?	How much do you agree that you better understand what microaggressions are after this experience?	83	104.536	16	0	0.561
	How much do you agree that you better understand the negative impacts of microaggressions after this experience?	83	127.720	16	0	0.620

There was one final significant result that warrants mentioning, but with a caveat. This result emerged when we looked at the interaction between ethnicity and the question "How engaged were you with the VR scene that you watched?" In this case, the chi-square results (33.847, df = 18, p = 0.013) indicated a significant effect, while Cramér's V (.452) indicates a large effect size. After looking further into the data we found that those who identified as both Black / African American and Hispanic / Latinx had a standardized residual of 3.2 for the neutral answer (which was the lowest response given by any respondent). However, there was only one respondent who reported this particular combination of ethnicities, so we are reluctant to identify it as a true finding. For this same question, though, when looking at Hispanic / Latinx respondents independently, the standardized residual for the neutral response was 2.1, thus indicating that Hispanic / Latinx respondents were more likely than expected to report that the VR scene was only neutrally engaging. Given the larger number of

respondents who reported this ethnicity (N=6), this finding is more likely to represent a meaningful connection between ethnicity and engagement with the VR scene.

Qualitative Results

The final question in the survey was a qualitative clearinghouse question meant to solicit any feedback that respondents wished to share about the project. In all, 48 out of 83 (57.8%) respondents gave a response to this question, and their responses fell into several key themes. Some responses contained multiple themes, and not all responses coalesced around major themes, so the numbers in this section may not sum to 48.

Primary among observed themes (N=17) were positive comments on virtual reality's strengths as a modality for teaching about social issues, again emphasizing the value of the tool for building empathy and understanding of others. Responses particularly mentioned the aspect of taking the perspective of someone in the scenario, in line with the results of Herrera et al. (2018). Responses of this type highlighted VR as "a good tool" that allowed participants to "pla[y] the role of another individual, and se[e] things from their perspective." A few respondents highlighted the ability of VR "to demonstrate microaggressions," with one respondent noting, "[h]aving someone look me in the eye and say micro-aggressions gave me a more effective understanding than if I had just heard about it." Finally, one respondent said, "[a]s a white peer I never experience this so the VR put me in that place."

The second most common theme among the responses was comments about actors and acting. Four respondents made positive comments about particular actors or noted that the acting had elicited an emotional response ("I felt bad for Karim and Duy"). On the other side, six respondents provided negative feedback about the acting: two suggested generally that the "[a]ctors could have sold it a little better." Two respondents suggested that the use of an older actor in the role of the professor "would have been more realistic and might have affected me differently." And one respondent also believed that "Karim … seemed miscast, as I wasn't sure if the guy playing him was actually a black person."

Tied for the third most common theme addressed by respondents was the discussion of, and reflection on, the concept of microaggressions. Some reported unfamiliarity, saying, "[t]he most important lesson was the clarification of what microaggressions actually are" while another noted that "as a white student it is hard to see and understand the expectations of students of different ethnicities." Other respondents, however, reported being all too familiar: "It felt real and reaffirming the harm of micro aggressions where some people don't think they exist. My partner is an Asian American and the conversations in this project were nearly word for word what they experience weekly;" "I feel like I have witnessed a lot of what was taking place in this video with friends so it was a good thing brin[g]ing awareness to it."

DISCUSSION

Empathy and Understanding

One goal of this research was to assess what factors, if any, are associated with participants' reported levels of empathy and understanding following the VR experience. The first relevant finding has to do with factors external to the experiment, namely their personal background and experiences.

External Factors

One salient point was how commonly members of our sample experience microaggressions. Well over half of respondents (63%) reported having experienced microaggressions in their lifetime, which is higher than some previous research has shown. However, this aligns with recent research showing microaggressions are common, especially among younger people and marginalized groups. For instance, Douds and Hout (2020) found that "[o]ne in five Americans was disrespected at least weekly" (539), and that younger people were more likely to report experiencing microaggressions than older people, which meshes well with the overrepresentation of 18-24 year-olds in our sample. Other research also indicates that in some workplaces experiencing microaggressions by women is nearly universal, with 94% reporting it, and separately 81% of racial/ethnic minorities reporting experiencing them as well (Sudol et al., 2021). Still other research also indicates that experiencing microaggressions is a commonplace experience for students of color who attend historically White universities (Lewis et al., 2021). And although rates of commonly reported microaggressions are typically lower – sometimes in the single digits – among White males than among members of other race/sex pairings (Lloyd, 2020), such data is often gathered using a recollection period of one year, whereas our survey instrument inquired about lifetime incidence. Our survey also did not specify microaggressions, instead asking simply if respondents had experienced any, thus potentially broadening the range of incidents identified as microaggressions.

Although knowledge of, and personal experience with, microaggressions was commonplace, it was not universal; this gap in knowledge and experience revealed one of our key findings. The univariate results support the effectiveness of VR as an intervention, with strong support for statements asking about the effectiveness of VR in understanding others' experiences (85%), and for the potential for VR to affect people's attitudes about microaggressions specifically (79%). However, the multivariate results revealed that those respondents who were least familiar with microaggressions were more likely both to view VR as an ineffective means of affecting others' views, and less likely to report that they had gained a better understanding of the negative impacts of microaggressions. From this data it is possible to conclude that, when it comes to social justice, VR technology may be perceived as more effective by those who are already aware of, and support greater efforts around, the issues under discussion. This could be viewed as a problem of "preaching to the converted." Further research is needed to explore whether this effect holds only for microaggressions, and/or only for racial issues, or whether it is broader in scope. Future projects in this area might profitably explore new ways of presenting VR media, using different perspectives

(e.g., first-person vs. third-person), as well as utilizing avatars with different attributes, to identify the most effective methods of influencing viewers' perceptions and attitudes.

Regardless, our study shows a strong correlation between empathy for microaggression victims and related cognitive statements, such as better understanding of microaggressions and their impacts. While we couldn't discern if empathy was pre-existing or induced by the VR session, our findings represent a valuable addition to the literature in demonstrating the co-occurrence of these related cognitive states, and their persistence across participants of different races viewing a scene from the perspective of characters of two different races. This not only supports the idea that empathy can potentially be generated in shorter VR sessions than previously tested (Roswell et al., 2020), but it also suggests that otherness may not be required for the development of empathy. However, further research will certainly be required to provide firm empirical grounding for wider conclusions on these points.

The same type of work could be done around empathy, specifically in terms of what elements of a VR scene may elicit empathy most readily, and how respondent demographics, attitudes, and/or experiences may alter these outcomes. And even if this level of sophistication is not achieved, researchers could attempt something similar by, for instance, assigning participants a VR experience based off of their familiarity with the topic at hand. Rather than having everyone view the same experience – or randomizing which one is seen – perhaps those who are more familiar with the concept being discussed would view a more nuanced experience that gets into additional detail, whereas those unfamiliar with it would view a more introductory experience designed to acquaint them with it.

Dual-Perspective Methodology

One additional key finding from our study arose from the methodological/technological innovation of allowing respondents to view the scene from one of two perspectives – that of an Asian American student, or of a Black student. Results indicate that respondents perceived the presentation shown from the Asian American student's perspective to be a better tool for understanding microaggressions than the one shown from the Black student's perspective. There are a number of potential interpretations of this finding given the content of the VR scene.

One set of interpretations is that respondents might feel differently based on which character they perceived as experiencing worse treatment. However, there are two key issues with this interpretation. First, not only is there no objective way to rate what type(s) of discrimination are the worst but, anecdotally, respondents could not seem to agree among themselves which character had it the worst. Although this was not a question on the survey instrument, the researchers nevertheless had multiple respondents report that they felt that the character whose perspective they had taken on was the one who experienced the worse treatment. Tellingly, though, these reports came at approximately equal rates from those who had viewed the scene from the Asian American student's perspective and those who had done so from the Black student's perspective. Secondly, it is not clear whether – in a VR scene – viewing another character experience racial microaggressions would be more or less impactful than having those same microaggressions directed towards one's own character. Many might assume that personal involvement would produce greater effects, but it is

possible that seeing someone else go through the experience could provide some distance and opportunity for reflection that allows for attitude change.

Another interpretation has less to do with race and more to do with context. In the VR script, the Asian American student was in the position of having his academic ability overestimated by those around him, and was subjected to microaggressions by both students and the professor, including the question, “where are you really from?” which is well known as a microaggression generally, but is directed especially often at Asian people (Friedersdorf, 2015). In contrast, the Black student has his academic ability underestimated, and is targeted with a form of another well known – though more general – microaggression, “People like you…” Given that our respondents are undergraduate students who encounter increasingly difficult academic subject matter each semester, it could simply be that they empathize more with a student who is being asked to tackle difficult work than someone who is already very skilled in a subject area, regardless of the racial microaggressions that are directed at them.

Another possibility is that respondents felt less comfortable taking the role of a Black person than an Asian American person, and this manifested in lower reported perceptions of the effectiveness of the VR methodology. However, very little literature exists on how racist beliefs manifest in situations of inter-racial embodiment in VR. So, without further data, we must set this possibility aside for the moment.

In the end, it is intriguing that we saw the differences that we did across perspectives. Unfortunately, though, given the exploratory nature of this research we were unable to dig into exactly what caused this difference in perception. Future research – potentially involving a series of A/B tests – could be conducted with various audiences to determine how, and with whom, various messaging is most effective.

Demographics

There are a number of potential reasons why we saw an underrepresentation of Hispanic / Latinx respondents and an overrepresentation of respondents of two or more races. One possibility is down to differences in data collection. The university's Common Data Set uses race/ethnicity categories that do not denote anthropological origins, and restricts individuals to be counted in only one group. For instance, it specifies that Hispanic individuals are only reported under "Hispanic," while non-Hispanic multi-racial individuals are reported under "Two or more races." On the other hand, our data-gathering tool asked respondents to select all ethnicities that apply without providing "Two or More Races" as a separate option; instead, researchers assigned this category if a respondent chose multiple boxes.

Regarding Hispanic/Latinx students, it is possible they may have found our project less relevant, possibly due to the lack of specific racial conflict pertaining to their ethnicity. This could explain their lower engagement with the VR scene, and could potentially have led them to discourage peers from participating. However, as the lowest response to the question was "neutral," it seems unlikely that merely ambivalent respondents would actively advocate against peer participation.

The relevance hypothesis also doesn't fully explain why only one group is affected negatively. If all non-White groups had low participation, it could suggest concern among respondents about potentially traumatizing experiences. This is not a far-fetched idea, as even projects that are not designed to cause negative emotions may do so unintentionally:

"[w]omen and people of color … have a very different relation and response to these spectacles of immersive suffering. Seeing black and refugee bodies shot, drowned, and abused in VR is often experienced as trauma rather than as empathetic identification" (Nakamura, 2020, p. 62). However, we instead see a small overrepresentation of people of more than one race, and only marginal effects associated with other races. It seems unlikely that the Hispanic / Latinx population alone would avoid participating in this research and these effects would not extend to any other group.

In the end, more information would be needed to draw a definitive conclusion about why the Hispanic / Latinx population is underrepresented in our sample. Future researchers should keep a close eye on the racial demographics of their samples, and potentially consider utilizing quota sampling methods, to ensure balanced samples.

The majority of our participants were male (60.2%), contrasting with the slightly female-majority university population (54.4%). This may be because as many as 71% of university students who actively use VR technology are male (Frost et al., 2020), indicating an interest and familiarity gap. Considering only 27% of participants were first-time VR users, the male-majority result isn't unexpected.

Regardless of other considerations, though, female underrepresentation in VR research is an important issue, especially as the technology becomes more mainstream. If – as we've seen – female participants are less likely to volunteer, or be recruited, for VR studies then the field risks producing systematically biased data. Recent scholarship also indicates that female researchers are less likely to be involved in VR research, thus introducing further bias into the field (Peck et al., 2020). In future research it is crucial that researchers make an effort to address these gaps and try to achieve appropriate representation in their samples for members of all sexes.

One final demographic issue to explore is age. Our sample was overwhelmingly (90%) in the 18-24 age range, whereas just 74% of the student population is in that age range. This issue most likely stems from a pre-existing gap in familiarity and interest. Recent surveys indicate that younger people (18-34) report both the highest level of interest in, and knowledge of, VR technology among all age groups, and so it is reasonable to conclude that this manifests as a lower likelihood of older respondents volunteering for the research (Alsop, 2023a, 2023b).

Technological Aspects

Finally, it is important also to reflect on some methodological points raised in the research related to the technology that was used. To begin with, the restrictions around allowing participation only by those who pass a motion sickness screening – while it was intended to protect participants from harm – may have been unnecessary, at least for this methodology. Only 5% of participants reported any physical discomfort, and all cases were mild, which is well below the rates reported in other studies (see e.g., Rebenitsch & Owen (2020)). Furthermore, researchers could recall just one instance in which a student volunteered but was denied participation after filling out the motion sickness survey.

The nature of our VR project, which involved only stationary viewing, may explain the low incidence of motion sickness. Likely, more active scenes might induce more discomfort. Notably, several participants told researchers that they associated their past VR-induced

sickness with extensive use or high-movement games. As VR becomes more common, researchers can potentially rely on participants self-selecting into low-movement VR scenes, and only screen new VR users for motion sickness. Our findings, therefore, suggest that 360-degree video might be more accessible than interactive VR for a wider audience. However, there was no significant relationship between being a first time VR user and whether or not they experienced any discomfort (chi-square = 2.361, df = 2, Cramér's V = 0.169, p = 0.307), so it is possible that no instrument is required at all.

We recommend that researchers resist the trend of including complex medical terminology in consent forms, extensive health warnings, and stringent requirements like 1:1 participant monitoring. Given the prevalence of motion sickness in VR, its inclusion in the informed consent process is necessary, but the emphasis on its risk—particularly in low-movement VR scenarios—appears exaggerated relative to the potential for actual harm. Overemphasizing medical risks may deter participation overall by inducing fear, especially among VR novices such as women and older individuals, potentially exacerbating existing disparities in VR research participation.

On the issue of new users, there were some occasional technological challenges associated with getting first-timers acclimated to the VR environment. Some amount of this is due to operating an unfamiliar technology, as well as needing to adapt to the sudden perspective shift associated with viewing a VR scene. However, some amount of it is also due purely to the "cool factor" of being able to look around in a virtual environment for the first time. This created an issue, however, because our scene contained some important information within the first few seconds of the video, namely introducing the viewer to the character from whose perspective they'd be viewing the video. There was some thought of allowing participants to have a "warm-up" time during which they could get used to the technology in a neutral VR scene. However, the amount of time per participant was already relatively high due to the need to describe the project, obtain informed consent, administer the motion sickness instrument, demonstrate the VR technology, explain the use of the single-use face shield, assist respondents in putting on the VR headset and accessing the VR scene, allow them to watch the scene, inquire about their motion sickness, administer the post-survey, and then provide them with and explain the debriefing sheet. In the end, it was common for participants to spend 15-20 minutes all told doing these various steps. Adding on even 2-3 additional minutes for new users to get used to the technology risked further lengthening an already extended process. On the other hand, failing to offer this chance to become familiar with the technology puts users at risk of missing key information in the VR scene. We recommend that future researchers in this area develop their VR scenes with this issue in mind, and consider either building in an explicit extra step for new users, or perhaps structuring the VR scene such that it is front loaded with a small amount of time (such as a display of credits) to allow users to orient themselves before they need to pay attention to the material.

On the issue of tailoring material to users' needs, we received a small number of comments from students who were unsure whether the actor playing the character Karim was Black. Although this is later confirmed by a line in the script where Karim self-identifies as Black, participants who were confused might have already developed an inaccurate perception of the scene by that time. In any similar research ventures in the future, we

recommend that researchers take extra care to ensure that all key variables are made explicit, whether in voiceover, on-screen text, etc.

As noted above, we chose to use 360-degree video rather than an interactive VR environment. Future research should explore the impact of such technological decisions, measuring the difference in impact between 360-video and interactive VR, while also comparing this to instances of motion sickness. Would the inclusion of more interactive elements increase engagement and empathy outcomes while still remaining accessible? Would avatar embodiment affect these outcomes? Our dual-perspective approach also raises new questions. How would participants react if they experienced the scene from both perspectives rather than just one, for example? Our research has contributed to ongoing discourse about the potential role of VR technology in social justice education, while highlighting both the importance of and need for further study of the technological approaches implemented in such projects.

CONCLUSIONS

This research offers an intersectional, exploratory approach to using VR, including the use of a unique two-perspective methodology that allowed respondents the ability to both experience and witness the occurrence of microaggressions at the same time. The finding that one of these perspectives (the Asian American student, whose math abilities are overestimated) created a larger impact than the other is a novel finding that should be explored in subsequent research for purposes of replication, but also to explore the effects of changes to things like the racial identity of characters, the setting in which the interactions take place, power/status differentials, etc.

Additionally, our results support previous findings that VR can help users better understand, and empathize with experiencing, microaggressions and that both cognitive and affective impacts can be increased through VR experiences and are most likely connected to one another. However, we found that VR appears to have the greatest impact on those who are already aware of, and engaged with, a particular issue. This is a crucial point to address especially as VR technology advances and is used more widely and in a greater variety of settings. Caution may be warranted for those seeking demonstrable impacts of VR based training, especially around social issues (e.g., companies implementing diversity, equity, and inclusion training). Further exploration of the points raised in this research will be important to the long-term understanding of the impact of VR experiences, especially in their use for social justice related projects.

IMPLICATIONS FOR RESEARCH, APPLICATION, OR POLICY

This study demonstrates the effectiveness of VR as a way to generate empathy and understanding in those who experience it. However, it sounds a cautious note because VR appears to have the greatest impact on those who are already aware of, and engaged with, a particular issue. This is a crucial point to address especially as VR technology advances and is used more widely and in a greater variety of settings. Caution may be warranted for those

seeking demonstrable impacts of VR based training, especially around social issues (e.g., companies implementing diversity, equity, and inclusion training), and additional research is required to explore this. Additional awareness of, and research into, the impact of the race of the perspective being taken in the VR scene also needs to be completed, as our research suggests that this impacts the overall effectiveness of the experience.

This study also identifies several best practices for VR researchers to consider when designing studies, particularly for those in settings where it is compulsory to seek approval from an IRB. Hopefully these recommendations will be adopted widely and can contribute to standardization in the field, thus facilitating further research.

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Appendix A

Non-Significant Results

Variable 1	Variable 2	N	χ2	df	p	Cramer's V
What is your ethnicity?	How much do you agree that VR is an effective tool for understanding the experiences of other people?	83	45.664	36	0.130	0.371
	How much do you agree that after participating in this VR session, you feel you can better empathize with people who experience microaggressions?	83	41.702	36	0.237	0.354
	How much do you agree that you better understand what microaggressions are after this experience?	83	41.109	36	0.257	0.352
	How much do you agree that you better understand the negative impacts of microaggressions after this experience?	83	47.438	36	0.096	.378
	How engaged were you with the VR scene you watched?	83	15.613	12	0.210	0.307
What is your gender?	How much do you agree that VR is an effective tool for understanding the experiences of other people?	83	19.451	24	0.728	0.242
	How much do you agree that after participating in this VR session, you feel you can better empathize with people who experience microaggressions?	83	23.404	24	0.496	0.266
	How much do you agree that you better understand what microaggressions are after this experience?	83	22.599	24	0.544	0.261
	How much do you agree that you better understand the negative impacts of microaggressions after this experience?	83	20.172	24	0.687	0.246
	How engaged were you with the VR scene you watched?	83	1.360	2	0.507	0.128
Which character were you in this video?	How much do you agree that VR is an effective tool for understanding the experiences of other people?	83	2.952	4	0.566	0.189
	How much do you agree that after participating in this VR session, you feel you can better empathize with people who experience microaggressions?	83	1.353	4	0.852	0.128
	How much do you agree that you better understand what microaggressions are after this experience?	83	7.586	4	0.108	0.302
	How engaged were you with the VR scene you watched?	83	2.620	6	0.855	0.126
How old are you?	How much do you agree that VR is an effective tool for understanding the experiences of other people?	83	5.194	12	0.951	0.144
	How much do you agree that after participating in this VR session, you feel you can better empathize with people who experience microaggressions?	83	7.375	12	0.832	0.172
	How much do you agree that you better understand what microaggressions are after this experience?	83	5.340	12	0.946	0.146
	How much do you agree that you better understand the negative impacts of microaggressions after this	83	4.057	12	0.982	0.128

	experience?					
Was this your first experience with VR?	How engaged were you with the VR scene you watched?	83	4.538	2	0.103	0.234
	How much do you agree that VR is an effective tool for understanding the experiences of other people?	83	3.945	4	0.413	0.218
	How much do you agree that after participating in this VR session, you feel you can better empathize with people who experience microaggressions?	83	3.341	4	0.502	0.201
	How much do you agree that you better understand what microaggressions are after this experience?	83	7.433	4	0.115	0.299
	How much do you agree that you better understand the negative impacts of microaggressions after this experience?	83	6.798	4	0.147	0.286
Did you experience any physical discomfort during the VR session?	How engaged were you with the VR scene you watched?	83	2.917	4	0.572	0.133
	How much do you agree that VR is an effective tool for understanding the experiences of other people?	83	6.960	8	0.541	0.290
	How much do you agree that after participating in this VR session, you feel you can better empathize with people who experience microaggressions?	83	7.572	8	0.476	0.214
	How much do you agree that you better understand what microaggressions are after this experience?	83	2.876	8	0.942	0.132
	How much do you agree that you better understand the negative impacts of microaggressions after this experience?	83	4.152	8	0.843	0.158
Before participating in this experience, were you familiar with the term “microaggression”?	How engaged were you with the VR scene you watched?	83	5.258	4	0.262	0.178
	How much do you agree that after participating in this VR session, you feel you can better empathize with people who experience microaggressions?	83	12.115	8	0.146	0.270
	How much do you agree that you better understand what microaggressions are after this experience?	83	10.788	8	0.214	0.255
Have you experienced microaggressions in your lifetime?	How engaged were you with the VR scene you watched?	83	0.196	2	0.907	0.049
	How much do you agree that VR is an effective tool for understanding the experiences of other people?	83	3.201	4	0.525	0.196
	How much do you agree that after participating in this VR session, you feel you can better empathize with people who experience microaggressions?	83	2.480	4	0.648	0.173
	How much do you agree that you better understand what microaggressions are after this experience?	83	2.283	4	0.684	0.166
	How much do you agree that you better understand the negative impacts of microaggressions after this experience?	83	2.337	4	0.674	0.168
	How engaged were you with the VR scene you watched?	83	6.338	10	0.786	0.195

How often have you experienced microaggressions?	How much do you agree that VR is an effective tool for understanding the experiences of other people?	83	25.509	20	0.183	0.277
	How much do you agree that after participating in this VR session, you feel you can better empathize with people who experience microaggressions?	83	27.978	20	0.110	0.290
	How much do you agree that you better understand what microaggressions are after this experience?	83	28.008	20	0.109	0.290
	How much do you agree that you better understand the negative impacts of microaggressions after this experience?	83	29.566	20	0.077	0.298
What was the last grade of school that you completed?	How engaged were you with the VR scene you watched?	83	6.777	10	0.746	0.202
	How much do you agree that VR is an effective tool for understanding the experiences of other people?	83	12.378	20	0.902	0.193
	How much do you agree that after participating in this VR session, you feel you can better empathize with people who experience microaggressions?	83	14.339	20	0.813	0.208
	How much do you agree that you better understand what microaggressions are after this experience?	83	10.618	20	0.956	0.179
	How much do you agree that you better understand the negative impacts of microaggressions after this experience?	83	8.713	20	0.986	0.162

Appendix B

Full Text of Respondent Post-VR Survey

"Changing Minds" post-VR survey

This survey will allow you to share your experiences after viewing the "Changing Minds" VR project at Fitchburg State University. Your responses will be kept confidential and not shared with anyone outside of the research project. Your participation in this research is completely voluntary and you may choose to stop participating at any time without penalty.

* Required

1. Which character were you in this video? *

   Mark only one oval.

   Karim Monroe (Black student)
   Duy Nguyen (Asian student)

2. How old are you? * Mark only one oval.

   18-24 years old
   25-34 years old
   35-44 years old
   45-54 years old
   55-64 years old
   65+ years old

3. What is your ethnicity? (please select all that apply) * Check all that apply.

American Indian or Alaska Native
Asian
Black or African American
Hispanic or Latinx
Native Hawaiian or other Pacific Islander
White
Prefer not to answer

Other:

4. What is your gender? (please select all that apply) * Check all that apply.

Man
Woman
Non-Binary
Transgender or gender non-conforming
Prefer not to answer
Other:

5. Are you currently enrolled as an undergraduate student? * Mark only one oval.

Yes
No

6. What was the last grade of school that you completed? * Mark only one oval.
Grade school (8th grade or less)
Some high school (did not graduate high school)
High school graduate (12th grade or GED)
Some college (1 or more years without graduating)
Associates Degree/Technical Degree
College Graduate (4-year college, Bachelor's degree)
Some postgraduate (no advanced degree)
Master's degree
Professional degree
Doctorate degree
Prefer not to answer

7. Did you experience any physical discomfort during the VR session (e.g. dizziness, vertigo,
etc.)? *Mark only one oval.

Yes
No
Not Sure

8. Was this your first experience with Virtual Reality (VR)? * Mark only one oval.

Yes → Skip to Question 10
No
Not Sure

9. How many previous experiences have you had with VR? * Mark only one oval.

1-2
3-10
10-20
21+

10. How engaged were you with the VR scene that you watched? * Mark only one oval.

Very engaged
Somewhat engaged
Neutral
Somewhat unengaged
Very unengaged

11. How much do you agree with each of the following statements? * Mark only one oval per row.

Strongly disagree
Somewhat disagree
Neither agree nor disagree
Somewhat agree
Strongly agree

- This VR session is an effective tool for understanding the experiences of other people.
- After participating in this VR session, I feel that I can better empathize with people who experience microaggressions.
- I better understand what microaggressions are after this experience.
- I better understand the negative impacts of microaggressions after this experience.

12. Before participating in this experience, were you familiar with the term "Microaggression"? * Mark only one oval.

Yes
No
Not Sure

13. Have you experienced microaggressions in your lifetime? * Mark only one oval.

Yes → Skip to question 14
No → Skip to question 15

14. Microaggression Followup: How often have you experienced microaggressions? * Mark only one oval.

Very often
Often
Sometimes
Seldom
Rarely

15. Additional Comments

Please feel free to add any additional comments. For example: Which aspect(s) of today's experience were most memorable? And why? Was there anything negative about your experience with VR or anything that could be improved about the experience for the future?

Which character were you in this video?
Karim Monroe (Black student)
Duy Nguyen (Asian student)

How old are you?
18-24 years old
25-34 years old
35-44 years old
45-54 years old
55-64 years old
65+ years old

What is your ethnicity? (please select all that apply)
American Indian or Alaska Native
Asian

Black or African American
Hispanic or Latinx
Native Hawaiian or other Pacific Islander
White
Prefer not to answer
Other (fill in)``

What is your gender? (please select all that apply)
Man
Woman
Non-Binary
Transgender or gender non-conforming
Prefer not to answer

Are you currently enrolled as an undergraduate student?
Yes
No

What was the last grade of school that you completed?
Grade school (8th grade or less)
Some high school (did not graduate high school)
High school graduate (12th grade or GED)
Some college (1 or more years without graduating)
Associates Degree/Technical Degree
College Graduate (4-year college, Bachelor's degree)
Some postgraduate (no advanced degree)
Master's degree
Professional degree
Doctorate degree
Prefer not to answer

Did you experience any physical discomfort during the VR session (e.g. dizziness, vertigo, etc.)?
Yes
No
Not Sure

Was this your first experience with Virtual Reality (VR)?
Yes
No
Not Sure

How many previous experiences have you had with VR?
0

1-2
3-10
10-20
21+

How engaged were you with the VR scene that you watched?

Very engaged
Somewhat engaged
Neutral
Somewhat unengaged
Very unengaged

The following question was posed: “How much do you agree with each of the following statements?” followed by these statements:

This VR session is an effective tool for understanding the experiences of other people.
After participating in this VR session, I feel that I can better empathize with people who experience microaggressions.
I better understand what microaggressions are after this experience
I better understand the negative impacts of microaggressions after this experience..

Before participating in this experience, were you familiar with the term "microaggression"?

Have you experienced microaggressions in your lifetime?

[If yes to base question] →
How often have you experienced microaggressions?

Very often
Often
Sometimes
Seldom
Rarely

Please feel free to add any additional comments. For example: Which aspect(s) of today's experience were most memorable? And why? Was there anything negative about your experience with VR or anything that could be improved about the experience for the future? [Open-ended response.]

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DESIGNING A FRAMEWORK FOR ETHNOGRAPHY-DRIVEN PROMPT ENGINEERING IN SOCIAL WORK

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Abstract: *This study proposes a framework for integrating ethnographic principles into prompt engineering (PE) for large language models (LLMs) in social work. While PE has emerged as a key methodology for optimizing LLM outputs, it often lacks grounding in the cultural contexts of end users. By bridging theoretical approaches and methodologies from social and computer sciences, the proposed framework addresses the limitations of a strictly semantic approach in PE. The framework's theoretical foundations are grounded in empirical data gathered during an ethnographic field study conducted within a social service organization. Ten interviews were analysed following the key stages of the ethnographic analysis method. Key cultural themes composed of multiple semantic relationships were uncovered and then connected to core prompt components. These components were further elaborated into various prompting techniques and developed into a set of prompt templates that can be applied to LLM evaluation and further customization.*

Keywords: *large language models, prompt engineering, ethnography, social work.*

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INTRODUCTION

Background. Recently, AI systems have revolutionized a range of professional workflows (Ratnayake and Wang, 2023), and social work professional settings are no exception. Specifically, variations of programs powered by large language models – including chatbots, virtual assistants, simulations, and conversational agents – have been increasingly adopted across typical work environments (Ranade et al., 2024) and have gradually been employed in social service delivery (Seniutis, Sas, Gružauskas, 2024). Several countries have successfully implemented these LLM-driven solutions in public services. In Sweden, 95% of local authorities have replaced certain staff functions with AI-powered digital coworkers (O'Dwyer, 2020). In Norway, the virtual agent "Frida" has handled 270,000 inquiries on social security benefits during the COVID-19 pandemic, equivalent to the workload of 220 service agents (Ringes, 2020). In Finland, Kela has processed 3 million interactions, with 72% of benefit applications submitted online (Kela, 2021).

The rapid expansion of large language models (LLMs) has sparked significant interest, not only in their social impacts – primarily focusing on the benefits and risks their outputs pose to users – but also in understanding and enhancing their performance from a technical perspective. A substantial body of literature highlights that crafting effective prompts is crucial to maximizing the capabilities of LLMs (Ein-Dor et al., 2024; Ranade et al., 2024; Schulhoff et al., 2024; Wei et al., 2022; Liu et al., 2023b;Napieralski et al., 2024).

Since general-purpose LLMs, also known as pre-trained or foundation models, trained on large datasets, may not always perform optimally for domain-specific tasks, specialized LLMs are developed to deliver enhanced performance and tailored outputs for specific applications. One fundamental approach to specializing LLMs is fine tuning (see Table 1). It involves using a custom dataset tailored to the target domain to further train a pre-trained general-purpose model. This process adjusts the model's parameters, enabling it to capture domain-specific nuances and improve performance on specialized tasks. Beyond adjusting the model itself, prompt engineering, can be employed as an effective way to improve LLM performance. By crafting precise hard prompts, users can steer a general-purpose model toward generating more accurate and contextually relevant responses to their inputs without needing the model to be retrained (Schulhoff et al., 2024). When managing complex and specific tasks with LLMs, prompt tuning, which leverages AI-driven design of soft prompts, can serve as both a substitute for additional training data and a method to guide the model toward desirable outputs. To automate and optimize the process of prompt creation, prompt tuning introduces the concept of soft prompts. Instead of manually designing prompts, soft prompts are learnable embeddings that the model adjusts during training (Khattab et al., 2024; Yuksekgonul et al., 2024; Kolková & Ključnikov, 2022).

Our study focuses primarily on prompt engineering (PE), aiming to explore how methodological strategies from social research can inform the process of prompt crafting. Through this exploration, we actively engage in the process by not only providing guidance but also constructing prompts, incorporating certain techniques from prompt tuning (PT) in the process.

Table 1. Approaches to specialize a pre-trained model for domain-focused tasks

Approach	Fine tuning	Prompt engineering	Prompt tuning
Lifecycle stages	Training	Deployment	Training/ Deployment
Status of LLM	Pre-trained model (untuned)	Pre-trained or fine-tuned model	Pre-trained or fine-tuned model
Input sources	Labelled data + Input	Hard prompt + Input	Soft prompt + Input
Task roles	Humans create and annotate datasets; inputs are used after training.	Humans craft hard prompts (text) and provide inputs to guide outputs during exploitation.	Humans provide input-output examples for training; the model optimizes soft prompts (learnable embeddings) for use during exploitation.
Description	Enhances a pre-trained model during the training phase by incorporating a large number of tunable examples. This ensures the model generates domain-specific outputs in response to user inputs.	Guides an untuned pre-trained model during the exploitation phase by using human crafted hard prompts. These prompts precede user inputs to help the model deliver accurate and relevant outputs.	Optimizes soft prompts in a lightweight training phase, adjusting their parameters to guide responses without altering the model. The optimized prompts are combined with user inputs.

State of art. Prompt engineering (PE), defined as the process of crafting effective input queries to enhance LLM outputs (Brown et al., 2020), is considered one of the most robust methodological approaches for evaluating model effectiveness. However, PE has been criticized for its narrow focus on prompt engineering techniques, primarily involving trials and tests to establish best practices for prompt design (see Short and Short, 2023; White et al., 2023). To address these limitations, Ranade et al. (2024) proposes a theoretical foundation for effective prompt engineering by integrating rhetorical theory, combining the architectural workflows of algorithms with insights from writing studies. Goloujeh et al. (2024) and Sanchez (2023) also highlight the predominant focus in PE on the semantic structure of prompts, including syntax (Jiang et al., 2022), the role of word order (Lu et al., 2022), use of constrained vocabularies, prompt formulation, and writing techniques (Liu et al., 2023; Liu and Chilton, 2022). Goloujeh et al. (2024) further emphasize the general tendency to focus on individual interactions between the user and the LLM (Pereira et al., 2023) and extend their analysis to the social dynamics within prompt communities. They illustrate how prompts emerge as social constructions shaped by the competing interests of different groups and highlight that collective knowledge is just as crucial for the development of new prompt creation practices as the technical tools used for crafting prompts.

Our study views prompt engineering not merely as a socially constructed practice but as an integrated process encompassing both social and technical dimensions. It offers a methodological framework designed to ensure a human-centred approach in prompt engineering, effectively linking social contexts that require LLM solutions with the technical PE strategies which enhance models' performance. Guided by ethnographic principles, this framework ensures that prompt design is deeply rooted in the complexities of social realities.

Study aim. Drawing on our preparation for a case study aimed at creating prompts to evaluate the effectiveness of a specific LLM in social work practice, we developed and examined the methodological steps involved, providing examples of how to incorporate socio-technical contexts, such as the use of LLMs in social work practice, into the prompt design process. This framework aims to inform the prompt design process with insights from prompt users (social workers), ensuring that the prompts are effectively tailored to their professional interests and settings. The objective is to move beyond the surface-level semantic symbols (folk terms) used by social workers to uncover the cultural meanings that shape their professional practice and convert these insights into effective prompts.

First, we review theoretical and methodological perspectives drawn from social and computer sciences to contextualize our choice of ethnography and prompt engineering as foundational elements for developing our new framework. Next, we outline a range of ethnographic principles essential for formulating research questions that uncover specific insights and detail how these insights can be analysed and systematically organized into relevant topics. We then review the essential structural components of a prompt and the most relevant prompt engineering techniques, providing examples of each. Finally, we demonstrate how topics drawn from our ethnographic analysis inform the key structural components of a prompt and can be embedded into various prompting techniques.

METHODOLOGY

To formulate the theoretical and methodological foundations of the framework outlined in the 1-3 objectives and further elaborated in the corresponding paragraphs of the Results section, we conducted an exploratory review of interdisciplinary literature, covering both social and computer sciences. We did not conduct a traditional systematic literature review, due to the limited amount of existing peer-reviewed literature on integrating social research methodology into prompt engineering. Instead, our approach was more aligned with scoping studies, which focus on swiftly identifying the fundamental ideas driving a research domain and the main evidence and sources available, especially in fields that are complex or have not been thoroughly reviewed (Arksey & O'Malley, 2005). Such methodological approaches have proven effective in emerging interdisciplinary fields where systematic literature reviews may be constrained by limited peer-reviewed literature (Farchi et al., 2021).

Our review was guided by these three research questions: 1) What are the common approaches within social and computer sciences for conceptualizing, developing, and evaluating sociotechnical systems? 2) How are ethnographic data collection and analysis methods applied to examine human and non-human cultures? and 3) What are the key components of prompts, and the techniques used for prompting? After identifying an initial set of sources for each of the questions across Web of Science, EBSCO, and SCOPUS, we reviewed the reference lists to find additional literature.

Table 2. Ethnographic interviews with social workers

Client group	Number of interviews (units)	Interview duration (h)
Homeless	2	02:22:30
Migrants	2	03:14:38
Families experiencing separation	2	01:56:33
Formerly incarcerated individuals	2	02:16:10
Single mothers raising children	2	02:23:28
	Total: 10	**Total:** 12:13:19

Additionally, in order to construct and test our framework, as outlined in Objective 4 and the corresponding paragraph of the Results section, we conducted an ethnographic field study in a NGO by observing the daily work practices of and interviewing social workers engaged in face-to-face interactions with their clients (see Table 2). We developed an interview

instrument, gathered and analysed data according to ethnographic principles and procedures (see Spradley 2016), which are thoroughly discussed in the Results section. Data analysis was conducted manually using conventional software tools, without the involvement of artificial intelligence (AI) or machine learning (ML) techniques. We also demonstrated how the gathered insights can be integrated into prompt formulation.

RESULTS

1. Theoretical and methodological connections between social and computer sciences

In the initial part of this study, we review theoretical and methodological perspectives derived from social and computer sciences, which offer sufficient analytical concepts and methodological principles to explain and investigate such phenomena as socio-technical systems. Looking at the historical debate on technology and society, we identify shared efforts among researchers in these fields to conceptualize socio-technical systems while striving to avoid deterministic views. This discussion highlights the importance of these approaches to our framework. We then examine the dominant methodological positions held by scholars on either side of the debate.

1.1. Overcoming technological and social determinism in conceptualization of sociotechnical systems

The academic debate about digital technologies and society within social and computer sciences began in the mid-20th century, as the commercialization of early computers opened the door to their wider use (Kling et al., 2005). From the 1950s to the 1970s, due to the high costs of emerging computer technologies, these advancements were mainly used in business. This led researchers to focus on how computerized systems affected organizational structures. Scholars from various fields also studied the social impacts of these systems, each bringing the methods and theories of their disciplines. On one side were social scientists – sociologists, educators, communication experts, and political scientists. On the other were experts from the formal sciences1, including informatics, computer science, and information science (Mitchel & Talburt, 2003; Wanda J. Orlikowski & Barley, 2001; Wanda J. Orlikowski & Iacono, 2001; Yatsko, 2018).

Advances in digital technologies opened new applications, encouraging researchers to adopt innovative approaches. For example, the 1970s saw a rapid expansion of digital technologies in the public sector. By the late 1980s, Rob Kling, a key figure in the formal sciences, formally established the field of social informatics, defining it as “the interdisciplinary study of the design, uses, and consequences of information and communication technologies that takes into account their interaction with institutional and

1 Formal sciences are a field of study in which knowledge is created by analysing abstract structures or, in other words, formal systems, rather than elements of the natural or social world, which respectively become the objects of the natural and social sciences.

cultural contexts" (2005, p. 5). His work emphasized the need to integrate theoretical and methodological perspectives from both formal and social sciences, aiming to create a more comprehensive understanding of the social dimensions of computerization. This shift ultimately required researchers to broaden their focus – from solely examining organizational contexts and computerized systems to exploring the wider applications and social implications of emerging digital technologies.

A similar shift occurred among social scientists, moving from purely intradisciplinary approaches – focused on a single field – to interdisciplinary approaches that integrate insights from multiple disciplines. In the 1960s, this shift led to the formation of a new field, closely linked to sociology, which borrowed tools and methods from anthropology, geography, history, organizational studies, and philosophy of science. Formally named "Science, Technology, and Society" (STS), it is also known by other titles such as "Science Studies", "Science and Technology Studies", "The Sociology of Scientific Knowledge", and "Social Studies of Science and Technology" (Law, 2008, pp. 624–626).

While social informatics began with studies on how computerized systems impact organizational work, STS pioneers like Thomas Kuhn, Wiebe Bijker, Steve Woolgar, Michel Callon, and Bruno Latour were more interested in the sociological foundations of the scientific method and the technologies it produces. Although they originated separately, both fields moved in a similar direction: social informatics began focusing on social knowledge and the societal impacts of technologies, while STS increasingly concentrated on technology itself and the knowledge fields that interpret it. Researchers in both disciplines shared an interdisciplinary commitment to understanding the socio-technical nature of these phenomena. Their central question was this: does society shape technological advancement, or do technologies determine societal change? This question formulation underscores a divide between two theoretical perspectives: one side leans toward social determinism, while the other supports technological determinism. Notably, both formal and social scientists are represented in these opposing viewpoints.

Kling introduced social informatics as a response to the dominance of technologically deterministic theories within informatics (Kling et al., 2003, 2005; Lamb & Sawyer, 2005). His approach – STIN (Socio-Technical Interaction Network) – draws on the socio-technical principles of Bijker, an early STS pioneer, whose ideas laid the groundwork for the SCOT (Social Construction of Technology) approach within STS (Sawyer & Tyworth, 2006). SCOT ultimately led to a shift within the STS movement – from theories rooted in social determinism to more radical perspectives that emphasize the autonomy of technology relative to social reality.

SCOT is grounded in the idea that technologies are socially constructed, suggesting that they are forms of material culture shaped by active social interests. In this view, the structure of technologies is seen as a reflection of social order. However, some STS scholars have criticized this SCOT view, arguing that technologies, as technical systems, contain a distinct relational logic – reflecting relationships among system components – that can influence and reshape social reality. Therefore, social reality alone cannot fully explain technical systems and requires explanation itself (Law, 2008).

An alternative perspective was offered by STS representatives Michel Callon and Bruno Latour, who laid the foundations for Actor-Network Theory (ANT). To avoid a reductionist view of socially constructed technologies, they propose a radical interpretation of sociality.

The primary assumption of this approach is that sociality is constantly constructed and transformed in real interactions between heterogeneous (non-homogeneous, diverse in nature) elements: people, technologies, natural phenomena, documents, non-human life forms, knowledge, social factors, and so on. Some critics associate ANT with technological determinism due to the unique autonomy granted to non-human actors according to this perspective (Collins & Yearley, 1992; Grint & Woolgar, 1997). Key ANT concepts show that ANT offers an unusual yet valid approach to traditional sociological thinking, avoiding social or technological determinism when creating knowledge about the socio-technical systems (Tatnall, 2005). For example, within this approach, agency is understood as the ability of both human and particularly non-human actors to involve other actors in action in unexpected ways, thereby assembling a heterogeneous network. This contrasts with the traditional understanding in social sciences, where action is controlled by human consciousness and confined exclusively to the human realm, as well as with the natural sciences, where action is perceived as material causality driven by the logic of cause and effect, thus being largely predictable (Latour, 2005).

The analysis of theoretical perspectives drawn from social and computer sciences shows that socio-technical systems, whose composing elements should be reflected in prompt design, must be ontologically understood in a way that avoids both social and technical determinism. Contemporary research in transportation and urban planning demonstrates similar challenges in understanding complex socio-technical interactions, where technological innovations like autonomous vehicles require careful consideration of both social acceptance and technical implementation (Razavi & Sierpinski, 2024). This can be achieved by accounting for the unpredictable agency of both human and non-human actors (see Table 3).

Table 3. Theoretical perspectives within social and computer sciences

Science field	Social science		Computer science
Discipline	Science Technology and Society (STS)		Social informatics (SI)
Theoretical perspective	SCOT	ANT	STIN
	Towards social determinism	Overcoming technological and social determinism	From technological towards social determinism
Relevant authors	Bijker W. E.	Latour B.	King R.

1.2. Overcoming technological and social determinism in developing and evaluating impact of sociotechnical systems

User-centred design emerged as a fundamental approach within computer science, particularly in the field of human-computer interaction (HCI), during the 1980s. It emphasized that designing computer systems is not simply a technical undertaking but also a social and cognitive process (Norman, 2013). This approach highlighted the significance of considering the user's context and needs throughout the entire design process (Winograd & Flores, 1986). Ethnographic methods, recognized as the most effective means, were employed to gain deeper insights into the situated nature of human interactions with technology (Suchman, 1987).

Rooted in the social sciences, ethnography has been traditionally viewed as a privileged methodology in anthropology and began making its way into human-computer interaction

research – a subfield of computer science – as early as the 1980s. This shift occurred when studies in computer system design moved away from a focus on the individual user's cognitive experience and needs, instead embracing a perspective centred on group work processes and social interactions (Blomberg et al., 2017). Today, there is a broad field of research that prioritizes ethnography, assigning it the status of the most reliable approach in studies assessing the development of computerized technologies or their impact in business and social service organizations (White et al., 2009).

Ethnography's methodological principles and techniques are informed by the assumptions underlying ethnomethodology and the ANT approach. At least three of them can be identified. The first ethnographic principle of "being there" involves the researcher's direct participation in the field, conducting participant observation, and employing other minimally mediated data collection methods (Murchison, 2010, pp. 12, 14, 16). This approach helps the researcher understand, acquire, and convey the local perspective (i.e., insider's perspective), aiming for inductive, embodied, personalized, epistemically inclusive, actively engaged, and deeply immersed knowledge generation (Nycz, 2017; Spradley, 2016b; Spradley & McCurdy, 2012). It aligns with what Bruno Latour (2005) calls knowledge generation "from the inside" rather than "from the outside", by following the participants who represent the reality being studied rather than creating explanations a priori, to minimize the risk of confusing "what is explained" with "what needs to be explained".

Ethnography also includes the possibility of involving diverse groups of informants, integrating their conflicting positions and perspectives, and employing various data collection and analysis methods and techniques, as well as different theoretical approaches. This allows for the creation of knowledge about objects of a heterogeneous nature (belonging simultaneously to different spheres of reality) and capturing their variability (Murchison, 2010, pp. 4, 10-13). As a multifaceted approach, ethnography provides tools to overcome "asymmetric anthropology," which focuses exclusively on studying static human cultures and shifts attention toward the performativity of natural objects (Latour, 2004, p. 87).

According to the ethnographic principle of reciprocity, it is required that the ethnographer try to integrate the practical interests of the participating community with the scientific goals and available resources of the researcher (Atkinson, 2007). In this way, the knowledge generated cannot be solely attributed to the researcher's merit nor be addressed exclusively to the academic community. Scientific production should be directed toward the community. Moreover, the scientific explanations created should encourage changes within the group that participated in the research. It does not imply researcher bias or partiality in the explanations developed. On the contrary, integrating the interests of the stakeholders indicates the importance of attentiveness to empirical reality, creating theoretical explanations that not only reflect empirical reality but also become part of it and transform it from within (Latour, 2005).

The examination of methodological approaches from social and computer sciences suggests that to effectively develop and evaluate sociotechnical systems, it is essential to choose epistemological strategies that address both social and technical realities. Thus, the prompt design process – an integral step in building specialized LLMs – should be guided by insights derived from data collection and analysis methods capable of capturing both materiality and sociality (see Table 4).

Table 4. Methodological approaches within social and computer sciences

Science field	Social science	Computer science
Discipline	Anthropology	Human-computer interaction (HCI)
Methodological approach	Ethnography	User-centred design
	Overcoming technological and social determinism	From technological towards social determinism
Relevant authors	Spradley J.	Norman D.

APPLYING ETHNOGRAPHIC DATA COLLECTION AND ANALYSIS METHODS

Having discussed the theoretical and methodological foundations of our framework for integrating socio-technical context into prompt design, this section focuses on gathering key insights for prompt formulation through ethnographic interviews and the application of ethnographic analysis principles. Our preparation for the ethnographic field research started with a systematic literature review (SLR) (Seniutis, Gružauskas, Sas, 2026), revealing key concepts like stages in the helping process, everyday work tasks, work tools, challenges and professional identity (see Table 5). These concepts served as initial guidelines for our fieldwork, particularly in designing the questionnaire for formal interviews. Similar initial topics can also be identified by conducting pilot interviews or through participant observation.

Table 5. Topics deriving form SLR conceptual framework PICOC

Concepts	**Description**	**Topics for field research**
Population	Social work professionals, particularly social workers, and representatives of various other helping professions, involved in social work practice. This includes both practitioners and managers.	Professional identity
Intervention	Use of various Large Language Model (LLM) tools in social work practice.	Work tools
Comparison	The application of LLMs: a) across various organizational settings; b) for diverse professional tasks; c) at different stages of social service delivery; and d) for different client groups; e) and in shaping professional identity.	Stages in the helping process Everyday work tasks Professional identity
Outcomes	Benefits and risks arising from the use of various LLM tools.	Challenges
Context	Social work practice includes particularly the social service delivery process and its different stages, and more broadly it refers to social assistance or social problem-solving processes and their stages.	Stages in the helping process

Designing ethnographic questionnaires

To elicit extensive and detailed verbal accounts from our informants and gain deeper insights into their specific knowledge, practices, and perspectives, we adopted Spradley's (2016) methodology for ethnographic interviews in designing our research questionnaire (see Table 6). This approach uses various question types categorized into three groups: descriptive, structural, and contrast questions, each designed to uncover unique insights.

Descriptive questions aim to elicit a large sample of utterances in the informants' native language, thereby uncovering the insider's perspective on a particular cultural scene. For instance, descriptive grand tour questions invite informants to provide a broad overview of their routine activities by guiding the researcher through their experiences. In contrast, mini-tour questions focus on exploring specific, smaller aspects of an informant's experience. Other descriptive questions include example questions, which ask informants to discuss real, concrete incidents that illustrate broader practices. Similarly, experience questions prompt informants to share specific experiences from particular settings. These questions often reveal atypical or unique events, whereas native language questions ask informants to use the terms and phrases most commonly used in their environment.

Table 6. Designing ethnographic questionnaires

Topics	Question group	Question type	Question formulation
Stages in the helping process	D*	Grand Tour Question	Could you take me through the entire client helping process step by step?
	S**	Cover Term Question	What are all different stages in the helping process?
	C***	Contrast Verification Question	You mentioned a few stages in the helping process; could you explain how they differ?
Everyday work tasks	D	Mini-tour Question	Could you walk me through the detailed tasks you handle at every stage of helping a client?
	S	Included Term Question	Do all the tasks you mentioned belong to a specific stage of the helping process?
	C	Direct Contrast Question	How does task (A) that you mentioned differ from task (B)?
Work tools	D	Native Language Question	How would you refer to work tools and which of them do you find yourself using most often? Can you list them?
	S	Cart Sorting Structural Question	Work tools can be listed on cards, placed before the informant, who may then be asked, "Are these all the types of work tools?"
	C	Contrast Set Sorting Questions	Please list the work tools on these cards and organize them into piles that reflect how they are similar or distinct from one another.
Challenges	D	Example Question	Can you give an example of an issue you encounter while performing tasks at different stages of helping?
	S	Substitution Frame Question	You mentioned some challenges you face. Can you think of other terms that fit the sentence: "I struggle with ____"?
	C	Triadic Contrast Question	Among the issues you mentioned, which two are most similar, and which one stands out as different?
Professional identity	D	Experience Question	From your experience, which knowledge, skill, or value do you find most critical in your role, and why? Could you share some examples?
	S	Verification Question	Are there any other knowledge, skills, or values that you consider essential in your work?
	C	Rating Questions	Which of your professional competencies do you see as most important, somewhat important, and least important?

* - Descriptive questions → Domain analysis
** - Structural questions → Taxonomic analysis
*** - Contrast questions → Componential Analysis

Structural questions delve into how informants categorize and organize their knowledge, providing insight into their cognitive frameworks. For example, verification questions check for the existence of a knowledge domain by exploring its types and included terms. Cover term questions focus on broad categories – cover terms within informants' knowledge domain, identifying different types of specific cover terms. They help reveal the components of the domain. Included term questions narrow the focus to intrinsic structure of these broad categories, which clarifies how informants organize their knowledge within a domain. Substitution frame questions prompt informants to think of alternative terms, while card sorting questions involve writing terms on cards and asking informants to categorize them based on their own understanding of how terms relate to each other.

Contrast questions explore how informants make distinctions and comparisons within their knowledge. For instance, contrast verification questions help ensure clarity, by confirming researcher's understanding of the differences and similarities among folk terms. Similarly, direct contrast questions ask informants to compare folk terms by focusing on a known characteristic and asking how other terms contrast on that characteristic. Meanwhile, contrast set sorting questions ask informants to classify items by similarities or differences, which uncovers their classification systems. Further, dyadic and triadic contrast questions ask informants to distinguish differences and similarities between terms. This clarifies the boundaries and meanings they assign to key concepts. Rating questions further explore priorities by asking informants to rank various items.

Outlining data analysis procedures

Each of the discussed groups of ethnographic questions according to Spradley (2016) corresponds to a specific analysis procedure. In other words, insights gained through descriptive, structural, and contrast questions require the following types of ethnographic analysis: domain, taxonomic, and componential, concluding with thematic analysis.

Domain analysis is the first step in organizing descriptive data, identifying broad areas of knowledge – or "domains" – that represent how informants perceive their experiences (see Bernard, 2017). Each domain consists of a "cover term", a broad category, along with "included terms", the specific elements within that category. Semantic relationships illustrate how these terms (both cover and included) are interconnected. In our field research, we examined nine universal semantic relationships as outlined by Spradley (2016) (see Table 7).

Table 7. Domain analysis

Domain	Cover term	Semantic relationship	Included term
Z	Y	Strict inclusion (X is a kind of Y)	X
		Spatial (X is a place in Y, X is a part of Y)	X
		Cause-effect (X is a result of Y, X is a cause of Y)	X
		Rationale (X is a reason for doing Y)	X
		Location for action (X is a place for doing Y)	X
		Function (X is used for Y)	X
		Means-end (X is a way to do Y)	X
		Sequence (X is a step (stage) in Y)	X
		Attribution (X is an attribute (characteristic) of Y)	X

Definition (X is a way to define Y)		X

Taxonomic analysis builds on domain analysis by investigating how informants categorize and organize their knowledge within each domain (see Bernard, 2017). This analysis uncovers the relationships and hierarchy within a domain, revealing which elements the informant considers central versus peripheral. It provides insight into how informants interrelate concepts within their cognitive structures, offering a more nuanced understanding of their knowledge system. An example of the results of taxonomic analysis from our field research is presented below (see Table 8).

Table 8. Taxonomic analysis

Domain	Cover term	Semantic relationship	Included term (first level)	Semantic relationship	Included term (second level)
Z	Y	(X is an attribute (characteristic) of Y)	X_1	(X is an attribute (characteristic) of X_1)	$X_{1.1}$
					$X_{1.2}$
					$X_{1.3}$
			X_2	(X is an attribute (characteristic) of X_2)	$X_{2.1}$
					$X_{2.2}$
					$X_{2.3}$

Componential analysis focuses on the differentiation of terms or elements within a domain. Using contrast questions, this analysis reveals the criteria informants use to evaluate and distinguish between similar items, highlighting subtle variations and tacit knowledge (see Hammersley & Atkinson, 2007; Bernard, 2017). By exploring these distinctions, researchers gain insights into the values and priorities that inform informants' decisions and actions (see Table 9).

Table 9. Componential analysis

	Dimensions of contrast		
Contrast set	**1**	**2**	**3**
Folk term X	Attribute X-1	Attribute X-2	Attribute X-3
Folk term Y	Attribute Y-1	Attribute Y-2	Attribute Y-3
Folk term Z	Attribute Z-1	Attribute Z-2	Attribute Z-3

The final stage, thematic analysis, involves identifying patterns across cultural domains to uncover overarching cognitive principles or shared beliefs that guide behaviour and interpretation within a culture. These themes may be explicit, such as formal norms, or tacit, requiring inference from unspoken patterns (see Hammersley & Atkinson, 2007). The process highlights connections between cultural subsystems, demonstrating how different aspects of a culture interrelate. Researchers might consider utilizing hypermedia tools, including AI-based software that integrates text, images, audio, and video, to facilitate multi-modal exploration of cultural themes. Such tools enhance both the accessibility and depth of ethnographic presentations (Dicks et al., 2005).

EXPLORING PROMPTS' STRUCTURE AND PROMPT ENGINEERING TECHNIQUES

In the following section, we move from ethnographic data collection and analysis to examining the key components of prompt structure. We also present an overview of fundamental prompting techniques, highlighting their connection to specific components of a prompt and providing illustrative examples.

Key components of a prompt

A prompt in the context of generative AI and LLMs may be defined as a textual input provided by users to guide the model's response (Meskó, 2023; Wojciechowski & Korjonen-Kuusipuro, 2023). The structure of a prompt is critical for eliciting the desired response from the model (Amatriain, 2024). Prompts can range from simple queries to complex instructions and may include structural elements such as instructions, examples, input data, output formatting, style instructions, and role definitions (Schulhoff, 2024) (see Table 10).

Table 10. Components of a prompt

Component	Description	Prompt template*
Directive	The primary intent or goal of the prompt, often expressed as an explicit or implicit instruction or question, serves as the core task for LLM.	**Q:** Translate/explain/paraphrase/summarise/edit this text: [INPUT TEXT] **A:** [OUTPUT]
Examples	Also referred to as exemplars or shots, these are demonstrations of the expected task included in the prompt.	**Q:** Example 1 [INPUT] - [OUTPUT] Example 2 [INPUT] - [OUTPUT] Summarise provided text: [INPUT TEXT] **A:** [OUTPUT]
Additional information	Also referred to as input or external data, it is supplied to the model as context or a text passage for analysis.	**Q:** Based on the following passage, answer the question: **1. Passage: [EXTERNAL DATA AS CONTEXT]** **2. Question: [INPUT TEXT]** **A:** [OUTPUT]
Output Formatting	Instructions that define the tone or format of the response, such as writing in a narrative or academic style, or presenting information as bullet points, a table, JSON, or a paragraph.	**Q:** Analyse the input data: [EXTERNAL DATA AS ADD. INF.]. Identify key trends or patterns. **A:** [OUTPUT] **Q:** [INPUT TEXT] **1. Extract details about [TOPIC] from the provided text, listing them in bullet points.** **2. Summarize the extracted details in a formal tone in no more than one short paragraph.** **A:** [OUTPUT]
Role	Specifies the persona or identity the AI should adopt while responding.	**Q:** Answer the question about [TOPIC], excluding any references to [SENSITIVE SUBJECT] **A:** [OUTPUT] **Q:** You are [SPECIFY ROLE]. Respond to the following question [INPUT TEXT]. **A:** [OUTPUT]

***** - An example of a prompt with a predefined structure, including placeholders for dynamic content.

Advanced prompting techniques

As becomes clear from what has been stated, the components of a prompt structure are the fundamental building blocks of a prompt, forming the foundation of any prompt, regardless of its complexity (Schulhoff et al., 2024). Meanwhile, when it comes to solving complex tasks that require advanced reasoning, various prompt techniques built upon the foundational structure of the prompt are applied (Amatriain, 2024). Based on the essential components of a

prompt structure, we selected from a variety of prompting techniques those that emphasize specific components and, in some ways, serve as their extension of functionality of each prompt component. In Table 11, we detail how prompting techniques build on and refine specific prompt components, using template examples as visual representations.

Table 11. Advanced prompting techniques

Prompt component	Prompting technique	Description	Prompt template
Directive	Chain-of-Thought (CoT) Prompting	CoT extends directives by breaking down complex instructions into smaller, logical steps. Used for tasks requiring multi-step reasoning (Ratnayake & Wang, 2024).	**Q:** Explain the process of [TOPIC] step by step. **A:** [OUTPUT]
Examples	Few-Shot Prompting (FSP)	FSP uses examples to guide the model in replicating patterns and improving accuracy for specific tasks. Few-shot examples help clarify expectations. (Brown et al., 2020).	**Q:** Perform [TASK] based on provided examples: Example 1 [INPUT 1] - [OUTPUT 1] Example 2 [INPUT 2] - [OUTPUT 2] Apply the same to the following: [INPUT TEXT] [EXPECTED OUTPUT]
Additional information	Retrieval-Augmented Generation (RAG)	RAG incorporates external knowledge retrieved from databases or other sources, enriching the context for the generation process (Goloujeh et al. 2024).	**Q:** Retrieve relevant information from [SOURCE] about [TOPIC]. Use the retrieved data as context to generate a comprehensive answer to the following question: [QUESTION]. **A:** [OUTPUT]
	Thread-of-thought (ThoT) prompting	ThoT structures the reasoning process into sequential steps, each of which integrates user-provided or external contextual information (Schulhoff et al. 2024).	**Q:** Explain [TOPIC] step by step. After each step, pause and ask: "Did this make sense? Shall I continue?" Proceed only after the user confirms. **A:** [OUTPUT]
Output Formatting	Automatic Prompt Engineering (APE)	APE creates and optimizes prompts by iteratively generating, scoring, and refining them, using either external systems or the same LLM (Ein-Dor et al. 2024).	**Q:** Generate three prompts for [TOPIC] using this LLM. Score each for specificity and alignment and refine the best into an optimized version. **A:** [OUTPUT]
Role	Role-Playing (RP)	RP contextualizes directives by assigning the LLM a persona to guide its interpretation of instructions, which is particularly useful for domain-specific tasks (Amatriain, 2024).	**Q:** Act as [SPECIFY ROLE] and provide step-by-step instructions for [TASK]. **A:** [OUTPUT]
	Self-Refine Prompting (SRP)	SRP builds on directives by iteratively improving responses through feedback, (Schulhoff et al., 2024)	**Q:** Summarize the following text: [TEXT]. Provide three versions, score each for clarity and relevance [OR OTHER CRITERIA], and refine the best version. **A:** [OUTPUT]

CONNECTING ETHNOGRAPHIC FIELD WORK TO PROMPT ENGINEERING

In this final section, we present the results of our ethnographic analysis and demonstrate how we connected them to the prompt structure. We also explain how these specific findings guided us in preparing prompt templates aligned with particular prompting techniques as well as with specific prompt components. Given text constraints, we provide a concise overview of the initial analysis (not exhaustive) and a limited set of prompt template examples (not complete).

Assembling the findings across different stages of ethnographic analysis

After identifying a relatively exhaustive range of various semantic relationships with their cover and included terms (domain analysis) and grouping them based on similarities (taxonomic analysis) and differences (componential analysis), the primary overarching

ethnographic theme we uncovered from the informants' perspectives was the "helping process" (thematic analysis). This theme was articulated into five domains, each connected to the main ethnographic theme through the semantic relationship of sequence (where X represents a step or stage in Y), namely the various stages of the helping process (see Table 12). These five stages constitute a set of contrasting domains that are aligned and compared with one another, distinguishing a series of dimensions. These dimensions, in turn, can be considered subdomains for each stage of the helping process and are connected to each stage through the semantic relationship of attribution (where X is an attribute or characteristic of Y). In other words, each stage is defined by having a specific definition, goal, and set of challenges. The specific actions of social workers and their clients, as well as aspects of social workers' professional identity, can be attributed to each stage of the helping process. The included terms for each subdomain are primarily connected to their cover terms through a relationship of strict inclusion (where X is a kind of Y). For example, "problem identification" is a kind of "definition" associated with the "first stage"; "to overpower a client seeking help" is a kind of "issue" relevant to the "first and second stages"; "breaks agreements" is a kind of "client action" at the "third stage"; and "to resolve conflicts" is a kind of social worker's professional competency applicable to all stages.

Table 12. Summary of ethnographic analysis results

Contrast dimensions	**Contrast set**				
	The helping process				
	Stage 1	**Stage 2**	**Stage 3**	**Stage 4**	**Stage 5**
Definition	Problem identification	Planning process	Intervention	Handling unexpected situations	Result evaluation
Goal	– To establish a trust-based relationship with the client – To identify the client's problem	– To set goals and outline the steps to achieve them	– To act according to the plan in order to achieve the set goals	– To prepare for and handle unexpected problematic situations	– To evaluate whether the set goals were achieved, and which methods were used to reach them
Challenges	– Client's refusal to cooperate due to a lack of trust – To overpower a client seeking help		– **The client lies and/or manipulates the social worker** – It takes a long time to search for and understand new and diverse information – New unexpected situations may arise	– The social worker may give the client too much power to act on their own – To feel crappy and disappointed due to the time and effort spent with no outcome	– To withstand the client's negative emotions in a conflict situation – The social worker's fear that the client has not achieved the necessary changes and skills
Social worker's actions	– Builds a trust-based relationship with the client. – Identifies client's problems – Notes key facts about the client.	– Searches, delves into, and verifies information – Creates the plan themselves – Creates the plan in collaboration with the client	– Assigns too much responsibility to the client – Takes responsibility and works together with the client	– Before unexpected situations arise, assesses potential risks and, if they occur, updates information to prevent them	– Ensures that all the client's problems are solved, and the set goals are achieved (if not, returns to the first stage) – Evaluates whether they, as the social worker, have done everything and how

					much the client has contributed to their own change
Client's actions	– Does not recognize their problems and is often in a state of stress – Resists acknowledging their problems, which often persist for a long time – Over time, learns to accept, disclose, and acknowledge their problems	– Recognizes what needs to be done to solve their problems (e.g., stop drinking, pay the bailiffs) – Identifies the reason for seeking help and the kind of help they expect	– Lacks social skills (such as fearing phone calls, going to institutions, or accepting help) – Tries to avoid and delay unpleasant tasks – Breaks agreements	– Is unable to achieve set goals due to unexpected situations affected by external factors or caused by the client	– Experiences mixed emotions: celebrates the achieved results, has increased self-confidence, yet feels anxiety and fear due to uncertainty. – After reaching the goals, stays in touch with the social worker – calls and seeks further help – If the goals are not achieved, ends the helping relationship with the social worker, expresses anger, and provokes conflict.
Social worker's knowledge, skills, values, and personal qualities	– Although it is possible to lack certain knowledge, continuously adds to and updates their existing knowledge base – Refuses to gather and update knowledge because they don't know how to do it, thus raising the risk of unexpected situations – Uses knowledge from various fields, applying it to the client's specific needs: from substance abuse, informal education, and benefits, as well as construction, electrical engineering, and more.				
	– Constantly monitor and recognize the client's changes – Avoid becoming too close to the client, but still be there for them in every way – To resolve conflicts (with a client) – Work with documents and people alike – Collaborate with the client, colleagues, and external organizations – Use humour appropriately – Talk to the client using words that they understand – Support and encourage the client – Perform practical tasks (make a bed, rake leaves, screw in a light bulb, mold clay) – Learn new skills to relax your mind and, through that, build a connection with the client				
	– See the person as a human being, just like yourself, not as crap, and accepting them without judgment; Tolerance; Respect; Honesty.				
	– Courage, self-confidence, and empathy				

Formulating prompts informed by results of ethnographic analysis

After analysing the cultural scene, shaped by social workers' perspectives on their professional practices, and identifying the main domains, composed of semantic relationships, their interconnections, and the themes they constitute, we formulated prompts for each stage of the helping process. First, we focused on crafting the "directive", the essential component of each prompt, referencing the contrasting dimensions and their included terms. Then, we evaluated whether other components could be fulfilled, such as "examples", "additional information", or "output format". For certain prompts, we specified a distinct "role". We then evaluated which component was essential for each particular prompt and, based on this, defined a specific prompt technique.

Table 13. Ethnographic evidence informing prompt design

Ethnographic theme, domains and subdomains	Prompt component: Directive	Example	Add. Inf.	Out. Form.	Role	Prompting technique	Prompt template
Stages in the helping process **Stage 1: Problem identification** Social worker's actions in identifying the client's problem Social worker's knowledge, skills, values, and personal qualities Client's actions Social worker's measures to avoid an unexpected situation	+	+	+		+	**Chain-of-Thought (CoT) + Automatic Prompt Engineering (APE)**	**QUESTION:** As a social work supervisor, provide detailed, step-by-step guidance on how I, as a social worker, can actively engage a client in the problem identification process. This includes aspects such as the questions to ask during the conversation, how to provide effective feedback, and how to create a safe environment. Please follow **[INSTRUCTION 1]** and **[INSTRUCTION 2]**. **[INSTRUCTION 1]** In your response, consider my role as a social worker **[INPUT 1]** and the characteristics of the client **[INPUT 2]**. **[INPUT 1]**: My characteristics as a social worker: a) … e.g., my areas of knowledge b) … e.g., my professional skills c) … e.g., my core values d) … e.g., my personal qualities e) … and/or other **[INPUT 2]**: Characteristics of the client: a) … e.g., demographic data b) … e.g., key issues c) … e.g., character or behavioural traits d) … and/or other **[INSTRUCTION 2]** Respond as a social work supervisor who understands the key characteristics of a social worker's professional identity **[INPUT 3]** and the potential characteristics of social work clients **[INPUT 4].** **[INPUT 3]**: Social workers' professional identity characteristics: 1. Applies interdisciplinary knowledge to meet specific client needs (e.g., expertise in substance use, informal education, social benefits, construction or electrical work, etc.) 2. Possesses various competencies (e.g., ability to identify client progress, setting appropriate boundaries while offering holistic support, conflict management, collaboration, effective use of humour, speaking in terms that the client understands, encouraging and supporting clients, performing practical tasks or learning new skills, updating outdated information, evaluating and reassigning responsibilities between themselves and the client, clarifying the client's needs and adjusting the support plan accordingly, etc.) 3. Guided by core values (e.g., human dignity, tolerance, respect or honesty, etc.) 4. Demonstrates specific personal attributes (e.g., courage, self-confidence or empathy, etc.) 5. And/or other. **[INPUT 4]**: Possible characteristics of social work clients: 1. Demographic data (e.g., different age, gender, cultural background, religious beliefs, educational background, profession, employment or marital status, etc.) 2. Key issues (e.g., substance dependence, domestic violence, other behavioural or mental health challenges, etc.) 3. Character or behavioural traits (e.g., resists assistance, rarely acknowledges their own issues, has difficulty identifying their problems, eventually accepts and acknowledges their difficulties, lacks social skills - such as fearing phone calls, going to institutions, or accepting help, tries to avoid and delay unpleasant tasks, or fails to adhere to agreements, etc.) 4. And/or other. **ANSWER: [OUTPUT]**

Table 13 presents the prompt for the first stage – "problem identification". The "directive" (see Question) focuses on the issue of social workers "overpowering a client seeking help" while attempting to identify the client's problem without their involvement. Strategies for client engagement, as outlined in the "directive," such as ensuring effective feedback and cultivating a safe environment, address the issue of "client's refusal to cooperate due to a lack of trust". Additionally, two instructions follow the formulation of this prompt. The first instruction (see Instruction 1) allows the social worker to input "additional information" specific to their own and their client's unique characteristics.

This input (see Input 1 and 2) helps the model generate more individualised and relevant output. The second instruction (see Instruction 2) provides an "example" of the common characteristics of social workers and their clients (see Input 3 and 4). This example also acts as "additional information", offering the model a concrete scenario that enhances its understanding and improves the accuracy and relevance of the generated output. The structure and content of the characteristics of social workers and their clients are derived from two main subdomains: "client's actions" and "social worker's professional identity". Finally, the role of a social work supervisor was conferred to the model to ensure that the generated output strictly pertains to the professional activities of social workers, which are focused on their interactions with clients (see Instruction1 and 2).

We also employed a prompt tuning (PT) technique, specifically the automatic prompt engineering (APE), to enhance our manually generated prompts. For this purpose, we utilised ChatGPT 4.0, tasking the model with refining the original versions of each prompt. The focus was on preserving folk terms while improving the structure and clarity to ensure the prompts were comprehensible to users with limited experience in large language models (LLMs). Additionally, the refined prompts were tailored to be particularly useful and actionable for social work professionals. However, the process of automated improvement was less seamless than anticipated. The automated refinement process, however, proved more challenging than expected, requiring repeated adjustments and clarifications. This aspect warrants further analysis in future research.

CONCLUSIONS

The results of our analysis provided a theoretical and empirical foundation for a methodological framework that bridges research methodologies from social science with the process of prompt engineering within computer science. Our theoretical exploration of mainstream analytical and methodological approaches in social and computer sciences highlights the need to overcome theoretical and social determinism in the conceptualisation, development, and evaluation of socio-technical systems. One such system may be considered the process of creating prompts, which involve an assemblage of human and non-human elements.

We showed that specifically ethnography, as a research strategy, offers effective tools for data collection and analysis, enabling the inclusion of cultural meanings, which underlie social realities, into the process of prompt formulation. This approach addresses the limitations of a purely semantic focus in prompt engineering. In addition, we outlined step by step how to uncover cultural themes composed of multiple semantic relationships articulated

by social workers in their verbal accounts of professional practice. Finally, we demonstrated how to link the organised qualitative data sets to key prompt components, which serve as the foundation for various prompting techniques.

IMPLICATIONS FOR THEORY, APPLICATION, OR POLICY

Additional research is essential to assess the quality and validate the results – specifically, the prompts engineered through the proposed framework. Experimental methodologies can support this effort by enabling intrinsic evaluation of the prompts or extrinsic evaluation of LLM outputs. In the first case, by testing and evaluating the prompts' effectiveness, they can be refined, and customised prompt libraries can be created to guide the LLM without full retraining. In the second case, datasets built from prompts, outputs, and their evaluations may be used to fine-tune general-purpose LLMs into domain-specific models.

This framework advances the methodological development of prompt engineering by grounding it in cultural contexts, thereby providing various stakeholders – including researchers, practitioners, managers, and policymakers – with a robust tool for evaluating existing LLMs and developing new specialized models tailored specifically to social work practice. The framework can be applied to evaluate or customize an LLM's alignment with professional social work interests, the specific needs of various vulnerable groups, organizational settings within social service organizations, diverse social service modalities, or ethical standards in social work.

ENDNOTES

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FAMILY MATTERS – WARM EXPERTS, OLDER ADULTS AND SOCIAL SUPPORT FOR LEARNING: A SEQUENTIAL EXPLORATORY MIXED-METHODS APPROACH

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Abstract: *The extent and quality of social support for learning provided by warm experts has received limited scholarly attention. Using a sequential exploratory mixed-methods approach, and a point of departure in theory regarding opportunities for and barriers to learning, the study starts with qualitative interviews with 22 individuals aged 70-94. Relationships between older adults and their children and grandchildren are analyzed, and experiences of opportunities and barriers for learning are identified. These findings are operationalized into items in a survey distributed to a representative sample of Sweden's population aged 65-90 (n=1,610), to measure variations in the quantity and quality of social support for learning. Findings reveals that children are mainly engaged as warm experts, and the more frequently families meet, the more frequently support for learning takes place, and the higher the perceived quality. Age, income and education, show no relationship with the perceived quality of social support for learning.*

Keywords: *warm expert, older adults, mixed-methods design, learning, digital media.*

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INTRODUCTION

Digitalisation is an ongoing process in large parts of the world. This affects all areas of social life, from how banking services are offered, via everyday social media encounters, to the ways in which we arrange and receive healthcare. In fact, it is taking place in all societal spheres, in the market, in civil society, and in the state in its varying formations (Hepp, 2019).

One particularly salient aspect of digitalisation is the ways in which digital information and services are becoming the preferred mode for contact between welfare providers and their users. The re-shaping into digital information and interaction covers a wide span of public services. These include healthcare services (Sætra & Fosch-Villaronga, 2021), citizens' interaction with tax agencies (O'Sullivan & Walker, 2018) and information from and communication with municipal service agencies (de Mello & Ter-Minassian, 2020). The re-shaping of welfare services is a global phenomenon, but it is particularly advanced in certain parts of the world. According to the DESI-index (DESI, 2022), Finland, the Netherlands, Denmark and Sweden have been particularly quick to appropriate digital technology for all kinds of public information and services.

In the Swedish case, as for instance in Denmark (Pors & Schou, 2021; Schou & Hjelholt, 2018), the digital transformation of public information and services is based on an overall and explicitly stated governmental vision. The ambition is to make digital information and services the default choice in public sector contact with individuals and organisations (Digg, 2023). While this development is obviously beneficial to a lot of people, as it can make governmental services and information more accessible and perhaps also more effective, is it also challenging. It is especially challenging for those who are not as comfortable with digital technology as the 'digital by default' policy implicitly suggests that they ought to be. Relating to extant research it becomes obvious how this development potentially becomes specifically challenging for some parts of the citizenry. Older adult citizens are certainly one of these groups (cf. Friemel, 2016; Llorente-Barroso et al., 2023). There are, of course, important differences between older adults when it comes to their degree of access to and abilities to use digital technology (Olsson et al., 2019a; Olsson et al., 2019b), but as a group they are not in any obvious ways beneficiaries of the digitalisation of public information and services (Marston & van Hoof, 2019). As an overall process, digitalisation contrasts starkly with older adults' more limited access to digital media, their more limited abilities to make use of them, and – importantly – their rather weak interest in digital information and services and preference for other methods (Olsson & Viscovi, 2023). In fact, both structural and individual factors have an impact on the extent to which older adults appropriate ICTs and develop necessary literacy (Kärnä et al., 2022).

In this context research has come to pay attention to the actual and potential role of *warm experts* (Bakardjieva, 2005) as mediators between digital opportunities and the everyday lives of older adults. The warm experts are 'nonprofessional persons who help more inexperienced users come to terms with digital devices and services' (Olsson & Viscovi, 2018, p. 324), and in the literature they have received increasing research attention focusing on *what* sort of support they can offer and *how* they do that in the everyday lives of older adults (see below). However, the extent to which this social support from warm experts also *provides sustainable opportunities and support for older adults' learning* have so far been paid very little

systematic research attention. To start compensating for this deficit, to gain insights into older adults' actual *learning* with warm experts, this article centres on five research questions:

RQ 1: Who becomes engaged as warm experts for older adults' learning?
RQ 2: To what extent are the different categories of warm experts engaged?
RQ 3: How is the quality of support for learning perceived by older adults?

Our initial findings (see below) reveal that older individuals' children occupy a special position as by far the most involved category. We therefore also ask:

RQ4: Is there a connection between the extent of socialising between generations and the extent of support for learning?
RQ5: Is there a connection between the extent of socialising in families and the perceived quality of support for learning?

In order to answer the RQs, we followed a sequential exploratory mixed-methods design (Creswell & Plano Clark, 2017). Hence, our results and analyses are presented in six consecutive steps, starting from the construction of an interview guide based on the notion of warm experts and Illeris' (2017) theorising regarding opportunities for and barriers to learning (step 1) and ending with the execution of factor and regression analyses (step 6).

Warm Experts and the Quality of Social Support for Learning

The notion of *warm experts* was established by Maria Bakardjieva in her book *Internet Society: The Internet in Everyday Life* from 2005. Drawing on rich ethnographic data covering the domestication of computers and the internet in Canadian households at the turn of the millennium, Bakardjieva illustrated the importance of friends and family in helping novice users start using their home computers and enter the online world. At that time, their support typically included dealing with technical obstacles (hardware issues, internet connections, etc.) and offering support in suggesting what could be useful areas of usage for the equipment. In the words of Bakardjieva, the warm expert 'mediates between the technological universal and the concrete situation, needs and background of the novice user with whom he is in a close personal relationship' (Bakardjieva, 2005, p. 99).

Since the turn of the millennium, many important changes have taken place. Internet usage technologies have multiplied, and now include devices such as smartphones, tablets, and smart watches, to mention just a few examples. Meanwhile, the very meaning of 'the Internet' has also been transformed. In the early 2000s, the internet was still mainly perceived, and used, as a source of information ('searching on the internet') and communication (mainly email). Today, the internet has instead become the very backbone of digitalisation, and now encompasses all aspects of our everyday lives, from banking to contact with healthcare, shopping and maintaining social networks via social media applications. This reshaping of our everyday lives has several implications, but in this context it is specifically relevant to consider how it has most definitely not made the role of the warm expert any less relevant. The potential need for everyday support has increased rather than decreased. Such support can be provided by different actors, for instance older adult teachers

and tutors in an instructional project (Pihlainen, Korjonen-Kuusipuro, & Kärnä, 2021) or – as in our case – by people identified as warm experts.

The continued importance of warm experts is also mirrored in the research literature. This research offers, for instance, important insights into the identity of warm experts. According to Comunello et al. (2017), older adults' warm experts are often found in their networks of younger relatives, most often among children and grandchildren. Drawing on Swedish survey data from 2015, Olsson and Viscovi (2018) revealed a preference among older adults to get assistance from their children rather than their partners or grandchildren. The guiding role of younger relatives is also the topic in Barrantes Cáceres and Cozzubo Chaparo (2019). That study shows how 'the presence of minors in older adults' households encourages their access to the internet' (p. 263).

Apart from paying attention to who the warm experts are, research has also offered insights into what types of support they typically offer. When studying warm experts, Leong (2017) points out how they often become involved in doing the actual downloading and installation of programs and applications. Drawing on domestication research, Olsson and Viscovi (2018) revealed how warm experts play an important part in all stages of domestication, ranging from initial discussions before a decision to acquire digital devices is made to actual everyday usage. Oreglia and Ling (2018) note how warm experts are important assets when it comes to older adults' 'digital imagination'. They play a part in framing how to make sense of technologies and how to use them.

Together with similar studies (cf. Courtois & Verdegem, 2016; Hänninen et al., 2021; Neville, 2021), the research efforts referred to above have made important contributions to our knowledge of *who* warm experts are and *what* sort of support they offer to older adults. In our view, however, the research conducted so far falls short regarding at least two different aspects. Firstly, research has so far, and with very few exceptions, fallen short when it comes to offering insights into the actual *quality of social support for learning*, the extent to which older adults learn and develop from support offered by warm experts. The quality of social support has been touched upon by Helsper and Van Deursen (2017); their quantitative survey analysis introduced the notion of quality of social support, which they operationalised by 'asking the respondents who received support in the past three months whether they felt they would still need support the next time in a similar occurrence' (p. 706). The question obviously refers to learning and development. However, it offers little detail regarding both the forms and content of social support for learning. This article has the ambition to both (qualitatively) elaborate on the notion of social support for learning and (quantitatively) develop measures to assess its quality.

Secondly, the literature on warm experts is almost exclusively derived from qualitative research. It draws on group interviews (Hänninen et al., 2021), focus groups and semi-structured interviews (Madsen & Kræmmergaard, 2016), qualitative thematic analysis of videos and viewer comments on YouTube (Neville, 2021), as well as observations and case surveys (Sawchuk & Lafontaine, 2022). The research has offered rich insights into everyday life around digital applications, and the important part played by networks for social support. It has also been theoretically suggestive. This article adds to this knowledge by presenting research that departs from insights derived through qualitative research but elaborates on the findings in ways that allow the establishment of statistically generalisable insights derived from a national survey.

A Sequential Explorative Mixed-methods Design

According to Creswell and Plano Clark (2017), an explorative mixed-methods design combines qualitative and quantitative data collection and analysis in a sequential manner. It starts with a phase that involves the collection and analysis of qualitative data, which then provides the basis for the collection and analysis of quantitative data. The qualitative phase is designed to help generate hypotheses and explore the context of the phenomenon, whereas the quantitative phase allows for generalisation based on statistical analysis (cf. Creswell, 2014).

At a more detailed and specific level, our approach is inspired by the sequential approach developed in Cabrera's study of racial hyperprivilege in higher education (Cabrera, 2011). As in Cabrera, our approach follows several consecutive steps, from initial conceptualisation and then the interview phase through to collection and analysis of quantitative data. This is also how our methods and analyses will be presented in the following sections.

Step 1 centres on the construction of our interview guide for interviews with older adults with experience of learning about digital media from their children and/or grandchildren. In this phase, the theoretical notion of warm experts, above all learning with warm experts, and Illeris' (2017) theorising regarding opportunities for and barriers to learning, is specifically informative regarding which areas are to be covered during the interviews (see also Martínez & Olsson, 2022).

Step 2 covers both the recruitment of interviewees and the actual interview procedures. For the recruitment we used a purposive sampling, but the selection also involved additional considerations, such as including people with different ages, genders and socio-economic backgrounds. The interview procedures include the actual and somewhat different ways in which the interviews were executed.

Step 3 in our sequential approach presents the coding and analysis of interview data. Our interview data are broad, but in this context the analysis focuses specifically on what insights they offer regarding opportunities for and barriers to learning with children and grandchildren as warm experts. What ideas for statistical analysis can be derived for further analysis?

Drawing on insights from the interviews, step 4 operationalises opportunities for and barriers to learning and includes the designing of a survey. In order to allow for generalisation of the insights from our qualitative interviews, a postal survey is designed and sent to a simple random sample of 2,500 Swedish citizens aged 65–90.

Step 5 presents descriptive statistics from the survey. The statistics include insights into who the warm experts are, the frequency of family gatherings (meeting with potential warm experts) as well as the older adults' general perception of the quality of social support.

Step 6 develops the quantitative analysis using factor and regression analyses. The factor analysis identifies two factors in older adults' evaluation of their social support for learning – one positive and one negative. A subsequent regression analysis reveals how the evaluation of social support for learning varies between the groups of older adults.

RESULTS AND ANALYSIS

Step 1: Construction of interview guide drawing on the notion of warm experts

The interview guide was designed based on the overall aim to elicit the older adults' views and experiences of learning about digital media together with children and grandchildren. Here, it was especially important to understand whether interactions with children and grandchildren regarding digital media actually involved a learning process (Illeris, 2017), or whether the younger family members helped them solve technical issues without actually involving the older adults (Martínez & Olsson, 2022). Previous research on warm experts has not been clear about this difference, and not been specific about whether or not 'helping out' with digital media involves actual learning opportunities.

To gain insights into the older adults' experiences, the interview was designed as a semi-structured lifeworld interview based on Kvale and Brinkmann (2009), where the aim was to understand the nuances and lived experiences of everyday events (Martínez & Olsson, 2022). Several strategies were used to facilitate participants' memory, including asking about their current media use and how they started using this media, and conducting shorter follow-up interviews to ask about possible new learning events. Posing concrete questions about how they started using certain media devices or apps was particularly helpful in gaining insights into the support they were given. It was common that participants gave concrete examples of how learning events took place, or events where they received support without being given actual instruction. Participants often had their mobile phone or tablet at hand in the interview situation, which facilitated their memory about the array of apps they had access to and how they started using them (Martínez & Olsson, 2022).

The interview guide was also designed to capture differences in learning from different groups of people, with a focus on children and grandchildren. For instance, to aid participants in thinking about potential differences, the following question was asked: Are there any differences concerning learning together with children compared to grandchildren? These kinds of specific question were posed to support memory and to obtain nuanced descriptions of real-life events (Kvale & Brinkmann, 2009). To gain contextual understanding of the older adults' everyday lives and their relationships with family members, initial questions were also asked about the children and grandchildren they had and where they lived. Additional information about their family context often surfaced throughout the interview when they talked about which family members they learned about digital media together with, and which not, and what factors contributed to the involvement of certain warm experts (geographical distance, meeting patterns, teaching style etc).

Step 2: Selection of interviewees and interview procedures

The aim in the sampling process was to include participants with different ages, genders and socio-economic backgrounds. Participants needed to have some form of experience of learning about digital media together with their children or grandchildren, and this was stated in the information sheet provided during the recruitment process. As a result of the selection process, the interview study included 22 individuals aged 70 to 94 (9 men and 13 women). As stated above, follow-up interviews were conducted after the initial in-depth interviews.

All the interviews were individual interviews, except for one which included a couple. The interviews took place in the homes of the participants or in community centres for older

adults in the south of Sweden (Martínez & Olsson, 2022). Participants could choose the location and time that suited them best, and the interviews were performed with the aim of promoting a friendly environment in which participants were given space to engage in small talk before and after the conducting of the interview. Participants were provided with information about the study both verbally and through an information sheet, via which they also gave their informed consent. The interviews were audio recorded and transcribed verbatim.

Step 3: Analysis of the interview data

The interviews were analysed based on Knud Illeris' theory about the fundamental structures of learning (Illeris, 2017, Martínez & Olsson, 2022). First, the analysis distinguished between the two levels of the interaction process that shape the learning situation, namely the societal level and the close social interaction level (Illeris, 2017). The societal level concerns the opportunities for and barriers to learning between generations relating to societal and cultural norms and conditions, for instance that older adults in North European countries usually do not live in multigenerational households (Martínez & Olsson, 2022). The close social interaction level concerns opportunities for and barriers to learning between generations when meeting face-to-face or interacting through mediated communication. Here, the level of *involvement* in the situation shaped the possibilities for learning, for instance being able to see the screen or practice oneself when the warm expert is performing a task related to digital media. Involvement is fundamental for learning to take place, and can range from mere *perception*, where the individual picks up on bits of information, to participation, where there is joint activity in which the parties are engaged in performing goal-directed activities (Illeris, 2017). Hence, if warm experts solve technical issues without involving the older adults in an effective way, this hinders possibilities for learning.

The analysis focused on mapping the older adults' experiences of various barriers to and opportunities for learning related to the societal level and the close social interaction level, using qualitative coding in NVivo. In relation to the societal level, the analysis showed that living close to children and grandchildren and the possibility to meet regularly functioned as an opportunity for learning, as this facilitated the establishment of learning situations. Learning primarily occurred through face-to-face interactions rather than digital media like telephone calls. Hence, learning with children and grandchildren had a clear embodied dimension, grounded in physical presence and shared experiences.

However, the younger generation's life circumstances, often involving a busy everyday life, served as a hinder for creating learning situations, as they could have a lack of time to meet, or as the older adults did not want to bother their children and grandchildren with additional tasks and demands (Martínez & Olsson, 2022).

In relation to the close social interaction level, the analysis identified three overarching social situations where barriers to and opportunities for learning emerged: social situations of non-involvement, social situations of partial involvement and social situations of extensive involvement (Martínez & Olsson, 2022). In the first situation, concerning non-involvement, the warm experts helped the older adults but did not involve them in what they were actually doing – or the older adults did not want to be involved – which hence constituted a barrier to learning. In the second situation, regarding partial involvement, the older adults were

involved to some extent in the task related to digital media, but several different barriers to learning emerged. These included deficient communication from the younger generations, if they for instance spoke too fast or showed actions too fast on the screen. Deficient communication also concerned deficient explanations, if the warm expert skipped key bits of information and steps in the instruction or used technical terms that the older adults did not understand (Martínez & Olsson, 2022).

However, in social situations of extensive involvement, the warm experts involved the older adults in ways that facilitated their learning. These situations were characterised by constructive communication where the warm experts gave clear and calm instructions, explaining step-by-step and providing all the relevant information. In addition to this, being able to test oneself was also considered important by the older adults for their learning (Martínez & Olsson, 2022).

The barriers to and opportunities for learning with warm experts identified in the analysis can be understood to be indicators of what constitutes good-quality and poor-quality learning situations. In learning situations with poor quality, the older adults' learning is hindered in several ways relating to the interaction with warm experts, with the character of the communication playing a fundamental role. Here, high speed and the misplaced use of language are important features of poor-quality learning. In contrast to this, in good-quality learning the interaction with warm experts facilitates learning, as the older adults are deeply involved in the situation at hand through the use of constructive communication and opportunities to try oneself. Here, low speed, relevant information shared step-by-step, and the possibility to practice constitute central elements of good-quality learning.

Step 4: Operationalisation and survey design

The findings on warm experts, and opportunities for and barriers to learning, guided the design of new survey items: a postal survey was distributed in late 2020 to a simple random sample of 2,500 people aged 65 to 90 living in Sweden. 1,610 questionnaires were returned, which is a gross response rate of 64.4 percent. The sample represents Sweden's older population fairly well in terms of gender, education, income, etc. (cf. Olsson & Viscovi, 2023).

In the questionnaire, we initially ask which people are engaged as warm experts – 'child(ren)', 'friends/acquaintances', 'grandchild(ren)', 'partner', 'relatives', 'other' or 'no one to ask'– and whether it is for technical support or more importantly, social support for learning (see Table 1). We also include 'internet' as being an important resource for technical support as well as learning. Furthermore, respondents are asked to report how often these warm experts are engaged. The measure is subjective with the options, 'very often', 'quite often', 'rarely', and 'never'. This primarily reflects the individual's self-assessed need for support and learning, but as we will see below, it seems to correlate with real frequency as the degree of involvement of warm experts correlates positively with the frequency of interaction (Table 2).

The questionnaire also includes an item on social interaction where the respondents report how often – 'every week', 'every month', 'a few times a year', 'less often', 'never' – they meet with 'family', 'relatives' and 'friends' respectively. In Swedish, family in this context means close family, i.e. usually children and grandchildren and possible great-grandchildren.

The items on quality of social support mainly emanate from the interviews described in Step 3, and to some extent from interviews with experienced instructors from SeniorNet, Sweden, who for many years have been in involved in adult education on digital media (c.f. Olsson & Viscovi, 2019a). Instructions with a high level of quality, according to the interviewees, are characterised by being divided into clear steps, having a moderate pace, a low degree of difficult technical terms, and in addition giving the instructed person space to try for themselves. Such instructions, constitute opportunities for learning, and instructions with opposite properties constitute barriers.

In the questionnaire, respondents are therefore asked to answer the following: 'When friends and family provide instructions, how do you think it works': 'Instructions are divided into clear steps'; 'Instructions are too fast'; 'They use words I do not understand'; 'I get the opportunity to try myself'. In addition, respondents are asked to make a more general evaluation of the instructions: 'I am encouraged to learn more'; 'My confidence is growing'; 'I do not learn much'. All with the options 'very often', 'quite often', 'rarely', and 'never'.

These variables, and a statistically generalisable data set, enable analysis of who is engaged as warm experts (children, partners, etc.), and to what extent this is done for the purposes of technical support and learning. Furthermore, they enable analysis of whether a family's frequency of socialising can be related to how often learning takes place and the perceived quality of social support for learning.

Step 5: Descriptive statistics

Warm experts are mainly found, as Comunello et al. (2017) states, in older adults' networks of younger relatives, primarily children and grandchildren. The observations are supported by Table 1, below, which furthermore reveals that partners, friends and relatives in a broader sense are also engaged as warm experts.

Table 1. *Warm Experts Giving Technical and Social Support for Learning. Percent.*

	Technical	n	Learning	n
Child(ren)	53.0	1,135	53.0	1,133
Partner	27.3	1,058	23.1	1,036
Grandchild(ren)	17.7	1,039	19.2	1,033
Friends/acquaintances	11.9	1,016	15.1	1,009
Relatives	8.1	1,021	8.7	1,014
Other	2.9	1,017	0.8	1,007
No one to ask	6.9	1,008	7.5	997
Internet	33.2	1,035	30.1	1,025

Note. The table displays the responses 'very often' and 'quite often'. It includes, here and hereafter only individuals with children.

Regardless of the purpose, technical support or social support for learning, the results are similar. First and foremost, children are engaged as warm experts: 53.0 percent in both cases. In second place, the internet, rather than warm experts, is consulted, and in third place partners, followed by, in descending order: grandchildren, friends, relatives and others. Finally, about 7.5 percent report they have no one to ask – even though they have children.

Table 1 clearly shows that the second generation, the children, are the most frequently consulted category for learning, as well as technical support, and therefore occupy a unique position as warm experts. They constitute a conclusive social resource and opportunity for learning. In this regard, children are far more important than partners, at 23.1 percent, or grandchildren, at 19.2 percent.

For most older adults, it is closest at hand to ask their children, who by and large can be expected to feel responsible for their parents' well-being and can also be considered to be reliable. The children are furthermore usually old enough to be able to take on the role of teacher, and young enough to have comparatively better knowledge and digital skills than their parents. (Why grandchildren are not involved to the same degree as children can partly be explained by age. The oldest individuals have, on average, older grandchildren. A control for age reveals that, of the 80- to 84-year-olds, 27.6 percent report they involve grandchildren often or quite often. The corresponding figure for the 85- to 90-year-olds is 44.1 percent).

Furthermore, Barrantes Cáceres and Cozzubo Chaparro (2019), in a study conducted in three Latin American countries, find that 'the presence of minors in older adults' households encourages their access to the internet' (p. 263). In Sweden, it is quite unusual for adults over the age of 65 to live together with their children (only 5 to 6 percent, according to Statistics Sweden 2022, p. 19), but socialising between generations does of course not cease as a result of that, so in the Swedish context it is reasonable to assume that the frequency of family gatherings, the level of interaction, is an important factor regarding opportunities for learning and engaging warm experts.

Table 2. Frequency of Family Gatherings and Social Support for Learning. Percent.

	Every week	Every month	Less often	n
Child(ren)	60.3	49.8***	36.9***	1,093
Partner	23.1	23.9	22.8	1,002
Grandchildren	22.6	18.7	9.9***	999
Friend/acquaintance	14.2	15.5	16.4	975
Relatives	9.6	8.8	3.4**	982
Other	1.1	0.4	1.5	977
No one to ask	4.9	6.8	14.0***	968
Internet	29.4	31.3	32.0	992

*Note. The table displays the responses 'very often' and 'quite often'. Chi-Square: * $p < .05$. ** $p < .01$. *** $p < .001$.*

This assumption is supported by Table 2, as 60.3 percent of parents who meet with their family every week report that they engage their children as warm experts for learning often or quite often. Parents who meet their family every month tend to consult them to a slightly lower degree, at 49.8 percent. And finally, those with sparser interaction are noted for an even lower level, 36.9 percent.

A somewhat similar pattern exists for the involvement of grandchildren and other relatives; less socialising with family correlates with reduced provision of warm expertise from grandchildren and forms a descending pattern: 22.6 and 18.7 and 9.9 percent.

It is also worth noting that usage of the internet for learning remains constant, at about 30 percent, irrespective of the extent of the contact with family and children. This finding underlines the importance of face-to-face communication and more tangible assistance in these matters. Furthermore, less socialising with family and children does not correlate to a higher engagement of partners and friends; alternative resources do not seem to compensate for sparser interaction with children. Thus, sparser socialising with families generally means fewer opportunities for learning. This interpretation is reinforced by the fact that individuals who have very limited contact with their children are those who most often lack someone to ask, 14.0 percent.

How do older adults assess or perceive the quality of the support for learning?

Table 3. Quality of Social Support for Learning. Percent.

	Percent	n
I get the opportunity to try myself	72.7	1,085
I am encouraged to learn more	58.6	1,077
My confidence is growing	57.7	1,065
Instructions are divided into clear steps	44.2	1,033
Instructions are too fast	48.4	1,096
They use words I do not understand	35.6	1,053
I do not learn much	26.2	1,173

Note. The table displays the responses 'very often' and 'quite often'.

A clear majority, 72.7 percent, report they are given the opportunity to try by themselves. Nearly 6 out of 10, 58.6 percent, are encouraged to learn more, and 57.7 percent gain more confidence. 44.2 percent state that the instructions are divided into clear steps. Furthermore, nearly every other, 48.4 percent, report that the instructions are given too fast, and one third, 35.6 percent, find the terminology that is used difficult to understand. Finally, 26.2 percent state that they do not learn much.

The overall impression—despite the fact that as many as 72.7 percent have the opportunity to try on their own and language is a concern for only a third—is that far from everyone is satisfied with the instructions they receive from warm experts. Just over 40 percent are *not* encouraged to learn more, and a majority believes that the instructions are *not* divided into clear steps. In other words, engaging a warm expert is not necessarily an opportunity for learning, as the quality must also reach a satisfactory level.

Can the frequency of family gatherings influence the quality of support?

Table 4. Frequency of Family Gatherings and Quality of Social Support for Learning. Percent.

	Every week	Every month	Less often	n
I get the opportunity to try myself	76.3	73.2	63.9***	1,046
I am encouraged to learn more	61.2	61.1	45.9***	1,036
My confidence is growing	60.8	60.7	47.1 ***	1,029
Instructions are divided into clear steps	46.6	43.4	38.2 ns	1,004
Instructions are too fast	49.1	50.1	41.6*	1,058

They use words I do not understand	34.5	39.1	33.2 ns	1,018
I do not learn much	26.3	23.4	29.7 ns	1,013

*Note. Chi-Square: as the figures for 'every week' and 'every month' are very similar, the test compares the sum of 'every week' plus 'every month' with 'less often'. * p < .05. ** p < .01. *** p < .001.*

Table 4 reveals that self-reported quality correlates somewhat with the frequency of family gatherings. Whether the gatherings take place weekly or monthly does not seem to matter in this regard, but the latter can be considered to be a threshold value: those who see their families and children less often than once a month deviate, as they are less satisfied overall with the support they receive. They do not try themselves as often (63. 9 percent compared to roughly 70 percent), are not encouraged to learn to the same extent (45.9 percent compared to approximately 60 percent), and are not given the same degree of confidence (47.1 percent compared to approximately 60 percent). Admittedly, those with more frequent gatherings find that instructions are too fast to a slightly higher degree (50.1 percent compared to 41.6), but apart from that there are no significant differences.

So far, our results indicate that with regular contact, at least monthly, with family and children, the social support for learning occurs more frequently and is valued qualitatively higher by the recipients.

Step 6: Factor and regression analysis

However, not even regular access to warm experts seems to guarantee a high level of involvement and support of satisfactory quality. At best, the items in Table 4 result in 60 to 70 percent contentment, sometimes only 50 percent or even less. This deserves further attention, as a factor analysis, displayed in Table 5.

Table 5. Quality of Social Support for Learning. Factor Analysis.

	Factor 1	**Factor 2**
I get the opportunity to try myself	**.843**	.039
I am encouraged to learn more	**.834**	.089
My confidence is growing	**.849**	.017
Instructions are divided into clear steps	**.773**	.039
Instructions are too fast	.045	**.841**
They use words I do not understand	.096	**.848**
I do not learn much	.001	**.721**
Explained variance	40%	27%
Eigenvalues	2.82	1.87

Note. Principal component analysis, varimax with Kaiser normalisation.

The seven items measuring quality of social support form two factors. The sample is thus divided into two separate groups, with varying conceptions of the quality of support. Factor 1 consists of positive evaluations and experiences. For this group, the support can be regarded as opportunities for learning. Factor 2, on the other hand, has a higher degree of negative evaluations, thus indicating the opposite, i.e. barriers to learning.

Are there any differences between the two groups in terms of gender, age, education, resources etc.? On the one hand, it could be assumed that comparatively younger individuals, with longer formal education and computer experience from working life, would be better equipped to ask relevant questions and comprehend instructions from warm experts, and therefore benefit in that regard (c.f. Courtois and Verdegem 2016; van Dijk 2020). On the other hand, it could be the other way around. Helsper & van Deursen (2017, p. 710) explicitly rejects the hypothesis that: 'The more socio-economic resources (i.e., education, income, employment, and health) one has, the higher the quality of support …'. A linear regression analysis, where the two factors form two different indices, might shed some light on the matter.

The first one, an Opportunity Index, constructed from factor 1, has a Crombach's Alpha value of 0.87. The second, a Barrier Index from factor 2, has a value of 0.75. This confirms that the variables measuring social quality of support are theoretically consistent and therefore suitable for index construction. The indices in Table 5 vary between 5 and 20; the higher the value in the Opportunity Index, the more positive the experiences, the higher the value in the Barrier Index, the more negative the experiences.

Table 6. Opportunity Index and Barrier Index. Linear Regression Analysis.

	Opportunity Index				Barrier Index			
	B	**S.E.**	**β**	**Sign**	**B**	**S.E.**	**β**	**Sign**
(Male) Female	.892	.251	.129	***	-.645	.245	-.097	***
Age	-.042	.023	-.066		-.018	.022	-.029	
Education								
(Short) Middle, Long	.588	.334	.068		.318	.324	.038	
(Short, Middle) Long	.521	.275	.074		.185	.268	.027	
Computer experience	.090	.273	.012		1.395	.268	.197	***
Income, SEK*)								
(0-300 000) 301,000–	.531	.319	.071		.068	.312	.009	
(0-600 000) 601,000 –	.475	.315	.058		.331	.306	.042	
(Single) Couple	.268	.348	.032		-.357	.339	-.044	
Association membership								
(Non-member) Member	-.007	.258	-.001		.038	.251	.006	
Family gatherings								
(Less often) Every week	.226	.289	.033		.307	.282	.046	
(Less often) Every month	1.059	.354	.125	**	-.384	.346	-.047	
Constant	13.008	1.806		***	14.331	1.749		***
Adjusted R^2				.065				.058

*Note. *) SEK = Swedish krona. * p < .05. ** p < .01. *** p < .001.*

The most tangible finding when analysing opportunities for learning is that characteristics and capacities that are usually strongly connected to access, usage and outcomes of digital media – such as age, experience of computers from working life, education (Friemel 2016; van Dijk 2020; Olsson & Viscovi, 2020) – have no significant impact on the reported quality of warm expertise.

The only significant factors are gender, women have more positive experiences than men (β .129), and socializing with family (β .125). Women in general tend to take more initiative than men for family gatherings, and for having a closer relationship with their adult children (Ahlberg et al., 2008). It is therefore probably no coincidence that women are slightly more satisfied than men overall in this regard.

This interpretation is strengthened in the second index, which exhibits an opposite correlation. Women have fewer negative experiences than men (β -.097).

A somewhat intriguing finding is that computer experience can be related to negative experiences, and not vice versa. However, the finding is in line with what Helsper and van Deursen (2017, p. 711) already stated: '… the more skilled one is, the less happy one is with the received support.' A plausible interpretation is that more skilled users, require a higher level of support for learning, which the warm expert cannot always meet.

DISCUSSION

In this paper, we started by pointing out a research gap, namely warm experts and the extent to which warm experts *provide sustainable opportunities and support for older adults' learning*. We further argued that this aim calls for a sequential exploratory mixed-methods design in 6 steps.

When extant research is sparse, it is fruitful to start with a qualitative method and broad explorative approach, both in terms of interviewees and themes. Thus, Step 1 involved the construction of an interview guide, informed by Illeris' (2017) notions of opportunities for and barriers to learning. In Step 2, 22 individuals aged between 70 and 94, with varying socio-economic backgrounds, were selected and interviewed about their everyday encounters with digital media, and gradually more about the role of their children and grandchildren as warm experts providing support for learning. These measures enabled a theoretically informed analysis in Step 3 that, on the one hand, revealed the warm experts' crucial role for older individuals' learning of digital media, and on the other hand, the importance of involvement and regular interaction—and instructions with specific characteristics. Avoidance of difficult words, comfortable pace, etc. were found to provide *opportunities for learning*, whereas sporadic interaction and rushed instructions with numerous technical terms are *barriers to learning*.

In Step 4, these variations regarding quantity and quality of social support were operationalised into survey items that enabled the measurement of who are engaged as warm experts, to what extent and how the quality is perceived by the recipients. In Step 5, a representative sample of Sweden's elderly population between the ages of 65 and 90 allowed for statistical analysis and statistical generalization. Through this, we were able to establish that one's own children are the most common warm expert, rather than grandchildren or partner, and that there is a positive correlation, quantitatively as well as qualitatively, between family gatherings and social support for learning.

In Step 6 a factor analysis of the quality of support substantiated the operationalisation of the findings in Step 3, and furthermore revealed that the sample is divided into two groups, with opposite perceptions of the quality of support. The construction of two indices, with satisfactory Cronbach's Alpha coefficients, provided further support for theoretical

consistency in this regard. Finally, a multiple regression analysis was conducted that, first and foremost, confirmed that frequent socialising with family promotes the quality of support, and, somewhat surprisingly, that socio-economic factors such as age, education, income etc. have limited impact on the perceived quality of warm expertise.

As also stated above, there is a lack of research on the quality of social support for learning about digital media. However, an important exception is Helsper and Van Deursen (2017) focusing on the quality and quantity of social support for digital engagement. Their study focuses on learning to some extent by asking respondents 'who received support in the past three months whether they felt they would still need support the next time in a similar occurrence' (Helsper & Van Deursen, 2017, p. 706). The assumption made in this question is that the support was successful if recipients managed to solve problems on their own the next time. Our investigation extends this study in the sense that it aims to cover additional aspects. Hence, our study makes an original contribution to existing research on warm experts by developing a multifaceted instrument for measuring self-reported experiences regarding quality of social support for learning. Our items have a high level of validity as they are based on a research design using learning theory (Illeris, 2017) and qualitative in-depth interviews. This instrument could be used in future studies to further test its relevance and gain better insights into the complexities of social support for learning in various contexts.

However, there are limitations connected to the present research design. The advantages of mixed methods can from another perspective be seen as a disadvantage. With two different methods and two different materials – reported within the framework and word limits of a scientific journal – details and variations cannot be reported as extensively as in conventional studies. There is a risk of leaving both quantitatively and qualitatively oriented researchers unsatisfied, and with modest impact as a possible consequence.

CONCLUSION

Digital divides and socio-economic inequality are well covered by research; access, usage and outcomes vary widely among younger individuals as well as older people (van Dijk 2020; Friemel, 2016; Llorente-Barroso et al., 2023). This study highlights yet another unevenly distributed component or aspect, which is warm experts and social support for learning. Above, we have seen that those who receive regular, high-quality support have opportunities. Others have to settle for sporadic support of lower quality—and still others have no warm experts to engage at all. Thus, even when taking informal learning and support within families into account, digital divides remain.

Our findings have policy implications. In 2030, it is assumed that almost 30 percent, or 3 million, of Sweden's population of 10 million will be 60 or older (Statistics Sweden, 2022). Increased digitalisation and the strategy Digital First are ways to meet this demographic change and the coming challenges for the welfare state. However, without knowledge of users' specific starting situations, the strategy risks contributing to rather than reducing inequality and thereby counteracting the compensatory functions of welfare policy.

Digitalisation gives individuals opportunities but also makes demands. It requires lifelong learning in the true sense of the term, i.e. long after working life has ended. The absence of standardisation and stability in this area is palpable: the lifecycles of devices are

short and usage skills have to continuously be re-acquired and re-learned. The interfaces of platforms and applications are even more inconsistent. Despite this, Sweden, like almost all countries, has not created a well-developed system for education and training in parallel with the digital expansion. Individuals must rely mainly on their own abilities and resources within the family. This will most likely not contribute to a more equal distribution of welfare and social rights.

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WHEN DOES PARASOCIAL INTERACTION MAKE INFLUENCERS MORE INFLUENTIAL?

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Abstract: *Consumers who experience higher parasocial interaction (PSI) with influencers are more likely to try an option that the influencer recommends. Are consumers with high PSI also more likely to follow an influencer's recommendation not to try an option? We predicted that PSI would matter more when the influencer encourages consumers to try an option than when she discourages them from trying it. Inconsistent with our prediction, consumers were more likely to follow the influencer's recommendation when the influencer encouraged them and when the influencer attempted to create high PSI with consumers, but these effects were independent.*

Keywords: *parasocial interaction, social media influencers, consumer behavior, persuasion, experimental research*

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INTRODUCTION

Bloggers, YouTubers, Instagram celebrities, and other social media influencers play a significant role in people's lives. For example, during the COVID-19 pandemic, the Finnish government used social media influencers to spread reliable information about the coronavirus to citizens (Pöyry et al., 2022). Influencers can also affect consumers' purchase intentions (Reinikainen et al., 2020), guide purchase behavior (Djafarova & Rushworth, 2017), and shape consumers' brand attitudes (Nafees et al., 2021). For instance, Kim Kardashian recently started promoting Guinness Irish beer, leading especially young consumers to want it so much that pubs almost ran out of Guinness (Hutchison, 2024).

Why do influencers, who most consumers have never met, hold such sway over consumers? One reason is because consumers experience parasocial interactions (PSI) with influencers. PSI refers to a consumer's illusionary experience of being engaged in social interaction (Horton & Wohl, 1956) with, for example, social media influencers. Although the relationship is one-sided, audience members may sense that the influencer is aware of them, pays attention to them, or reacts to their behavior (Dibble, Hartmann, & Rosaen, 2016; Horton & Wohl, 1956). Prior research has shown that influencers' verbal (e.g., saying "you" to the audience) and bodily (e.g., looking directly at the camera) addressing lead consumers to experience PSI (Cummins & Cui, 2014, Hartmann & Goldhoorn, 2011; Tukachinsky & Sangalang, 2016).

PSI with influencers often produces positive outcomes. For example, consumers can cope with their loneliness by experiencing PSI with celebrities because PSI makes viewers feel closer and more related to the celebrities (Aw & Labreque, 2020). Also, when influencers engaged in more PSI, consumers had higher purchase intentions toward products the influencers promote (Lee & Lee, 2021). Moreover, consumers who had higher PSI with other users (including celebrities) on the social commerce platform (Mogujie) had higher impulsive buying tendencies on that platform (Xiang et al., 2016).

Prior research has mainly focused on how PSI increases the likelihood that consumers follow a positive recommendation (Garg & Bakshi, 2024; Gong et al., 2025; Gopakumar & Dananjayan, 2024; Lee & Watkins, 2016; Xiang et al., 2016); it has not looked at whether PSI increases whether consumers are more likely to follow a recommendation to avoid an option. Social media influencers cannot only encourage their followers to try an option (i.e., positive persuasion), they can also discourage them from trying it (i.e., negative persuasion (Shadijanova, 2023). However, research has paid little, if any, attention to how consumers respond when influencers discourage them from trying an option. Additionally, it remains unclear whether consumers who experience higher PSI are also more likely to follow the influencer's recommendation to not try an option. The present study addresses this research gap by comparing the role of PSI in consumers' decision to listen to a recently published song when the influencer either recommends listening to it or discourages participants from listening to it.

Research shows that negative information (i.e., discourage to listen to a song this) is generally more persuasive than positive information (i.e., encourage to listen to a song) (Baumeister et al., 2001; Rozin & Royzman, 2001). Therefore, if negative information is more effective than positive, one could argue that PSI should make negative messages particularly persuasive. On the other hand, when an influencer discourages consumers from

trying an option, the effect of a negative message might be so powerful that PSI no longer increases its effectiveness (see. ceiling effect) (Garin, 2014).

The present study addresses this research gap by conducting a between-subjects experiment to compare the role of PSI and addressing in consumers' decisions to listen to a recently published song when the influencer either recommends or discourages them from listening to it. We examine this topic from the perspective of young consumers, since they are the most active followers of influencers and appear to be the most susceptible to their influence (Auxier & Anderson, 2021; Stok et al., 2016).

THEORETICAL BACKGROUND AND HYPOTHESIS DEVELOPMENT

Social Media Influencers and Parasocial Interaction

Social media influencers are independent (third-party) endorsers who shape their followers' attitudes on social media (Freberg et al., 2011). Influencers such as YouTubers and Instagram influencers typically promote or share their experiences of products on social media platforms with other users through images and videos (Sokolova & Kefi, 2019). Influencers can be categorized into groups based on the number of their followers. Celebrities and mega-influencers have over 1 million followers, macro-influencers 100,000 – 1 million, micro-influencers 10,000-100,000, and nano-influencers have less than 10,000 followers (Park et al., 2021).

Since influencers have a lot of followers, companies form strategic partnerships with influencers to reach different consumer groups (Borchers & Enke, 2021). This practice is also known as influencer marketing (De Veirman et al., 2019). Influencer marketing is a practice in which influencers can promote a company's products and services for financial compensation (Reinikainen, 2022). Influencer marketing has become a crucial part of companies' marketing strategies intending to increase the company's performance (Leung et al., 2022). The fact that the influencer marketing market size has vastly expanded globally (Statista, 2023) also illustrates the potential that influencers must help companies reach and persuade consumers.

One reason for influencers' effectiveness as endorsers is that audiences can experience parasocial interaction (PSI) with them. To illustrate, when the viewers watch influencers' videos, they might experience that the influencer reacted to what they said or did, or was aware of them (Dibble et al., 2016). Interestingly, scholars have often incorrectly used the term PSI to refer to parasocial relationships (PSR). While parasocial interactions (PSI) can only occur during an exposure condition (i.e., during viewing), parasocial relationships (PSR) refer to longer-term, one-sided relationships with influencers that may develop during exposure but extend beyond it (Dibble et al., 2016). This study focuses exclusively on PSI.

Researchers have attempted to create a parasocial experience by showing participants a short video in which the influencer addresses the audience bodily (e.g., looking directly at the camera) and verbally (e.g., saying "you" to the audience) (Dibble et al., 2016; Hartmann & Goldhoorn, 2011). Influencers can also make the video feel more interactive by using the pronoun "you" and asking viewers to leave their comments in the video's comment section (Penttinen et al., 2022). Some studies have also shown how self-disclosure (e.g., when the

influencer reveals personal details) can make the audience feel that the influencer is socially present, which subsequently increases the audience's parasocial experience (Kim & Song, 2016).

Studies have shown that consumers' perceived PSI increases consumers' purchase intentions (Colliander & Dahlen, 2011; Lee & Lee, 2022; Lee & Watkins, 2016; Shen et al., 2022). Also, participants who experienced higher PSI with the influencer were more likely to have higher purchase intentions toward products that the influencer promoted (Sokolova & Kefi, 2020). In the same vein, Aw and Labrecque (2020) revealed that PSI can make young adults feel more attached to celebrities, which in turn leads to higher purchase intentions. Another study demonstrated how consumers' perceived PSI with YouTubers helped consumers evaluate and understand products, reducing their perceived risk and consequently increasing their purchase intentions (Lee & Lee, 2022). Research suggests that consumers who experience PSI with influencers are more likely to follow the recommendation of an influencer because PSI increases their confidence, especially when consumers are uncertain about their preferences (Penttinen et al., 2022).

Social Media Influencers and Deinfluencing

While influencers can persuade their audiences to buy a product, they can also discourage consumers: The new rising "deinfluencing" trend reveals that influencers have started to tell consumers what products and services they should avoid (Shadijanova, 2023). For example, a video entitled *"Please do not Buy This Car (Unless You're a Mechanic)"* uploaded by American YouTuber #Scottykilmer has been viewed nearly a million times. Likewise, a famous YouTuber, #Mrwhosetheboss, published *"Don't buy this smartphone,"* a video review viewed by 4.4 million people in which he described the weaknesses of a certain smartphone model. The timeliness of the *"deinfluencing"* trend becomes apparent in TikTok statistics: while the hashtag #deinfluencing had approximately 264 million views at the beginning of 2023 (Bainotti, 2023), the number of views in 2024 is over 1.5 billion (Scott, 2024).

Few studies have examined de-influencing. One exception is a recent study by Kilic and Polat (2024), which defined de-influencing through content analysis as social media influencers raising awareness against excessive and unnecessary consumption. They identified several deinfluencing tactics, such as highlighting overpriced destinations or sharing better alternative options for travel. Moreover, Bainotti (2023) analyzed deinfluencing content on TikTok and revealed three key categories: 1) resistance, where consumers resist aspirational lifestyles and consumerism; 2) consumerist reappropriation, involving the authentic promotion of affordable consumer goods by reliable brands; and 3) trend-surfing, where consumers utilize the visibility of the deinfluencing trend to promote themselves. This rising trend of de-influencing is important because it can be more effective than influencing. For example, experiments have shown that de-influencing reduces purchase intentions more significantly than influencing increases them (Wallbaum, 2023).

Negative experiences, negative emotions, and negative information typically have a stronger impact than positive experiences, emotions, and information (Baumeister et al., 2001). Human brains respond more to bad than to good things and negative information evokes more thorough processing than positive information (Baumeister et al., 2001; Rozin &

Royzman, 2001), and when people make decisions, they attach more importance to the negative aspects than positive aspects (Vaish et al., 2008). Likewise, when people meet someone for the first time and form the first impression, new people's negative aspects weigh much more compared with positive aspects (Baumeister et al., 2001). People also tend to perceive negative information as more truthful than positive (Hilbig, 2009). It has also been shown that negative reviews are more powerful than positive reviews (Chevalier & Mayzlin, 2006).

Research shows that negative information demands more cognitive processing, which makes the information more persuasive (Hilbig, 2009). Because negative information is more persuasive generally, consumers might be more likely to follow the advice of an influencer who recommends avoiding an option, regardless of whether they have had PSI.

Parasocial Interaction and Negative Information

It is plausible that consumers who have PSI with influencers would be also more likely to follow the influencer's recommendation to avoid an option. On the other hand, research shows that bad is stronger than good (Baumeister et al., 2001), which could result in negative recommendations being influential regardless of whether consumers have PSI with an influencer. However, regardless that influencers are increasingly *"deinfluencing"* on social media, studies have exclusively examined whether consumers who experience PSI with influencers are more likely to follow the influencer's positive recommendation (e.g., purchase intentions) (Colliander & Dahlen, 2011; Garg & Bakshi, 2024; Gong et al., 2025; Gopakumar & Dananjayan, 2024; Lee & Watkins, 2016; Xiang et al., 2016). Studies have not investigated whether PSI increases the consumers' likelihood to follow an influencer's recommendation to avoid an option. However, it can also be that when an influencer discourages consumers from trying an option, the effect of a negative message is so powerful that PSI no longer increases its effectiveness (see. ceiling effect) (Garin, 2014). Thus, we predict that PSI will be less likely to increase the extent to which consumer follow an influencer's recommendation when the influencer discourages (negative) consumers from trying an option than when she encourages (positive) consumers to try the option.

H1. Consumers will be more likely to follow the recommendation of an influencer with high compared to low PSI when the influencer makes a positive recommendation than a negative recommendation.

MATERIALS AND METHODS

Participants and Study Design

Data were collected in Fall 2022 from US citizens aged 18–35 years recruited from Amazon Mechanical Turk (total n = 401). The participants were assigned to a condition in a 2 (Addressing: high, low) × 2 (Recommendation: positive, negative) between-subjects experimental design. We pre-registered the hypothesis of this study (https://aspredicted.org/blind.php?x=YBW_49J). The following link also includes the used

attention checks such as *"What is your favourite color? Regardless of your favourite color, choose blue"* and realism check such as *"When watching the video, I felt I could come across this kind of video on social media".*

Research Ethics

We followed the ethical guidelines of the Ethics Committee of the University. According to the guidelines of the Ethics Committee, the present study did not require an ethical review. Participation in this study was voluntary and participants were able to refuse to participate or cancel their participation at any time without any consequences. Research participants were informed about the study, and they needed to give their consent before entering the research. We did not collect any personal information including indirect identifiers. Also, this study did not include sensitive or harmful content that could be seen as ethically questionable.

Procedure

After consenting to participate in the study, participants read that they would watch a short video in which a nano-influencer, a native English speaker named "Julia", recommends listening, or not listening, to a song. We created four versions of the video to manipulate whether the influencer addresses the participant (which should create a high vs. Low PSI) and whether the influencer recommended listening (positive recommendation) or not listening (negative recommendation) to the focal song.

We attempted to manipulate PSI by varying whether the influencer addressed participants with her body (bodily addressing) and voice (verbally addressing). Scholars have used bodily addressing (e.g., eye contact) and verbal addressing (e.g., tone of voice) to manipulate participants' PSI experience (Cummins & Cui, 2014; Hartmann & Goldhoorn, 2011; Tukachinsky & Sangalang, 2016). Additionally, previous studies have demonstrated that PSI can be effectively manipulated using short video stimuli (Dibble et al., 2016; Hartmann & Goldhoorn, 2011). That is, participants who were bodily and verbally addressed by the influencer experienced significantly higher PSI than when not verbally and bodily addressed (Hartmann & Goldhoorn, 2011).

Bodily addressing occurs when an influencer looks directly at the camera rather than looking to the side. Research suggests that eye-gaze triggers automatic mindreading (inferring others' mental state) (Malle & Hodges, 2005), leading to a parasocial experience (Hartmann & Goldhoorn, 2011). Smiling can similarly produce automatic mindreading (Malle & Hodges, 2005). When two people interact, their bodily gestures (e.g., smiling) begin to synchronize because when one person shows their mental state with, for instance, facial expression, the other tends to automatically imitate their behavior (Malle & Hodges, 2005, pp. 36–37). This bodily addressing, in turn, should create PSI (Hartmann & Goldhoorn, 2011). Smiling also signals expressers' cooperative social motives (affiliative smiles) (Niedenthal et al., 2010), and people typically perceive a smile as an invitation for reciprocal smiling and cooperative behavior (Horstmann, 2003). Thus, the influencer smiled and spoke directly to participants in the high PSI condition, but did not smile and looked away from participants in the low PSI condition (see Figure 1). This procedure has been validated in previous studies (Dibble et al., 2016; Hartmann & Goldhoorn, 2011).

We manipulated verbal addressing by having the influencer speak directly to viewers by using the "you" pronoun, welcoming viewers back to the channel, and saying, "Thanks for watching. If you liked the video give it a thumbs up. See you next time." The influencer did not say these things in the low PSI condition. This procedure has been an established approach in previous studies (Cummins & Cu, 2014; Hartmann & Goldhoorn, 2011; Tukachinsky & Sangalang, 2016; Penttinen et al., 2022).

Figure 1. An illustration of bodily addressing

Note 1. The upper image illustrates low bodily addressing while the image below illustrates high bodily addressing.

The study included four videos: one in which the influencer endorsed a song by recording artist Left Vessel titled "This Year Be" with high addressing, a second in which the influencer endorsed the same song with low addressing, a third in which the influencer criticized "This Year Be" with high addressing, and a fourth in which the influencer criticized the same song with low addressing (see table 1).

After watching the video, participants chose whether they wanted to listen to "This Year Be" or "Eclipse" a song by the band Wages that the influencer did not discuss. We varied the prior views of each song to give participants a reason to not necessarily follow the influencer's recommendation. Specifically, we described "This Year Be" as having fewer views than "Eclipse" when the influencer encouraged participants to listen to "This Year Be" but more views than "Eclipse" when the influencer discouraged participants from listening to "This Year Be".

Next, participants reported their level of parasocial interaction with an established EPSI scale (α =. 95; e.g., "while watching the video clip, I had the feeling that the speaker was

aware of me;" 1 = strongly disagree, 7 = strongly agree; (Dibble et al., 2016; Hartmann & Goldhoorn, 2011). Finally, participants completed exploratory measures and reported their demographic information (see the appendix).

Table 1. Descriptive statistics

Video	Persuasion	Addressing	Behavioral outcome (Mean)	N	Standard Deviation
1	Positive	High	1.61	97	.491
2	Positive	Low	1.42	96	.496
3	Negative	High	1.48	107	.502
4	Negative	Low	1.31	100	.465

Note 1. Behavioral outcome = complying with the influencer's recommendation (1 = did not comply, 2 = complied).

RESULTS

ANOVA revealed that the addressing manipulation did not have the predicted effect on perceived experience of PSI. That is, participants reported a similar level of PSI regardless of whether the influencer addressed them (M = 5.25 vs. 5.12; F (1, 202) = .39, p = .53) or not; (M = 5.03 vs. 5.24; F (1, 195) = .76, p = .38). Addressing failed to increase perceived PSI regardless of whether the influencer recommended listening to "This Year Be" (M = 5.25 vs. 5.03; F (1, 192) = .86, p = .35) or not listening to "This Year Be" (M = 5.12 vs. 5.24; F (1, 205) = .32, p = .57).

Despite the insignificant effect of the Addressing manipulation on perceived PSI, we examined the effects of Addressing and Recommendation on whether the participants complied with the influencer's recommendation using logistic regression with contrast coded variables representing the Addressing factor, the Recommendation factor, and their interaction. The data revealed a main effect of Addressing, such that participants were more likely to follow the advice of the influencer with high addressing

(β = .75, OR = 2.12, p < .001, R^2 = 0.06), and a main effect of Recommendation, such that participants were more likely to follow the influencer's suggestion to listen to a song than to not listen to the song (β = .49, OR = 1.64, p < .017, R^2 = 0.06). The interaction, however, was not significant (β = .08, OR = 1.09, p =. *832*, R^2 = 0.06), which suggests that participants were more likely to follow the influencer's recommendation when she addresses them, regardless of whether she encouraged or discouraged them from listening to the song (see table 2).

Table 2. Predictors of complying with the influencer's recommendation

Variable	B	Odds Ratio	df	Wald	S.E.	*p*
Persuasion * Addressing	.08	1.1	1	.045	.41	.83
Persuasion						
Positive	.49	1.64	1	5.71	.21	.017
Negative	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)
Addressing						
High	.75	2.12	1	13.23	.21	<.001
Low	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)
Constant	-8.24	0.44	1	19.93	0.185	<.001

Note 2. Total n = *401.*

Note 2. Since only 3 participants reported their age as over 35 we did not exclude them from the study.

DISCUSSION

The objective of this study was to examine whether consumers who experience high PSI with the social media influencer are more likely to follow the influencer's recommendation when the influencer either encourages them to try an option or discourages them from trying it. We hypothesized that consumers are more likely to follow the influencer's recommendation with high compared to low PSI when the influencer gives a positive recommendation than a negative recommendation since negative information is stronger than good (Baumeister et al., 2001). Our hypothesis could not be supported or rejected because participants who watched videos with high addressing versus low addressing did not perceive a different level of PSI. This finding is not in line with Cummins and Cui (2014), Hartmann and Gooldhoorn (2011), and Tukachinsky and Sangalang (2016), who noted that high addressing yields PSI experience and that high and low addressing should yield a variation in the EPSI scale (Dibble et al. 2016), because our videos, which were manipulated to yield low PSI experience, also caused relatively high PSI. This raises the question of how influencers can effectively vary PSI with their followers, as our study suggests that verbal and bodily addressing may not be enough to reliably influence PSI.

Interestingly, we found that consumers are more likely to follow the recommendation of an influencer when the influencer addresses them, even though addressing did not increase perceived PSI. Since the PSI experience did not differ between those who watched low and high addressing videos, we conclude that the verbal (engaging speaking style) and bodily addressing (smiling and eye contact) caused the differences in participants' behavior. Although these results are inconsistent with research that suggests addressing increases PSI (Cummins & Cui, 2014; Hartmann & Gooldhoorn, 2011; Tukachinsky & Sangalang, 2016), it is consistent with research showing that smiling can increase purchase intentions (Trivedi & Teichert, 2019) and that eye contact increases cooperative behavior (Luo et al., 2016).

Theoretical and managerial contributions

Theoretically, this study contributes to the PSI literature. As the addressing manipulation did not have the predicted effect on perceived PSI, this raises questions about the robustness of the conventional methods (i.e., bodily and verbal addressing) used in prior research to yield PSI (Cummins & Cui, 2014; Hartmann & Goldhoorn, 2011; Tukachinsky & Sangalang, 2016). In line with Dibble et al. (2016) we recommend future studies to design more robust and reliable practices to induce greater differences in PSI between low and high addressing groups.

Second, this study contributes to the limited literature on de-influencing and responds to the call by Kilic & Polat (2024), who stated that, as a new concept, de-influencing requires further research and understanding. We found that participants were more likely to follow the influencer's suggestion to listen to a song than to not listen to the song. This contrasts with experiments showing that de-influencing is more effective than influencing (Wallbaum, 2023). However, our findings suggest that bodily and verbal addressing styles also increase the effectiveness of negative persuasion. Thus, given that the new *"de-influencing"* trend is becoming more prevalent on social media (Kilic & Polat, 2024; Shadijanova, 2023) our findings suggest that influencers should smile, make eye contact with the audience and

engage them verbally (e.g., welcoming to the video) to increase the effectiveness of their criticism. Furthermore, as participants were more likely to follow the influencer's suggestion to listen to a song than to not listen to the song, our findings do not support the negativity bias, which suggest that bad is stronger than good (Baumeister et al., 2001; Rozin & Royzman, 2001). Rather, our findings support the notion that bad is not always necessarily stronger than good (Wu, 2013). For instance, consumers were more willing to buy second-hand clothes when exposed to a positively framed message (i.e., you can help protect the environment by buying second-hand) than negatively framed (i.e., you can help stop the collapse of the environment by buying second-hand) (Grappi et al., 2024). Also, the question of whether bad is stronger than good likely depends on the individual characteristics of the message receiver. For instance, a study by Li et al. (2021) showed that consumers with a higher personal sense of power (i.e., a perceived ability to influence others) were more persuaded by positively framed advertisements than by negatively framed ones. This is because consumers with a higher sense of power are more likely to focus on potential gains, whereas those with a lower sense of power tend to focus on potential threats (Li et al., 2021).

From a managerial perspective, our findings highlight the effectiveness of influencers' addressing styles in shaping consumer behavior. This can be important for companies who collaborate with influencers. That is, if a company uses an influencer to promote its products and services, the company should ensure that the influencer addresses their audience in the videos with a smile, eye contact, and an engaging communication style to increase the effectiveness of the message.

Limitations and Future Research Directions

Because the addressing manipulation did not influence PSI, our research was not able to test the causal effects of PSI on participants' decisions. We hope that future research will continue to explore this important question. Also, as our results did not show a negativity bias, future studies would benefit from incorporating high-involvement decisions where participants have a higher stake in the outcome, and thus, negativity bias is more likely to occur (Rozin & Royzman, 2001). In general, research reveals that consumers are highly influenced by loss aversion – losses are twice as impactful for consumers as gains, meaning that losing 500 euros feels as significant for consumers as gaining 1000 euros (Baumeister & Finkel, 2010). However, as this study did not include scenarios with serious potential losses (e.g., losing money), consumers might have acted against the recommendation purely out of curiosity. To address this, we recommend that future studies design scenarios where consumers face greater potential losses, which would also reduce the influence of curiosity. For example, people are presumably more likely to listen to a criticized song out of curiosity than to watch a criticized movie, as a movie involves greater sacrifices (e.g., time, effort, or emotional investment) compared to listening to a short song.

CONCLUSION

This study shows that influencers are more effective persuaders when they address their audiences, regardless of whether they encourage or discourage their followers from trying an

option. Further, the addressing increases influence independent of PSI. To the best of the authors' knowledge, this is the first study that shows the effectiveness of addressing when an influencer recommends avoiding an option.

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Human Technology
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Appendix

Measured pre-covariates

Conformity

As we assumed that some participants would be more unwilling to follow anyone's recommendations than others (nonconformists), which would result in noise problems, we included an 11-item Likert-type scale (1 = strongly disagree, 7 = strongly agree) adopted from Mehrabian and Stefl (1959).

Other measurements

The following sociodemographic characteristics were measured: age, education, and gender identity. All the measured scales and sociodemographic characteristics were almost evenly distributed between conditions (adequate balance).

Manipulation check

We included the following manipulation check variable *"I felt that the influencer (Julia) was looking at me"* in the questionnaire adopted from Hartmann and Goldhoorn (2011). The participants did not differ in this variable between conditions; they felt that Julia was looking at them even when she was not. However, as this variable underlined the participants' subjective feeling of whether they "felt" that the influencer was looking at them, not whether the influencer actually had eye contact with them, this variable might not be applicable for the manipulation check. Rather, this measure can further explain why PSI did not yield variation in the EPSI scale; it might be that the mere existence of the influencer was enough to yield the PSI experience.

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MOBILE DEVICES AND MOBILE INTERNET DATA SERVICES: IMPLICATIONS FOR MOBILE BANKING

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Abstract: *Mobile devices allow users to access applications anytime and anywhere. Through mobile devices, users can download and get access to banking services, using mobile banking applications. In order to perform banking activities, users need to trust in this service first, and this includes the quality of the Internet connection. Moreover, considering that mobile devices have different screen sizes, these differences may also affect the intention to use mobile banking. Therefore, the aim of this paper was to analyze the potential effect of the size of mobile devices and of the mobile Internet data services on trust in mobile banking. The quantitative analysis includes descriptive statistics, confirmatory factor analysis and structural equation modeling. The main results suggest that mobile Internet data services presented a positive effect on trust in mobile banking, but the type of mobile device has no significant effect on trust. The discussion of the results considers the possibility of strategic alliances between different sectors to improve the adoption of mobile banking in developing countries.*

Keywords: *mobile devices, trust, wireless networks, mobile internet data service, Brazil.*

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INTRODUCTION

Over the past decades, computers have become smaller, more portable, and with user-friendly interfaces, allowing their constant presence in the life of people. An example of this evolution is the case of mobile devices, which allow their users to access networks anytime and anywhere (Yang et al., 2012). The proliferation of mobile devices is increasing at an incredible rate (Kortum & Sorber, 2015). This type of human-computer interaction facilitates personal and social life of people (Lee, 2009). In addition, new mobile technologies are available specifically for the development of financial services (Boonsiritomachai & Pitchayadejanant, 2019).

One application that uses the ubiquitous characteristics of mobile devices is mobile banking. With mobile banking, customers can perform banking tasks such as bill payments and money transferences, with the values of immediate accessibility and convenience (Cruz et al., 2010; Oliveira et al., 2014; Hanif & Lallie, 2021; Karjaluoto et al., 2021; Apau et al., 2025) and a potential to revolutionize the interaction with consumers (Ali et al., 2023). Both banks and customers benefit from this technology in many ways (Apau et al., 2025; Palamidovska-Sterjadovska et al., 2025), and many users access mobile banking services several times a day (Luo et al., 2025). It is also important to note that the needs of people with disabilities should also be considered when offering banking services through mobile devices (Borowska-Beszta et al., 2025).

The number of cell-phones is higher than the number of computers, therefore, the use mobile banking has become more popular than the use of e-banking (Mehrad & Mohammadi, 2017). Flexibility is another feature that makes mobile banking more attractive than e-banking (Palamidovska-Sterjadovska et al., 2025). The recent health crisis caused by COVID-19 encouraged the practice of contactless transactions (Kim & Ryu, 2025), which also contributed to the demand and interest in using mobile banking services (Zakariah & Shariff, 2025). Despite the benefits of mobile banking, its adoption for conducting banking transactions is not as widespread as expected (Cruz et al., 2010; Shaikh & Karjaluoto, 2015; Rababa et al., 2025; Zakariah & Shariff, 2025). Thus, a better understanding about factors that facilitate (or hinder) the adoption of this technology is important for banks, to telecommunication companies, to mobile banking developers, and to end users.

Users can access the applications in mobile devices through open wireless networks, private wireless networks, or still through mobile Internet data services. The concern about security of personal information and privacy (Liao et al., 2011; Montezemi & Saremi, 2014) could be mitigated when customers contract mobile data services, because they will not depend of other networks to use mobile applications. Together with this consideration is the fact that mobile devices are small, but this characteristic also includes small display sizes. The small size of mobile devices may decrease the intention of users to use them to perform mobile banking transactions, especially considering the risk involved. Mobile banking platforms have attracted the attention of hackers (Apau et al., 2025), a factor that may influence bank customers' risk perceptions. On the other hand, users may perceive phones as more familiar in comparison with tablets, and this familiarity can be converted in higher perception of usability (Kortum & Sorber, 2015). Due to compatibility, "smartphones can benefit users in many ways, such as business and personal communication, information on the health issues identified earlier and mobile banking" (Choudrie et al., 2018, p. 453).

Based on this reasoning, we find a motivation to develop this paper and contribute to the literature of IS by including a quantitative analysis of variables that may improve the interaction between users and mobile devices. Therefore, **the aim of this study is to analyze the potential effect of the size of mobile devices and of the mobile Internet data services on trust in mobile banking**. A recent literature review on mobile banking showed that no study has explicitly investigated the effect of smartphones or tablets use on mobile banking adoption (Shaikh & Karjaluoto, 2015), which indicates the relevance of developing such analysis in this paper. Moreover, based on a set of previous research, Chaouali et al. (2017) state that poor telecommunication infrastructure, poor internet coverage and the cost of Internet are variables that can affect the adoption of mobile banking. The advancement of mobile and telecommunication technology benefits the acceleration of mobile banking (Alalwan et al., 2017; Afshan & Sharif, 2016).

Traditional theories such as TAM (Davis, 1989), UTAUT (Venkatesh et al., 2003), TTF (Goodhue, 1995; Goodhue & Thompson, 1995), and IDT (Rogers, 1995) have been employed to explain mobile banking adoption (Zhou et al., 2010; Oliveira et al., 2014; Shaikh & Karjaluoto, 2015; Mehrad & Mohammadi, 2017). There is some agreement that security and trust are the most important factors affecting mobile banking adoption, as this technology involves monetary transactions. Therefore, it is fundamental for mobile banking providers to build users' initial trust (Zhou, 2012a), and maintain it over time. Moreover, according to Alalwan et al. (2017, p. 106), trust is important to motivating customers to use mobile banking and also in "shaping their perception toward such technology as more productive and novel technology". Trust is the dependent variable of this research.

We collected data from Brazilian respondents to test the hypotheses of the quantitative model. Brazil is a developing country in which the adoption of mobile banking is still low (Febraban, 2015). Cruz et al. (2010) found that perceived risk is one of the main barriers to improve mobile banking adoption in Brazil, which reinforces the relevance of the analysis of trust as a dependent variable. A common goal of policymakers is to increase bank account ownership (Riley et al., 2025). In regions where bank access is limited, mobile banking can bring benefits to citizens (Kouandou & Laajimi, 2025). Moreover, many adults in developing countries do not have access to bank accounts (Agurto et al., 2025), a factor that makes Brazil an interesting case to study the adoption of mobile banking.

Exploring the use of applications available in mobile devices contributes with their continuous improvement (Kortum & Sorber, 2015). It can benefit both customers and app developers, because it helps in identifying customer's preferences and attitudes toward contemporary mobile services (Lee, 2009). This paper explores a variable that may be useful for banks and telecommunications companies, since they can establish partnerships to expand both mobile banking adoption and mobile service usage. Mobile telecommunication service industry need to develop strategies to make their customers satisfied with mobile services, preventing loss and maintaining customer retention (Lee, 2009). These strategies also involve the risks (or security) perceived by users when they use Internet data services to perform personal activities in internet.

In developing countries, the cost of mobile Internet data services may represent a more significant amount of resources relative to an individual's income. Moreover, in most of previous research on mobile banking, the attention is dedicated to the context of developed economies (Kamboj, Sharma & Sarmah, 2022), a factor that highlights the relevance of new

research based on data from developing countries. Therefore, a study of the potential impact of the type of Internet connection can present on banking technologies can contribute to a better understanding of the factors that influence, even indirectly, the adoption of mobile banking in emerging economies.

HYPOTHESES DEVELOPMENT

In mobile technology, the quality of service perceived by users is an important concept (Lee, 2009), as well as the effective network performance (wired or wireless) (Saliba et al., 2005; Lee, 2009). Wireless data can be said as relevant issue to telecommunications companies (Saliba et al., 2005), especially when we observe the popularity of mobile internet (Yang et al., 2012). Even with the different applications that are available in mobile devices, users generally concentrate their attention on a few services of mobile internet (Lee et al., 2005).

Companies in dynamic industries such as computers, software and telecommunications have been increasingly using different kinds of cooperative relationships (Hoffmann, 2007; Lavie, 2007). Studying extreme mobile experiences, Salo (2014) found that utility is a dominant category of positive experiences with mobile applications. As mobile banking seems to be one kind of utilitarian application (O'Brien, 2010; Li et al., 2012), strategic alliances to improve the rate of mobile banking adoption could result in more people using telecommunication services.

Strategic alliances represent voluntary agreements between enterprises that can involve exchange and co-development of products, technologies and services (Gulati, 1998; 1999). New technologies can represent a stimulus to cooperative efforts, even between groups of competitors (Powel et al., 1996). These alliances can take a variety of forms and occur as a result of different reasons and goals, and an important issue for alliances is their effect on performance (both the performance of the alliance itself and the performance of firms involved) (Gulati, 1998; Lavie, 2007). In this sense, these partnerships can also be benefit for mobile banking adoption in developing countries.

There is a growing concern about how individuals can protect their personal information (Liao et al., 2011), so security and privacy of online transactions are essential for customers to trust in online banking (Montezemi & Saremi, 2014). Privacy concerns have a negative effect on electronic commerce adoption (Liao et al., 2011), and their effect on mobile banking adoption should be similar.

Users that have access to mobile Internet data services experience a different environment to develop their virtual activities, once they are presumed to have higher levels of trust in the internet connection. When compared to wired network, mobile internet networks may be more vulnerable to information interception (Zhou, 2012b). In this way, users that use their mobile applications only with open networks may present higher concerns about trust in their connection with the internet. We hypothesized that this security perception on the internet connection will be transferred to trust in mobile banking, so we have the first hypothesis of this study: **H_1** - the use of mobile Internet data services has a positive effect on trust in mobile banking.

The use of mobile devices in education, also known as m-learning, has some advantages such as portability and wireless connection; nevertheless, different screen sizes represent a

kind of disadvantage of mobile devices for learning (Furió et al. 2013). Despite it was expected that larger screen size would present a significant effect on variables such as satisfaction and interaction of users, Furió et al. (2013, p. 38) observed that both devices (iPhone and Tablet PC) "were equally suited for educational games". In a previous study about touchscreen keyboards, Sears et al. (1993) found that users' performance on smallest keyboards was lower than the performance of the largest ones; also, experience with small keyboards is an aspect to be considered. Considering that currently users are more familiar with small devices, perhaps some negative effects of small sizes decreased along time.

The perception of complexities and difficulties with novel technologies (such as mobile banking) can be reduced, preventing risk and promoting trust when compatibility issues are considered (Choudrie et al., 2018). Moreover, the attitudes and intentions toward mobile banking might differ considerably between smartphone and tablet users (Shaikh & Karjaluoto, 2015), since the applications available in these devices have different designs. Tablets are bigger than smartphones. Due to the size screen limitation, developers may need to choose carefully what contents and functions to display in smartphones apps (Kortum & Sorber, 2015), including the developers of mobile banking apps.

"Yet, graphic user interfaces (GUIs) often are not adapted to this; desktop computer GUIs are migrated to the smaller devices without consideration of their special requirements. This results in miniaturization of icons and buttons" (Conradi et al., 2015, p. 388). Furthermore, there is the case of virtual keyboards, especially because "touch screen interface has become prevalent on mobile devices" (Kim et al., 2014), and the size of keyboards can affect the performance of users (Sears et al. 1993).

Kortum and Sorber (2015) found that phone apps usability was being rated higher in comparison with the rates of tablet apps. McLellan et al. (2012) observed that users with more extensive experience with a technology tend to provide higher scores of usability for this technology. Following this reasoning, the results of Kortum and Sorber (2015) that phones were scored higher than tablets, can be explained by the experience and familiarity of the users with mobile phones. In this way, we stablish the second hypothesis of this study: **H_2** - the kind of mobile device has a significant effect on trust in mobile banking.

DATA AND METHOD

This paper has two goals: i) analyze the effect of mobile Internet data services, contracted from telecommunication companies, on trust in mobile banking; and ii) analyze if there are significant differences of trust in mobile banking among different kinds of mobile devices. We included three other characteristics in our model that may affect trust in mobile banking: task characteristics (Junglas et al., 2008; Zhou et al., 2010; Hwang & Jeong, 2016), age, and gender (Lee, 2009; Hwang, 2010).

The concept of task characteristics is relevant to understand mobile banking adoption (Zhou et al., 2010), since customers tend to adopt this technology in order to optimize their time spent with banking activities. Thus, it is natural to presume that customers with higher levels of banking activities will show higher levels of trust in mobile banking. Age and gender were included because younger customers tend to be more willing to adopt new technologies than their older counterparts (Cruz et al., 2010), and men tend to be less anxious

with technology than women (Laguna & Babcock, 1997). We expect that these effects will affect trust in mobile banking too. The two constructs that we used in our research model were measured as shown in Appendix A.

All these six questions were answered with a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The other variables of the model are age (in years); gender (male/female); if the respondent has mobile Internet data services in his/her mobile device (yes/no); and kind of mobile device that the respondent usually uses (smartphones / tablets). Data were collected through person-to-person questionnaires, with undergraduate students in the southeast region of Brazil. We obtained 1,083 valid questionnaires (which represents 92.01% of 1,173 questionnaires that we distributed).

To test the hypotheses, in a first moment we used confirmatory factor analysis (CFA), and then we applied structural equation modeling (SEM), as recommended by Anderson and Gerbing (1988). We also analyzed the descriptive statistics of variables, in order to explore more information about empirical data.

RESULTS

Descriptive Analysis

The first step of data analysis was the descriptive statistics. We observed that the respondents were 51.6% male (48.4% female) and ranged in age from 16 to 51 years old. The average of age was 21.72 years, indicating that the majority of respondents are young. This is a natural result, since we applied the questionnaires to undergraduate students. Almost three quarters of sample (73.41%) reported the use of mobile Internet data services, contracted from telecommunication companies.

The adoption of tablets among the students was relatively low (18.88%) in comparison with the adoption of smartphones (97.04%). These preliminary results indicate that the adoption of smartphones is widespread in the sample, and it is in accordance with the considerations made in the literature review (Kortum & Sorber, 2015), that smartphones tend to be more familiar than tablets among users. Additionally, due to compatibility (Choudrie et al., 2018), the higher rates of adoption of smartphones indicates a good panorama for an initial use of banking services through mobile devices.

These results are interesting, because the students in the sample have smartphones, and the majority have mobile Internet data services. Therefore, it is assumed that they have the minimum requirements to use mobile banking services, but the adoption of mobile banking in Brazil is still very low (Febraban, 2015). In this way, it is important to understand the variables related to trust in mobile banking, since trust is fundamental to the adoption of technologies that involve money transactions.

Table 1 shows the mean of each question used to measure latent variables. We can observe that students tend to trust in mobile banking more than distrust, because the average scores of questions tru1, tru2, and tru3 are all higher than 3. Results also indicate that the level of task activities in the sample tend to be high for questions tsk2 (manage account anytime anywhere) and tsk3 (acquire account information in real time). With these results,

we could deduce that the use of mobile banking for these students would be beneficial to save time and to optimize their activities.

Table 1: Descriptive statistics of the items used to measure latent variables

Items	n	Minimum	Maximum	Mean	Std. Deviation
tsk1	1,083	1.000	5.000	2.258	1.381
tsk2	1,083	1.000	5.000	3.025	1.601
tsk3	1,083	1.000	5.000	3.464	1.592
tru1	1,083	1.000	5.000	3.271	1.177
tru2	1,083	1.000	5.000	3.136	1.165
tru4	1,083	1.000	5.000	3.533	1.126

In general, the results of this descriptive analysis showed that it seems to exist a good potential for mobile banking penetration to respondents with similar characteristics in this region of Brazil. The main reasons for this affirmation are: i) respondents have the minimum skills and resources to use mobile banking; ii) respondents pointed out a frequency of tasks characteristics that could be optimized with the use of mobile banking.

CFA and SEM

The research model involves two latent variables: trust in mobile banking and task characteristics. We developed CFA in order to evaluate convergent and discriminant validity of these measures (trust and task). Table 2 shows the loadings of the questions in the factor analysis, and it can be observed that all questions were loaded according to their respective construct.

Table 2: Loadings of questions in the factor analysis

Items	Task	Trust
tsk1	**0.815**	0.145
tsk2	**0.907**	0.234
tsk3	**0.857**	0.214
tru1	0.267	**0.894**
tru2	0.210	**0.900**
tru4	0.107	**0.661**

Table 3 indicates the Cronbach's Alpha, Composite Reliability and the Extracted Variance of the constructs. The results indicated good indexes for internal consistency of measures, since all indexes registered values above those recommended by the literature. The root square of AVE is 0.835 (to task) and 0.750 (to trust). These values are above the

correlation between the constructs (0.492, $p<0.01$), which indicates good discriminant validity between these two latent variables.

Table 3: Reliability of the constructs

Const.	Items	Load. (Std.)	Average Variance Extracted (AVE)	Root Square of AVE	Composite Reliability	Cronbach's Alpha
TSK	tsk1	0.683	0.697	0.835	0.871	0.859
	tsk2	0.976				
	tsk3	0.820				
TRU	tru1	0.759	0.562	0.750	0.791	0.799
	tru2	0.857				
	tru3	0.613				
Recommended Values			0.500	0.707	0.700	0.700

In Table 4 we included the indexes for goodness of fit, for both CFA and SEM. The results of CFA includes data of the two latent variables (trust and task), and the results in the SEM column refer to the complete model, which also considers age, gender, mobile Internet data and kind of mobile device. There are evidences that the quantitative models are adequate for hypothesis testing. In the CFA stage, for only one index: RMSEA, the value was not below the threshold of 8%, but it is below 10% and the lower value of the confidence interval, with 90% of confidence, is lower than 8% (it is 7.6%, as we can see on Table 4). Furthermore, all the values of RMSEA were below 8% in the SEM analysis. In this way, we considered that these measures were adequate and we performed the hypotheses testing.

Table 4: Goodness of fit of the quantitative models

Items	CFA	SEM
chi-square	65.718	104.197
d.f.	6	22
signif.	0.000	0.000
GFI	0.981	0.981
AGFI	0.932	0.953
Standard. RMR	0.039	0.030
RMSEA	0.096	0.059
RMSEA (Low. 90%)	0.076	0.048
RMSEA (Up. 90%)	0.118	0.070
CFI	0.980	0.974
NFI	0.978	0.967
NNFI	0.951	0.946

Table 5 contains the sign of the coefficients in the path analysis (r-square of the model: 25.71%). The first hypothesis of this study (**H_1**) was that mobile Internet data services has a positive effect on trust in mobile banking. The results obtained through the questionnaires supported this hypothesis, indicating that students that already have mobile data services tend

to present higher levels of trust in mobile banking, in comparison with their counterparts that do not have mobile data services.

Table 5: Results for hypotheses testing

Hypothesis	Relationship	Coeff.	Coeff.
H1	Mobile Data	0.070 **	0.072 **
H2	Kind of Mob. Dev. (smartphone)	0.012 n.s.	
H2	Kind of Mob. Dev. (tablet)		-0.013 n.s.
control	Task Charact.	0.482 ***	0.483 ***
control	Age	-0.058 *	-0.058 *
control	Gender (male)	0.083 ***	0.082 ***

Notes: r-square for the model: 25.71% and 25.79%, respectively; Coeff.: path coefficients; ***: significant at 1%; **: significant at 5%; *: significant at 10%; n.s.: not significant.

This result indicates important information to mobile banking developers, banks and telecommunication companies. The existence of strategic alliances (Gulati, 1998; 1999; Hoffmann, 2007; Lavie, 2007) between these companies can contribute to a widely adoption of mobile banking in Brazil, because consumers can realize greater security to develop their banking transactions. Privacy / security concerns (Liao et al., 2011; Montezemi & Saremi, 2014) may be reduced when users contract mobile data services.

This result also reinforce the consideration made in previous research (such as Chaouali et al., 2017), that in developing countries the telecommunication infrastructure can affect the adoption of mobile banking. This also in line with studies (Afshan & Sharif, 2016; Alalwan et al., 2017) which link the advancements in mobile banking to the development of telecommunication technology in the country. In Brazil, the availability of a personal mobile Internet data services in the personal mobile device of the respondent of the sample seems to generate a positive effect on their trust in mobile banking. One alternative explanation could be that those users who are willing to use mobile banking at their mobile devices already have contracted internet channels that they perceive as safety. With this statistically significant effect, we can realize that the quality of Internet is a factor that may facilitate (or difficult) the adoption of contemporary technologies which requires personal data and financial information.

Age and gender have the expected effects. Even with a sample in which the majority of respondents are young, age had a negative effect on trust in mobile banking. Regarding to gender, men tended to trust more in this technology, when compared to their counterparts (women). This indicate that the strategies to introduce mobile banking should be different between users of different genders.

Shaikh and Karjaluoto (2015) pointed out the absence of studies about the effect of smartphone / tablet use on mobile banking adoption. Our quantitative analysis indicated that trust in mobile banking is not significantly different between these two kinds of mobile devices. In this way, **H_2** was not supported. Maybe the differences in the perception of quality of other mobile applications, that is due to the familiarity of users with phones (Kortum & Sorber, 2015), do not necessarily affect their perception about how mobile banking is secure and trustworthy. These results are not in different directions of those obtained by Kim et al.

(2014) and Furió et al. (2013), about a minimum (or not significant) effect of size on typing force, forearm muscle activity, engagement and/or user's satisfaction.

LIMITATIONS

This study has three major limitations. First, we assume (and argue) that mobile Internet data service is a predictor of trust in mobile banking. However, our results do not necessarily indicate a causal relationship from data service to trust. In this way, the observed positive relationship may be subject to endogeneity, and other variable(s) may simultaneously affect both trust and Internet data service. On the other hand, it is important to highlight that it is not common in Brazil for people to have free access to a secure wireless connection, which indicates the relevance of this result.

The second limitation is the use of dummy variables to measure the type of mobile device (smartphones / tablets), and the use of dummy variable to observe the adoption of mobile Internet data services. Further studies could explore other types of measures for these variables, especially for mobile Internet data services, which presented a significant effect on trust in mobile banking.

Another limitation relates to the characteristics of the sample. The majority of the study sample consisted of younger students. Despite the significant result that we observed in the path coefficients (for the variable age), we recommend new research with a more balanced composition between young and older people, in order to verify the robustness of the results that we obtained in this paper.

IMPLICATIONS AND FINAL REMARKS

In the context of mobile banking, this paper considered two variables that, to the best of our knowledge, have not been directly studied before: the use of mobile Internet data services, and the type of mobile device. We collected data from Brazilian undergraduate students, since Brazil is a country where the adoption rate of mobile banking is still low (Febraban, 2015).

The descriptive results, together with the hypotheses testing, showed a good potential for mobile banking adoption in Brazil. The popularity of mobile Internet (Yang et al., 2012) was also present in the sample, and this is a factor that may contribute to mobile banking adoption. Respondents reported higher levels of task activity related to banking services, and task activity was a significant variable in explaining trust in mobile banking. In this way, given the large market available for mobile services, banks could implement strategies to reach new customers, and these strategies must also take into account that men and women have different behaviors regarding trust in mobile banking.

Regarding the main results of the paper, despite our expectation of different levels of trust between smartphone users and tablet users (**H_2**), our analysis indicated that the type of mobile device does not seem to have a significant effect on trust in mobile banking. Thus, marketing efforts to reach new mobile banking users may have similar effects when combined with smartphone or tablet applications. This is an important finding from the

perspective of mobile banking developers. Perhaps users (and potential users) are not concerned with usability features (keyboard size, screen size, among others) to start using mobile banking. This finding also suggests some areas for future research, addressing, for example, the interaction between mobile device type and security features or users' previous experience with mobile banking.

Furthermore, and also based on the main results of this paper (**H_1**), we argue that banks, mobile banking developers and telecommunication companies should explore the possibility of strategic alliances in Brazil, especially when we observe that the penetration of mobile devices is increasing over time (Kortum & Sorber, 2015). Cooperative relationships are common in dynamic industries (Hoffmann, 2007; Lavie, 2007), especially in the case of new technologies (Powel et al., 1996), such as mobile banking.

These alliances could expand the adoption of mobile banking technology and provide new ways for banks' customers to access banking services. With this argument, this research extends the current literature on mobile banking, because we explore a variable (mobile data service) that indicates potential results of partnerships between different sectors to promote mobile banking adoption. Further research can also test the effect of this variable (use of mobile Internet data services) on other factors related to mobile banking use, such as security features and user experience.

Mobile devices represent a technology that allows users to access applications anytime and anywhere. Mobile banking is one of these applications, and the knowledge of the factors associated with its adoption can provide a special contribution to human-computer interaction. Based on the empirical findings of this research, there is a potential to improve this interaction through strategic alliances between telecommunications companies, banks and mobile banking developers.

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Appendix

Trust in mobile banking
I believe that mobile banking...
tru1 ... is trustworthy
tru2 ... keeps its promises
tru3 ... keeps users' interests in mind
(adopted from Kim et al., 2008; Zhou, 2011; Zhou, 2012a, 2012b; Oliveira et al., 2014)

Task Characteristics
I need to...
tsk1 ... transfer money anytime anywhere
tsk2 ... manage my account anytime anywhere
tsk3 ... acquire account information in real time
(adopted from Zhou et al., 2010; Oliveira et al., 2014)

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PATENT LANDSCAPE ANALYSIS OF HUMAN INTELLIGENCE

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Abstract: *Patent intellectual property in the field of human intelligence opens up greater opportunities to improve human life as a whole and has the potential to open enormous opportunities in various fields, such as technology, education, psychology, and health. This research was conducted to know the patent landscape and the main trends of intellectual property patents on the topic of human intelligence in all countries. Researchers applied a patent landscape analysis using data on a total of 5,470 patent intellectual property documents from the Lens database. The results of the study showed that there is a general trend of increasing the number of patents related to the field of human intelligence every year. There is an opportunity without paying royalties by using 821 patents discontinued. Intellectual property patents related to human intelligence are dominated by company ownership and inventors originating from the United States, with a total of 4,361 patents. Patents related to human intelligence are dominated by the physics (G) patent section. There are 2767 simple family patents on human intelligence in thirteen jurisdictions, and the highest is in the United States. In the future, we suggest conducting more research related to patent value analysis to evaluate patents. This study provides practical insights for various stakeholders. Businesses and entrepreneurs can leverage discontinued patents to innovate without having royalty fees, driving technological progress. Policymakers and researchers should create frameworks that protect intellectual property while also ensuring that society has access to innovation, allowing communities to get the value from patents.*

Keywords: *patent landscape analysis, human intelligence, technology.*

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INTRODUCTION

Human development and intelligence research are two distinct areas of study. Intelligence is important in the social, industrial, and educational domains, claim Dizaji et al. (2021). As technology develops, future studies on assessing human intelligence using neuroimaging data and a machine learning-based prediction framework might yield fascinating results (Teregulov, 2022). Recent studies show that people are better than machines at recognizing images (Hiremani & Senapati, 2019). Intelligent technology is now widely used, and interest in artificial intelligence research and development has constantly increased with scientific and technological advancements. This technology can improve people's living conditions and quality of life as technological innovations of human intelligence (Wang et al., 2021).

Human intelligence has changed and evolved to meet changing demands and conditions adapting to new needs and recognizing the importance of emotional and social skills. According to research findings by Kedziora and Kiviranta (2018), the value generated by RPA in the contemporary digital economy demands that the potential for automation be carefully evaluated, with an emphasis on materials that are devoid of analogue text, human judgment, or italicised in favour of strict requirements. Additionally, it is critical to concentrate on a sustainable shift towards the future "hybrid workforce," which combines digital and manual labour delivery (Kedziora, 2022).

The use of human intelligence faces several challenges. Accurate data collection and analysis are essential to achieve effective results. However, not all entrepreneurs adopt technological innovations based on human intelligence (Dana, 2020). Even if artificial intelligence has advanced significantly in recent years, there are still many obstacles to overcome before it can be used with human-like intelligence (Hassabis et al., 2017).

Advances in human intelligence have attracted the interest of researchers across various fields (Pfeifer & Scheier, 2020). Human intelligence advancements can help solve complex and multidimensional problems in a range of sectors, such as transportation, security, health, and the environment (Vialykh et al., 2020).

Many previous studies have shown that Human intelligence in education including the use of artificial intelligence to simulate human thinking processes and create a knowledge-based teaching and learning environment (Saravana & Kumar, 2019); the use of artificial intelligence in the delivery of human services (Wang et al., 2021); the application of artificial intelligence to systems that use algorithms or are related to artificial intelligence (Alter, 2022); the use of human intelligence as a means of achieving persuasive operational transformation in the majority of modern organizational settings (Dhamija & Bag, 2020); and the need for assessments based on human intelligence in higher education (Bearman & Luckin, 2020).

One of the research gaps in the study of human intelligence is the lack of data on relevant patents. Patent landscape analysis is used to explore innovation trends in patents related to human intelligence. This method supports companies and research institutions in research planning, technology transfer, and developing sustainable business innovation strategies. Additionally, governments and international organizations can use patent data to shape forward-thinking policies (Gassmann et al., 2021). Giving a global or regional overview of the patent environment for a particular technology is the aim of the patent landscape analysis approach. In patent landscape analysis, the first stage is a state-of-the-art search for pertinent technologies in a database of selected patents. According to WIPO 2021, the search results are

then analyzed and visually presented to facilitate understanding, form conclusions, and offer recommendations based on reality. "*How are the major trends in intellectual property patents on the subject of human intelligence and the global patent landscape doing?*" is the research question. Determining the global patent landscape and significant advancements in intellectual property pertaining to human intelligence is the goal of this study. Few studies, meanwhile, have looked closely at the study of human cognition from the perspective of invention across countries, legal statuses, inventors, and time to observe patterns and maps. One of the possible factors could be the absence of knowledge regarding AI patents in the business world. Thus, one of the best methods to assess and understand the level of invention and patents in human intellect is to examine the patent landscape.

METHODS

This study used a patent landscape analysis method, focusing on the topic of artificial intelligence in entrepreneurship. Researchers used 3,752 patent documents and 2,071 *simple family* intellectual property patents taken from the Lens database (https://www.lens.org/) through online searches in March 2023 (Litvinova et al., 2022). (Lens, 2023). The keyword search query for patents in Lens in the title, abstract, and claims is Patents= ("human intelligence"). Filters: Published Date (- 2022-12-31) (Lens, 2023). The analysis uses only a full year's worth of patent data, so searches on the database are limited to December 31. Data mining was limited to annual data to get full published data for twelve months each year. Thus, the patent data used is from 1979 to 2022.

This study analyzed the patent landscape by examining annual patent growth, legal status, top patent owners, leading CPC classification codes, geographic jurisdictions, and top inventors. The Lens Site's analysis tool was used to display patent landscape data on the selected topic. Researchers utilized this service to analyze and visualize patents related to human intelligence.

RESULTS

Annual Growth

Figure 1 shows an analysis of the annual number of patents related to human intelligence, categorized by published patents, granted patents, and filed patents from different countries. Patents awarded are those that the government has authorized following a thorough review and evaluation procedure. A published patent, on the other hand, shows the beginning of the evaluation process for awarding a patent. A patent filed has been submitted to a government body but has not yet been approved or made public (USPTO, 2022).

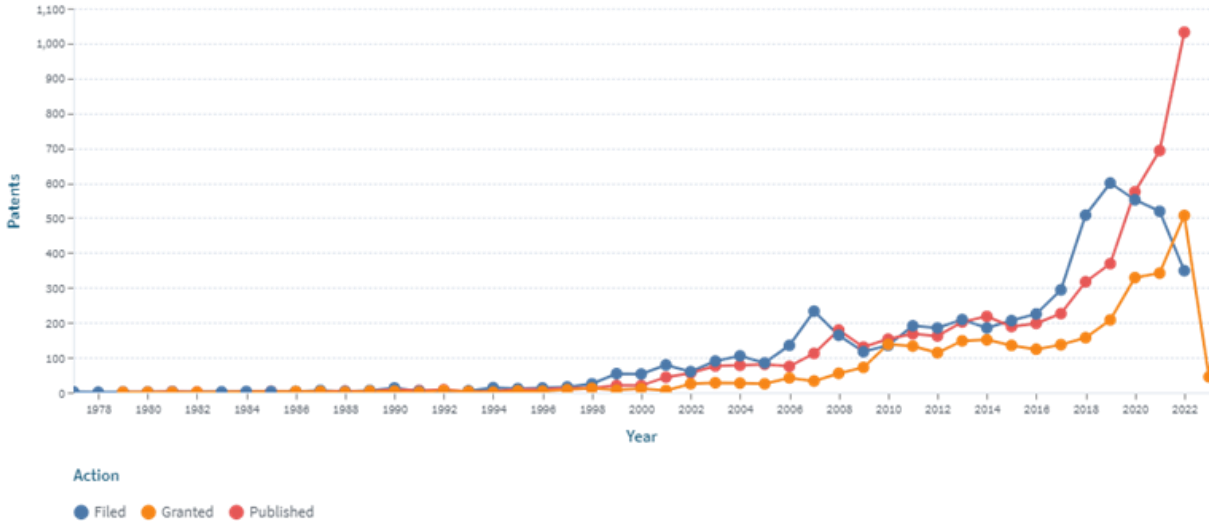

Figure 1. Annual growth of human intelligence patent documents.

The process of publishing patents related to human intelligence began in 1979 (n = 1). At the same time, a patent was granted (failed patent) in 1980 (n = 1). The process of filing patents from 1999 (n=54) to 2007 (n=223) experienced a significant increase. Since 2018 (n=157), the number of granted patents has increased, with the highest point in 2022 (507). Then, at the same time in 2016 (n = 198), the number of published patents continues to increase significantly until 2022 (1032).

The number of patents related to the study of human intelligence has been steadily increasing each year. This reflects the growing interest of entrepreneurs in leveraging advancements in human intelligence to establish and expand their businesses. Increased patenting activity has positive outcomes, indicating that a key factor driving the impact of human intelligence is the ability to quickly adapt to new situations and integrate technology into production processes (Damioli et al., 2021).

Legal Status

The legal status of intellectual property patents from various countries related to human intelligence can be seen in Figure 2. Active patents are those that remain valid, granting exclusive rights to the protected innovations or technologies. In contrast, discontinued patents are those that were granted but are no longer valid. A pending patent is a patent that is in the process of being assessed, but it is not yet known whether it will be granted or not. An expired patent is a patent that has been valid for a specified period (20-30 years) but is not renewed and is therefore no longer valid. Inactive patents are patents that are no longer valid but are still registered in the government body system. Patented is the process of granting a patent by a government agency (USPTO, 2022).

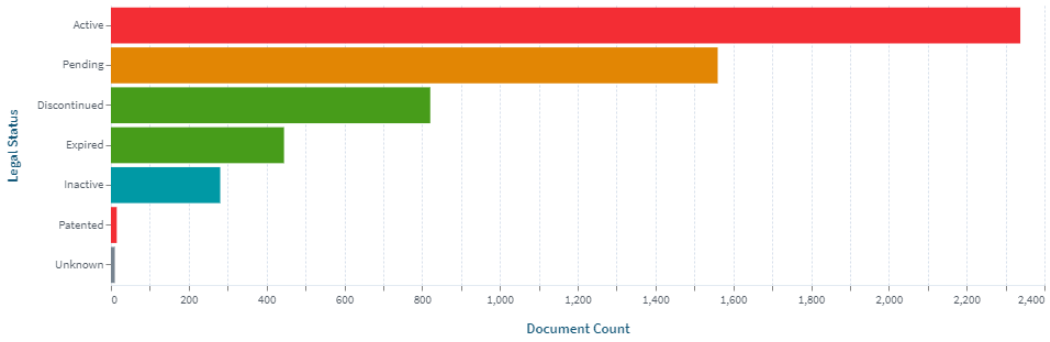

Figure 2. Human intelligence patent legal status.

Patent legal status related to human intelligence with active status is 2338 patents. In addition, 821 patents have a discontinued legal status. Patents with pending, expired, inactive, and patented legal statuses related to human intelligence number approximately 1,561, 445, 281, and 15, respectively.

There are 445 patents with the expired status and will become discontinued patents. Patent documents that have expired status will automatically appear and be available in the public domain. Entrepreneurs can study and use these patent innovations freely. This availability is an opportunity to utilize patents as a more comprehensive and thorough insight into the phenomenon of human intelligence through a multidisciplinary approach (Hunt, 2020).

Owners

Owners of intellectual property protection for artificial intelligence patents from various countries with the largest quantity can be seen in Figure 3. Tencent Technology (Shenzhen) Company Limited, China (n=248); Lg Electronics INC, South Korea (n=237); International Business Machines Corporation, United State (n=143); American Vehicular Sciences LLC, United State (n=104); Automotive Technologies International INC, United States (n=93), Beijing Baidu Netcom Science and Technology Co LTD, Hongkong (n=92); Baidu Online Network Technology (Beijing) Co LTD, Beijing (n=82); Microsoft Technology Licensing LLC, United States (n=73); Samsung Electronics Co. LTD. South Korea (n=60); and Trimble Navigation Limited, United States (n=42) and others are among the companies committed to expanding the size of the human intelligence market.

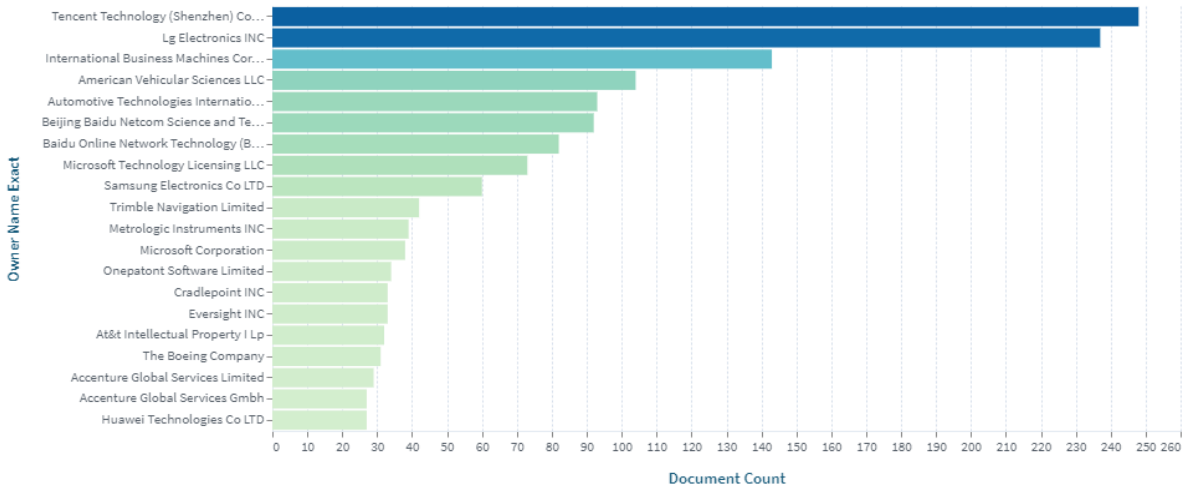

Figure 3. Owner Paten has human intelligence.

Intellectual property patents related to human intelligence are dominated by the ownership of five companies in the United States. In addition, the most productive ownership of intellectual property patents related to human intelligence is owned by a US company, Tencent Technology (Shenzhen) Company Limited, with 248 patents. This happened since Tencent Technology (Shenzhen) Company Limited has patent issuance regulations that continue to increase every year. An example of such increasing regulation of patent appearances can be seen through the award it received at the Singapore Business Review's 2021 Technology Excellence Awards for the Cloud Services category in April, marking another milestone for Tencent's advancement in the cloud computing space. In recent years, Tencent Cloud has built an infrastructure committed to developing industry-leading cloud products and services in 27 regions around the world. The existence of this patent award is an important milestone in Tencent Technology (Shenzhen) Company Limited's journey to create the most valuable technological innovations in the world. In addition, this award also reflects the long-term commitment of Tencent Technology (Shenzhen) Company Limited to the development of exclusive cutting-edge technology to continue to increase technology users (Cision, 2021).

Cooperative Patent Classification

Intellectual property patents from various countries related to human intelligence can be classified based on CPC as shown in Figure 4. Cooperative Patent Classification (CPC) is a development of the International Patent Classification (IPC). It is managed jointly by the European Patent Office (EPO) and the United States Patent and Trademark Office (USPTO). The CPC is divided into nine sections, classes, sub-classes, groups, and sub-groups (EPO, 2017).

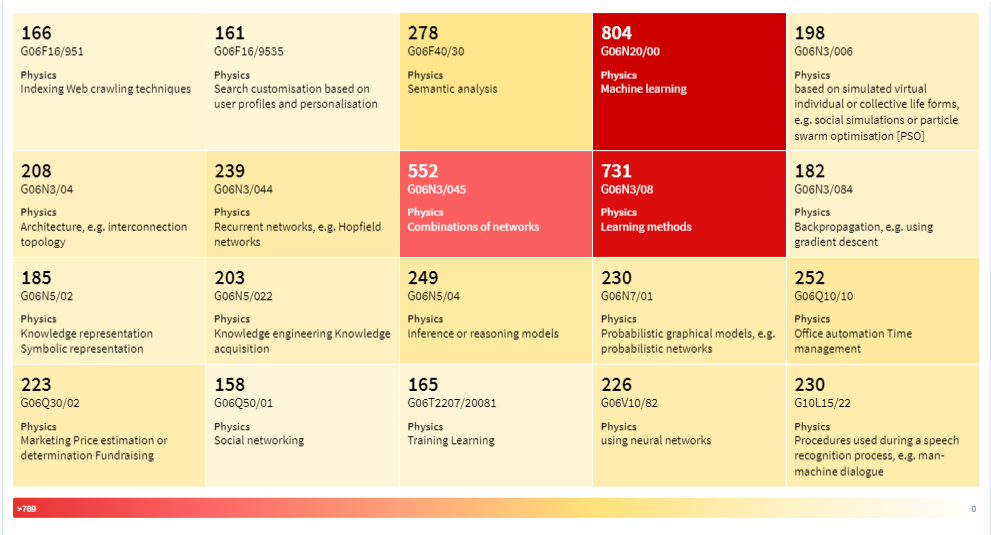

Figure 3. Patent CPC Classification in Human Intelligence

Patents related to human intelligence are dominated by the physics (G) patent section. The two most widely protected patent groups are G06N20/00 on physics, e.g., machine learning, and G06N3/08 on physics, e.g., learning methods. The physics (G) section comprises group patents G06N3/045 (n=552) on combinations of networks; G06F40/30 (n=278) on physics consisting of semantics analysis; G06Q10/10 (n=252) regarding physics, office automation time, management; G06N5/04 (n=249) regarding physics, inference or reasoning models; G06N5/044 (n=239) on physics, recurrent networks, e.g., hopfield networks; G06N7/01 (n=230) about physics, probabilistic graphical models. E.g. probabilistic networks; G10L15/22 (n=230) about physics, procedures used during a speech recognition process, e.g. manmachine dialogue; G06V10/82 (n=226) about physics, using neutral networks; G06Q30/02 (n=223) regarding physics, marketing price estimation or determining fundraising; G06N3/04 (n=208) on physics, architecture, e.g. interconnection topologies; G06N5/022 (n=203) regarding physics, knowledge engineering knowledge acquisition; G06N3/006 (n=198) regarding physics, based on simulated virtual individual or collective life forms, e.g. social simulations or particle swarm optimization; G06N5/02 (n=185) about physics, knowledge representation symbolic representation G06N3/084 (n=182) about physics, backpropagation, e.g. using gradient descent ; G06F16/951 (n=166) regarding physics, indexing web crawling techniques; G06T2207/20081 (n=165) on physics, training learning; G06F16/9535 (n=161) regarding physics, search customization based on user profiles and personalization; G06Q50/01 (n=158) about physics and social networking.

There is an effort to protect patent intellectual property related to human intelligence in the field of patent physics (G) G06N20/00. Patent protection is at the second level of the largest subgroup of CPC patents that experience longformer patent rejection models. This shows that the related patent G06N20/00 is the most widely protected patent on human intelligence innovation because the ability of assistive capabilities to manage data automatically and accurately is very important for many industries and businesses (Y. Zhang et al., 2020).

Geographical Jurisdictions

Geographical jurisdictions for patent intellectual property protection in various countries related to human intelligence can be seen in Figure 4. There are around 13 countries or regions that are listed as involved in patents on human intelligence topics. United States (n=4361), WO – WIPO (n=669), Europe (n=380), China (n=73), South Korea (n=11), Canada (n=6), Australia (n= 4), United Kingdom (n=4), Japan (n=2), Taiwan (n=2), Greece (n=1), Russia (n=1), and Ukraine (n=1) are the jurisdictions of the countries and areas related to human intelligence patents.

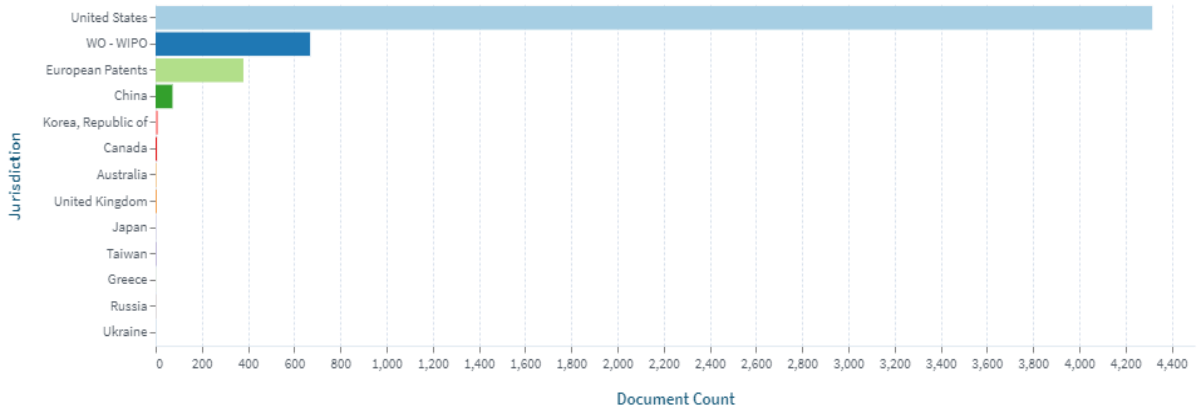

Figure 4. Human Intelligence Patent Geography Jurisdiction

The United States is the most productive and protective country regarding human intelligence patents since it has an important role in the development of artificial intelligence technology and has a significant influence on innovation in that field (Leusin et al., 2020), (F. Zhang, 2019).

Inventor

The most productive individual inventors for intellectual property patents from various countries related to human intelligence can be seen in Figure 6. Breed, David. S (Colombia, n=117); Duvall, Wilbur. E (United States, n=69); Zhu, Xiaoxun (China, n=27); Johnson, Wendell. C (United States, n=59); Allen Christopher (United States of America, n=39); Kotlarsky Anatoly (New York, n=39); Mandal, Sudhin (India, n=39); and Au, Ka, Man. (China, n=38) are the most prolific individual inventors of human intelligence patents.

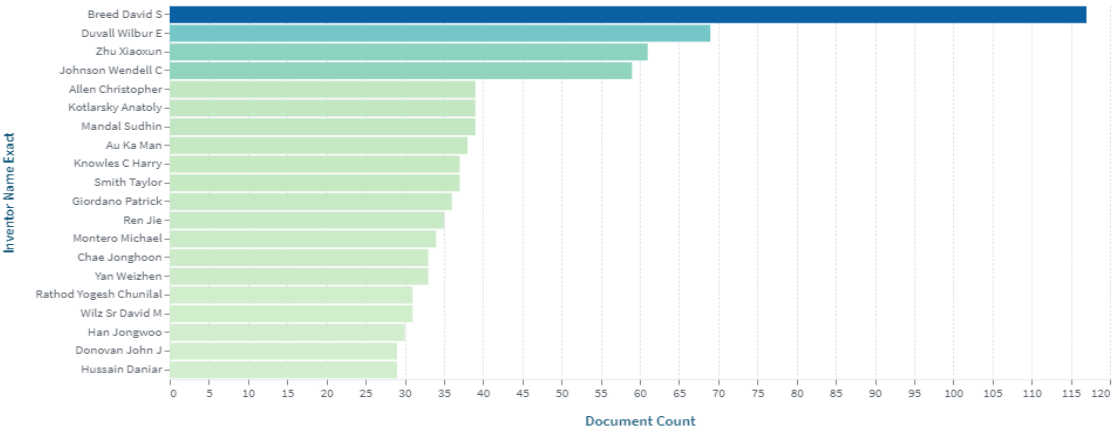

Figure 5. Inventor of Human Intelligence Patents

Intellectual property patents related to human intelligence are dominated by inventions by inventors from affiliated countries in the United States (n=2) and China (n=2). The relationship between human intelligence and patent analysis in the US lies in the ability of human intelligence to understand and interpret the information contained in patents (Sadiku et al., 2020). The role of artificial intelligence, which is starting to replace many sectors, is what has encouraged the United States to continue to develop its research in the field of rationalizing human intelligence, solving problems, and learning. The concept of cultural intelligence is relevant in the modern world of globalization (Regens, 2019).

Human Intelligence Categorization

Table 1. Categories Patent of Human Intelligence.

No.	Category patent	Patent Number
1.	Education	CN 201220404301 U (Enyi, 2012), US 201916657131 A (Shady, Chahid, and Fakhri 2018), KR 20010062819 A (Ram, 2001)
2.	Smartphone	US 201615053751 A (Calvin and Caleb, 2016) CN 201721508049 U (Huayun 2018)
3.	Personal assistance	IB 2020061556 W (Vahid and Azadeh 2021), US 2011/0023492 W (Dean 2011)
4.	AI	US 201715420028 A (Erik and Peter 2018), CN 202110435444 A (Mou et al. 2021)
5.	Home	IB 2019057280 W (BidHan 2020), CN 201720993736 U (Changshan and Changsong 2018), CN 201010513421 A (Zhao 2012) US 30741706 A (Hongyue 2007)
6.	Business Management	KR 0100922 W (Jin, 2001), US 96010507 A (Alexander et al., 2012), US 201313934608 A (John & Jonathan, 2013), US 95025110 A (M, Gregory, and Eric, 2011), US 2014/0012411 W (Gabriela, Gavin, and Natasa, 2015)
7.	Healthcare	KR 20010044701 A (Hyun 2001), CN 202210693972 A (Zhiwen, Yixuan, et al. 2022), CN 98123932 A (Anyu 1999), US 202217706267 A (Ryanghee 2022), CN 90207944 U (Lei 1991)
8.	Journalism	CA 2235030 A (Steve, 1999), GB 0810737 A (Timothy, 2009), US 201916460319 A (Daming & Hao, 2021)
9.	Translation system	US 201715603938 A (Hagen, 2019), CN 202211077086 A (Zhiwen, Xin, et al. 2022), US 201816044926 A (Qiang and Sheng, 2020).
10.	Assessment	RU 2001115157 A (N 2003), CN 01204586 U (Ying and Jianru 2002), US 14359802 A (L 2003)
11.	Internet	US 98019507 A (Ole-Petter et al. 2008a), US 91522401 A (K, H, and S 2002), US 201616306434 A (Dai et al. 2020)

12.	Supply Chain	US 65448307 A (Ole-Petter et al. 2008b), US 98019307 A (Ole-Petter et al. 2010), US 201113300087 A (Jason et al. 2017)
13.	Simulating	US 201314097377 A (Changbin and Li, 2018), IN 2020050560 W (Bosubabu 2021)
14.	Psychology	US 201917291003 A (Yehuda, Sholomo, and Liora 2022), IL 2019051222 W (Yehuda, Ernesto, and Liora 2020)
15.	Human Intelligence Task	US 201929711049 F (Joseph, Riccardo, and Alessandra 2021), US 201414203513 A (R et al. 2015), US 201314025880 A (Huai-Hsin et al. 2017)

DISCUSSION

Education

Human intelligence becomes the foundation for education-based learning and knowledge acquisition. Human intellect and education are closely interconnected, significantly influencing each other. Education helps individuals to enhance their cognitive abilities and overcome challenges, helping them reach their full potential. The utility model of patent CN 201220404301 U, according to the inventor (Chen Enyi), pertains to teaching aids, particularly educational goods or toys that serve to enhance human intelligence. Human intelligence affects educational outcomes: Success in school is significantly influenced by human intelligence. The integration of artificial intelligence and education has become an unavoidable development trend with the development of big data intelligence, deep learning, brain-like intelligence, autonomous control, and other new generations of artificial intelligence technologies (Qian & Feng 2020). This trend can foster the development of students' creativity more than traditional teaching (Qian & Feng 2020).

Inventors of US patent 201916657131 A (Shehata Shady, Ouali Chahid, Karray Fakhri) stated that Human intelligence and automatic interactive learning systems/methods are closely related in the context of learning and developing human abilities. Automatic interactive learning systems and methods are technologies designed to help humans learn various topics more effectively and efficiently. The relationship between human intelligence and automatic interactive learning systems/methods is a mutually beneficial symbiotic relationship in an effort to improve human abilities and achieve the desired learning goals, especially by educational institutions (Chen et al., 2020).

Preschool education assembly learning tools are supplied, according to patent KR 20010062819 A inventor Jung A Ram, to effectively foster the development of different human intelligences. Children's educational assembly resources can enhance general intelligence or general assembly intelligence. By letting kids freely explore and imagine, this tool can also aid in fostering their creativity and ingenuity. In this way, assembly education tools are a valuable resource that promotes the growth of excellence in school-age pupils and can aid in the development of critical and creative thinking abilities as well as the capacity to recognize and solve difficulties (Paz-Baruch, 2020).

Education greatly influences human intelligence. It can enhance social and emotional abilities like empathy, teamwork, communication, and emotion control, raising a person's EQ, or emotional intelligence score.

Smartphone

Human intelligence refers to the brain's capacity for information processing, problem-solving, learning, and environmental adaptation. Smartphones and human intelligence are related in that they can either impede or support a person's cognitive ability. According to the inventor of US patent 201615053751 A (Wiese Calvin and Wiese Caleb), one of the devices that can impair a person's cognitive capacities is a smartphone. Smartphone use can also contribute to greater access to knowledge and technology. A smartphone can facilitate communication and connections with others on both a social and professional level. When used wisely and responsibly, smartphone technology can support the growth of human intelligence, have an impact on individual attention and performance, and enable quick and efficient decision-making in the business world (Schwaiger & Tahir 2022).

Inventor of CN patent 201721508049 U (Wu Huayun) states that the utility model relates to human intelligence control systems such as lap wall, telephone devices, and high-definition digital cameras. Therefore, it can be claimed that human intelligence's utility models and control systems can relate to the use of telephone devices in a variety of ways. Users can choose the telephone equipment that will benefit them the most using a utility model. However, they also need to use a human intelligence control system to engage with and control the gadget (Chen et al., 2020).

Smartphones have had several positive impacts on human intelligence, including social connectedness. Thus, they make it possible for users to stay in touch with others around them and stay up to date on social trends. This may enhance one's capacity for social interaction.

Personal Assistance

Personal assistance is an individual or technology that assists a person in managing and completing daily tasks, as well as increasing a person's efficiency and productivity in carrying out daily life. They are a component of the human intelligence system that aids in daily task optimization, enhances decision-making abilities, and frees up time for more difficult and crucial tasks. Artificial intelligence technologies (Artificial Intelligence, Natural Language Processing, Deep Learning, Machine Learning, Social Networks, Cloud, SaaS, Multi-Platform (Web & Apps), Chat Bot, Question/Answer, Text Generation, Recommendation System, Online Learning) are disclosed in inventor of IB patent 2020061556 W (Salehi Vahid, Najafi Dejdeh Monfared Azadeh). They are created collaboratively with knowledgeable consultants, discussions with users, and step-by-step analysis. Humans can benefit from personal assistance that is integrated with artificial intelligence technology in analyzing massive or complex data, identifying trends or patterns, and improving decisions. According to numerous research, humans are more likely to choose personal help when perceived intelligence and anthropomorphism are considered to be significant elements. While anthropomorphism refers to personal assistance skills in mimicking human behavior, perceived intelligence includes personal assistance skills in offering practical answers or suggestions (Moussawi et al., 2021).

Inventor of US patent 2011/0023492 W (Stark Dean) states that Human intelligence personal assistance systems and methods enable users to interact with audio and video images when requested. Human intelligent personal assistance systems, such as virtual assistant technology or productivity apps, can assist humans in managing daily tasks and schedules.

With the help of this system, humans can improve their multitasking abilities, time management, and efficiency in completing tasks. In an organizational context, modern assistance functions such as virtual assistant technologies can assist humans in semi-automated invoice processing and intelligent calendar management (Morana et al., 2020).

Personal assistance can increase productivity, efficiency, and mental performance, all of which have a good effect on human intellect. It can also improve multitasking effectiveness, everyday task management, and information processing speed and accuracy in people. By doing this, people can enhance their cognitive skills and use their brains to the fullest extent possible to make better decisions.

Artificial Intelligence

Artificial intelligence (AI) aims to simulate human behaviour and carry out operations that call for human intelligence. In a technological setting, where AI development tries to imitate human cognitive capacities and improve human intelligence's capacity for problem-solving and decision-making, AI and human intelligence are related. A system that enables human intelligence and artificial intelligence to collaborate on problem solving in real time, as disclosed by the inventors of US patent 201715420028 A (Viirre Erik, Tagg James Peter), allows people to characterize complex data sets of interactions in order to identify systemic failure points and make improvements. Artificial intelligence techniques that are human-centered are more likely to result in systems that are dependable, secure, and trustworthy (Shneiderman, 2020).

One application of AI using multiple unmanned aerial vehicles based on intelligence-enhanced hybrids enhances planning effectiveness and job completion, according to the inventors of CN patent 202110435444 A (Chen Mou, Han Zengliang, Zhu Ronggang, Zhou Tongle, Wu Qingxian, Nie Zhiqiang, and He Jianliang). The connection between human intelligence and artificial intelligence (AI) is fascinating that signifies the capacity of automated machines to imitate or exceed human intellect in certain jobs or activities including a new generation of technology that can interact with the environment and replicate human intelligence (Glikson & Woolley 2020).

AI has the potential to have a substantial impact on human intelligence and how we perceive the world, such as augmenting human problem-solving abilities, expanding human constraints, and increasing productivity and efficiency.

Home

Home is a place where someone lives and feels comfortable and safe. In terms of human intelligence, the idea of home security can be factors related to the physical and psychological security of the people who live there. This can involve making sure the home is physically secure, such as by installing alarms, cameras, and locks, as well as making sure the environment inside is hygienic and safe. According to inventor of IB patent 2019057280 W (Podder Bidhan), home automation systems and techniques are offered. Multiple sensors built within the system can perceive a variety of devices' operational statuses. Since the system can track daily home activities in real-time and send alerts when anything suspicious happens, the

application of AI in home automation systems can also improve the safety and tranquility of the home's occupants. AI can make homes safer and more theft-resistant (Pala & Özkan 2020).

According to the use model disclosed in inventor of CN patent 201720993736 U (Bai Changshan & Bu Changsong), garden lights can be controlled by human intelligence to open and close, thereby realizing forced air cooling and heat dissipation. Based on an innovative and potentially ground-breaking method of designing lamp holders, the new garden lights are intended to offer a more customised and human-centred lighting experience in outdoor settings. These lights are fitted with sensors or other technology that enables them to recognize human presence, movement, or other behavior and react to it, for example by changing their brightness or color temperature. A favorable user experience can be provided by intelligent lamp designs that are low-cost, high-efficiency, and energy-saving (Lin et al., 2022).

According to the inventor of CN patent 201010513421 A (Sulong Zhao), as containerized housing gains popularity, more inventive solutions are likely to materialize, propelled by the creativity of architects and contractors. Buildings or residences constructed from shipping containers are referred to as container housing. Because they are frequently built of steel, these containers are strong and resistant to adverse weather. Increasingly more people are choosing containerized homes because of its affordability, sustainability, and adaptability. One can investigate how to create smart structures that attain the subtleties of sustainability, cost-effectiveness, and flexibility that are the hallmarks of this new building technology by examining patents pertaining to container dwelling (Marson & McAllister 2021)

By using real-life simulation, real-life simulation reactive, active, and intelligent response, the inventor of US Patent 30741706 A (Luo Hongyue) discloses intelligent home security methods that can significantly lower the likelihood of intruders breaking in or even prevent the occurrence of break-in. Additionally, distributed security is classified for the different operating and communication states of the connected apps (Alkatheiri et al., 2021).

Smart houses, home security systems, and street lighting are just a few examples of the advanced technologies that can be developed to improve comfort, safety, and efficiency in varied surroundings. The result is that human intelligence can also help to develop smarter, more energy-efficient street light systems, smarter, and more energy-efficient home security technologies, as well as smart homes that can increase occupant comfort and safety, reduce energy use, and optimize temperature and light settings as necessary.

Business Management

Using human intellect in strategy, decision-making, innovation, and problem-solving optimizes human resources and facilitates effective corporate management. Patent KR 0100922 W describes a communication-oriented human clock that consists of a control program, an integrated time function, and a data memory for storing voice information (Park Kyu Jin). The ability of these technologies to mimic human speech and thought processes, as well as their applications, is what links human intelligence to human-like clocks capable of carrying out bilateral conversations via telecommunications, data providing systems for them, and internet business methods for them. To make it more effective and human-like, artificial intelligence and machine learning are used (Kikerpill, 2021).

According to the inventors of US patent 96010507 (Alexander Gounares, David M. Chickering, Eric J. Horvitz, Michael Connolly, Lili Cheng, and Kamal Jain), the term "mass

auditing" describes the process of examining huge amounts of data or information to find patterns, trends, and potential issues. Human intelligence and mass auditing work together to enhance each other. While large-scale audits can aid in spotting possible issues, human intelligence is necessary for comprehending context, analyzing data, and coming to wise judgments. Human intelligence, however, can offer value by interpreting data, making judgments, and assessing the outcomes of these mass audits (Brody et al., 2020). As a result, human intelligence and emotional intelligence are interconnected, and they can both have a big impact on an auditor's performance and audit findings.

Taxonomy-based targeted search advertising can use human intelligence to maximize the success of advertising campaigns, according to inventors of US patent 201313934608 A (Zimmerman Jr Stephen John & Warden Jonathan). In order to gain greater knowledge and insight into how well these advertising efforts performed, human intelligence can also be used to evaluate and analyze the outcomes of these campaigns. In order to increase the success of future advertising campaigns and deliver better quality advertising results and experiences, this can help in making improvements or adjustments to advertising strategies (Chintalapati & Pandey 2022).

By fostering a work environment that supports learning, creativity, cooperation, and problem solving, business management can have a beneficial impact on human intelligence and help employees become smarter and more productive. By giving a company a defined framework for managing its resources, procedures, and employees, business management can have a positive impact on human intelligence.

Healthcare

Healthcare is an effort or activity that is performed to promote, maintain, and restore a person's or society's health and well-being. The management of illnesses and medical problems, as well as the prevention and control of diseases, are all included in healthcare. Cho Jae Hyun's invention is described in patent KR 20010044701 A, which relates to the tactile feeling care bottle. From conception to execution, nurses must be actively involved (Ronquillo et al., 2021).

Inventors of patent CN 202210693972 A (Yu Zhiwen, Chen Yixuan, Liu Jiaqi, Wang Liang, Guo Bin, Wang Yanfei, Zhang Xin) stated about methods and systems of medical diagnosis based on human-machine cooperation. When robots take the position of human doctors to conduct symptom investigations, machine intelligence and human intelligence are effectively merged, significantly decreasing the workload of human doctors. By effectively grouping individuals to grasp certain scenarios and enhance decision-making, a multipurpose machine learning platform for clinical data extraction, aggregation, management, and analysis can assist physicians (Ahmed et al., 2020).

The inventors of CN patent 98123932 A (Ren Anyu) described a nutritionally complete and balanced breakfast that integrates oral liquid medications for health care with foods like instant rice, noodles, vermicelli, and bean jelly based on the requirements of life, health, ecological beauty, and long life. To promote human intelligence and cognitive function throughout life, a diet rich in nutrients is crucial. Although diet alone cannot predict intelligence, it is crucial for preserving the health and best functioning of the brain. A better knowledge of the role that nutrition plays in promoting human intellect and cognitive function

could lead to the creation of more focused nutrition treatments, which would ultimately enhance the general standard of living for all people (Tardy et al., 2020).

Human intelligence is significantly enhanced by healthcare. One of the benefits is guaranteeing people's physical and mental health and wellbeing, which can enhance their intelligence and cognitive skills. They are more likely to have access to good food, a clean environment free of contaminants, and enough health services in a healthy environment. All of these can aid in enhancing cognitive abilities in people, allowing them to think more clearly, creatively, and with greater concentration while performing daily chores.

Journalism

Journalism is the process of disseminating information and news about real-world occurrences and facts with the intention of educating readers or the public at large. By providing society with pertinent and worthwhile news and information, journalism can significantly contribute to the growth and advancement of human intelligence., The inventors of patent CA 2235030 A (Mann Steve), describes systems for photojournalists, video documentarians, and electronic news gathering. Journalists can easily join a network of human intelligence and access the knowledge and expertise of a vast community in photography. The application of automated artificial intelligence processes to different areas of news production has transformed journalistic practice, especially on a huge economic scale (Jamil, 2021).

A video data source configured on a central coordination server to be an HIT (Human Intelligence Task) set consisting of a collection of frames collected from the video source is described in inventor patent GB 0810737 A (Cross Geoffrey Mark Timothy). Because the development of cognitive skills carried out by HIT can contribute to enhancing total human intelligence, there is a favorable association between HIT and HI. To boost user click-through rates for videos, a hybrid human-artificial intelligence system was created (Wu et al., 2021).

It is described in US Patent 201916460319 A (Lu Daming & Tian Hao) how to specify (raw) video content for news stories using various tools and methods. According to (Túñez-López et al., 2021), methods and tools for determining (raw) video material for news are techniques or approaches that use human intelligence to choose, determine, and edit video material to be used in news production. This will enable automated text news current to audio and video on demand.

When it comes to influencing knowledge, attitudes, and behaviour, news and journalism can make a significant beneficial difference in the field of human intelligence. People's understanding of social, economic, and political concerns that have an impact on their lives can be increased via news and media. People can make wiser and more knowledgeable decisions if they are more knowledgeable about these subjects.

When it comes to influencing knowledge, attitudes, and behavior, news and journalism can make a significant beneficial difference in the field of human intelligence. People's awareness of social, economic, and political concerns that have an impact on their lives can also be increased by news and journalism. People can make wiser and more knowledgeable decisions if they are more knowledgeable about these subjects.

Translation system

A software program or application that automatically translates text or speech from one language into another is referred to as a translation system. A mechanism for assessing the effectiveness of a machine translation system is shown in patent US 201715603938 A (Fuerstenau Hagen). The translation system attempts to mimic the human translation process, but it still has limits in comparison to the adaptability and nuance of human intellect. This shows how closely the two are related. The constructed translation model is highly clever and capable of addressing the required translations (Song, 2021).

The inventors of CN patent 202211077086 A (Yu Zhiwen, Zhang Xin, Liu Jiaqi, Wang Hui, Wang Liang, Guo Bin, Chen Yixuan, Wang Yanfei) claimed that when human intelligence and machine intelligence are successfully combined, the accuracy of the final program translation results improves and the workload of software engineers is decreased. Programs for human-machine collaboration are now translated more quickly and effectively. As a result, machine translation is becoming more and more significant in the field of language services (Yu, 2021).

The US patent 201816044926 A (Cheng Qiang & Qian Sheng) reveal techniques and tools for turning spoken English into writing. The approach is capable of accepting user-provided English voice data. The quality and simplicity of the transcription process, as well as the accessibility and effectiveness of gathering and processing information, can all be improved with techniques and tools for turning spoken English into text with human intelligence. According to (Yang & Yue 2020), deep learning can give learners quick, accurate, and objective feedback on their pronunciation.

Employing a translation system powered by human intelligence has various benefits, including expanding access to information, boosting output, promoting language development, fostering global cooperation, and raising translation quality.

Assessment

Assessment is a process used to measure an individual’s abilities in areas such as language, math, verbal, and visual-spatial skills. A person's level of intelligence, as well as their strengths and weaknesses in terms of their cognitive, emotional, and social skills, are commonly determined through assessment in the context of human intelligence. A technique for determining the level of information processing by the human brain is revealed in patent RU 2001115157 A (Anan Ev I N). Assessment must concentrate on human intelligence, particularly on skills that are difficult for robots to replicate (Bearman and Luckin 2020).

The inventors of CN Patent 01204586 U (Hu Ying & Zhou Jianru) describe a utility model for a meter that may graphically represent the mental and emotional intelligence and physical prowess of the human body. With the help of this utility model, it is believed that a more comprehensive grasp of human intelligence as a whole will be gained, as well as a better understanding of human potential and talents in a wide range of contexts, not only academic or intellectual ones. The development of knowledge-based intelligent systems has expanded as a result of technological advancements that emulate key features of human intelligence (Vigo, Zeigler, and Wimsatt, 2022).(Vigo et al., 2022).

The inventor of US patent 14359802 A (Klingler Gregory L) shows a technique used in management or marketing to anticipate or estimate market demand for a good or service. However, when discussing human intelligence, the procedures or techniques used to gauge someone's aptitude or intelligence can also be discussed. IQ testing, as an illustration. According to the predictive capacity of their demand, market factors are rated in importance (Nguyen et al., 2020).

From the preceding statement, it can be inferred that evaluation can assist in identifying a person's potential and areas for improvement in a variety of areas of intelligence, including cognitive, emotional, and social abilities.

Internet

Millions of computers and other devices are connected by a global network called the Internet. The Internet, on the other hand, can be regarded as a resource that is crucial for human ability to rapidly and efficiently receive, retain, and exchange knowledge if it is related to human intelligence. In the US patent 98019507 A, the inventors (Skaaksrud Ole-Petter, Dryden Cameron Dee, Smith Jeffrey Robert, Rhodes Robert Russell, Gordon Wayne Luke, and Zhu Xiaoxun) reveal that Internet-based transmission, tracking, and delivery networks comprise data collection and processing facilities that are operationally coupled to the Internet infrastructure. Humans and technology have co-evolved to create the Internet (Halpin, 2022).

The inventors of US Patent 91522401 A (Dar Vinod K, Abrew Frederick H, Rissman Michael S) show methods for retrieving information via the Internet. The strategies and tools used in online information search are essential for enhancing the effectiveness and efficiency of human information gathering. The process of finding information on the internet encompasses a number of techniques, including text, image, video, and voice searches, as well as a number of tools, including search engines, online databases, search applications, and specialized websites. ICT proficiency enables people to find relevant information quickly and accurately (Mahendran & Velmurugan 2020).

The inventors of US patent 201616306434 A (Tan Dai, Xu Qian, Li Jialin, Gao Lei, Li Zheng, Liao Dachun, Pan Xiaolei, Zhang Lun) disclose the use of artificial intelligence-based internet of things systems and techniques. Human intellect may be significantly impacted by the use of Internet of Things (IoT) technologies and techniques powered by artificial intelligence. IoT and AI can increase technology's effectiveness, productivity, and usability in many facets of daily life. The material well-being and happiness of people can be increased by the greater optimization of artificial intelligence Internet of Things technology and the logical application of technical methods (Zhang & Cheng 2022).

The internet has made access to information easier and more widespread, allowing people to learn new things quickly. By entering specific terms into a search engine, users can instantly find the information they need. In this way, greater access to information supports the growth of human understanding and knowledge.

Supply Chain

The term "supply chain" refers to a group of processes that include the coordination, planning, control, and execution of tasks linked to the production, acquisition, storage, distribution, and

delivery of goods or services from suppliers to ultimate customers. The US patent 65448307 A (Skaaksrud Ole-Petter, Dryden Cameron Dee, Smith Jeffrey Robert, Rhodes Robert Russell, Gordon Wayne Luke, and Zhu Xiaoxun) reveal that a system component for document image capture and transmitting, tracking, and delivery over the Internet. Its processing for transmission and recognition begins at the site of collection. It ends as the shipment is being delivered to the first scanning point on the network, accelerating information transfer through the network and cutting down on transmission time. AI can contribute to setting up supply chains to reduce the risk of disruption (Modgil et al., 2022).

The inventors of US patent 98019307 A (Skaaksrud Ole-Petter, Dryden Cameron Dee, Smith Jeffrey Robert, Rhodes Jr. Robert Russell, Gordon Wayne Luke, Zhu Xiaoxun) show that methods and apparatus for sending, tracking, and sending packages using document capture shipping and recognition processing starts at the point of collection and finishes. At the same time, the shipment is being transported to the first scanning point, to facilitate the start of billing processing for shipments. The proposed package delivery system can perform tasks quickly and efficiently (Feng et al., 2020).

Systems and techniques for labelling data from numerous sources are disclosed by the inventors of US patent 201113300087 A (Williams Jason, Alonso Tirso, Hollister Barbara B, and Melamed Ilya Dan). Systems and techniques can use human intelligence for data labeling from a variety of sources. Data labelling is the process of assigning labels or tags to data, such as images or text, to help computers recognise and comprehend the information. To improve data annotations for the same data set and to develop labels for new data sets, the most reliable and consistent label relationships are used (Cui et al., 2020).

Human intelligence can benefit from supply chain, which can enhance staff competencies. Employees who are involved in supply chain activities might receive training and development from a strong supply chain. In addition to helping them advance their professions and boosting their skills and abilities, this can help employees' skills and abilities. Employees that are involved in supply chain activities might receive training and development from a strong supply chain. Employees' skills and abilities may be enhanced, and it may also help with professional advancement.

Simulating

Simulating refers to the process of developing a computer program or system that can mimic or emulate human thought, behaviour, and interaction. A technique for virtualizing a computing system that resembles the human brain is described in US patent 201314097377 A (Tang Changbin & Xiong Li). attempts to develop computing systems that can simulate or model how the human brain processes information and performs intelligence-related activities. In a number of industries, social interactions and production are most affected by artificial intelligence and virtualization (Santos et al., 2021).

According to inventors of IN patent 2020050560 W (Sambana Bosubabu), artificial intelligence is used for telepathic data exchange with virtual reality holographic projections in virtual brain cloning. A technique known as *"virtual brain cloning"* permits the construction of a computer simulation model that represents the human brain's structure, connections, and neuronal activity. Through the regenerative development of professional skills, a cognitive

ensemble of intelligent cellular diverse agents with powerful artificial intelligence can be developed (Bryndin, 2020).

In the context of human intelligence, simulating and virtualizing have important advantages, such as raising productivity and efficiency. With the use of simulation and virtualization, humans can handle data and information more rapidly and effectively, which can boost productivity and effectiveness when carrying out specific jobs.

Psychology

The science that examines human behaviour and mental processes, including intellectual capacities or human intelligence, is known as psychology in the context of human intelligence. The Inventor of US patent 201917291003 A (Kahane Yehuda, Korenman Ernesto Sholomo, Weinbach Liora) describe computerized systems and methods for assessing psychological states based on sound analysis. A professional psychology evaluation system for students can, among other things, use scientific professional psychological assessments to assist students in better understanding their own interests, personalities, and professional skill inclinations (Ren, 2020).

The inventors of IL patent 2019051222 W (Kahane Yehuda, Korenman Ernesto, Weinbach Liora) disclose a computerized system and method for assessing psychological states through sound analysis. Technologies that use computers to analyze and interpret human speech data to evaluate a person's psychological condition, such as emotions, stress levels, and anxiety, are known as computerized systems and methods for evaluating psychological states based on sound analysis. The voice control method used in this paper is precise and effective for controlling intelligent systems involving human-computer interaction (Liu et al., 2020).

The positive impact of psychology on human intelligence is very important in understanding and improving the quality of human life, such as improving mental health. By examining the elements that affect mental health, such as stress, anxiety, and depression, psychology aids in the improvement of mental health and well-being. Psychology can assist people in overcoming mental health issues and enhancing their quality of life by comprehending these aspects.

Human Intelligence task

Human Intelligence Task (HIT) is a task or work that humans must do as part of the process of collecting or processing data for a specific purpose. Even while these activities are frequently straightforward, they call for a level of cognition or knowledge that current artificial intelligence algorithms or machines are unable to accomplish. HIT examples include data validation, data annotation, voice transcription, and picture or text recognition. The inventors of US patent 201929711049 F (Rhyu Joseph, Carlet Riccardo, Villaamil Alessandra) presents a Display panel with a graphical user interface of the primary news. The blue colour indicates keywords under high introduced cognitive burden, and the italic font and red colour of the keyword text provide the cognitive strain that the reader feels while reading news texts under low introduced cognitive load (Zhou et al., 2022).

The inventors of US patent 201414203513 A (Jorge R. Ramos, Rajesh Patel, Steven Shelford, and Yunling Wang) claim that the invention and efficient application of human

intelligence's reference jobs. The development of knowledge-based intelligent systems has expanded as a result of technological advancements that try to emulate key features of human intelligence (Vigo, Zeigler, and Wimsatt 2022).

Using task performance as a guide, the inventors of US patent 201314025880 A (Chi Ed Huai-Hsin, Dai Peng, Paritosh Praveen, and Rzeszotarski Jeff) explain how to manage the workflow of human intelligence jobs. The methods presented here are adaptable to the kinds of tasks offered throughout a process. This preparation may entail offering various jobs or activity breaks as workflow interruptions. In terms of effectiveness, security, and customer satisfaction, the suggested planner performs better (Paz-Baruch, 2020).

The Human Intelligence task improves cognitive abilities. These abilities, including concentration, problem-solving, analysis, and comprehension, are needed to complete HIT assignments. HIT activities can assist in expanding cognitive capacity and improving cognitive abilities through consistent practice.

One of the most striking examples from the study is the potential use of the 821 discontinued patents related to human intelligence, which are now accessible without royalty fees. This aspect highlights the immense opportunity for leveraging previously protected intellectual property to drive innovation across fields such as education, healthcare, and artificial intelligence. A key motivation behind this discussion is the urgency to advocate for more patents to be released from their protective status, thus enabling society to benefit from the documented intellectual value. To inspire readers, this review emphasizes the transformative impact of these patents, such as advancing cognitive tools and human-machine interfaces, which have significantly enhanced human intelligence capabilities. A more systematic and critical discussion is essential to examine how the patent mechanism itself influences society's ability to access and utilize these innovations. This exploration invites readers to reflect on the balance between intellectual property protection and the public's right to benefit from knowledge, urging actionable steps to maximize societal gains while ensuring sustainable innovation ecosystems.

The findings of this research have significant practical implications for various stakeholders. Businesses and entrepreneurs can leverage discontinued patents to innovate without incurring royalty fees, enabling cost-efficient advancements in human intelligence technologies. Policymakers may utilize these insights to craft strategies that promote sustainable innovation and facilitate the commercialization of such technologies. Researchers and academics are provided with a clearer understanding of emerging trends and gaps, offering direction for future interdisciplinary studies. For technology developers, the study reveals opportunities to design solutions in fields like artificial intelligence, healthcare, and education that align with global patent trends and societal demands. Additionally, educational institutions could integrate human intelligence advancements into teaching methods, enhancing learning outcomes. Finally, the geographical patent data supports international collaboration, fostering partnerships to drive innovation and technological progress. By applying these insights, stakeholders can effectively contribute to technological development and societal well-being.

CONCLUSIONS

To create innovations and discoveries in the subject of human intelligence, knowledge of patents that are pertinent to that sector is crucial. The number of patents pertaining to the study of human intelligence is generally on the rise each year. It is possible to start a business without paying royalties by utilizing 821 revoked patents that deal with human intelligence. Ownership of businesses and American inventors dominate patent intellectual property relating to human intelligence. The physics (G) patent section predominates in human intelligence-related patents. In 13 nations or areas, there are 2,767 simple family human intelligence patents, with the United States having the most. With 117 patents, Colombian citizen David S. Breeds is the most prolific inventor in the field of human intelligence.

The main restriction of this study is that it only uses Lens patent data. The benefits for different parts of life, including technological advancement, boosting efficiency, developing human resources, and improving quality of life, will expand with further development of scientific and practical methods, including the use of human intelligence. By developing human intelligence studies utilizing a patent landscape analysis approach, this research adds to the body of knowledge. Future predictions indicate that most businesses will adopt human intelligence as a standard. Text here with the first line of the paragraph flush left.

IMPLICATIONS FOR RESEARCH, APPLICATION, OR POLICY

This study highlights the significant potential of using discontinued patents related to human intelligence to drive innovation and societal advancement. Beyond the quantitative analysis, a more critical and systematic examination reveals the profound impact of these patents on enhancing cognitive tools, education, healthcare, and artificial intelligence. The findings highlight the urgent need to reconsider the current mechanisms of patent protection, advocating for more equitable access to intellectual property that can unlock transformative benefits for society. By releasing patents from their protective status, communities worldwide can harness their intellectual value to address pressing challenges and foster inclusive technological progress. This review encourages stakeholders to re-evaluate intellectual property frameworks to align innovation with broader societal benefits. By inspiring readers to reflect and act on these issues, the study aims to stimulate meaningful contributions toward a more inclusive and impactful landscape of human intelligence innovations.

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DIGITAL TRANSFORMATION IN BUSINESS PROCESS MANAGEMENT: THE ROLE OF EMPLOYEE ENGAGEMENT

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Abstract: *This article explores the complex interaction between employee engagement and digital transformation within the context of Business Process Management (BPM). It intends to assess how factors such as support from supervisors, or benefits of transformation, influence the acceptance of new digital processes within organizations. In the empirical part, a survey was conducted which aimed to identify factors influencing employee engagement. Then, the study utilizes Partial Least Squares Path Modelling (PLSPM) to analyze the impact of various factors on employee engagement during digital transformation initiatives. The work highlights the critical role of effective communication in ensuring successful digital transformation, proposing that clear, consistent, and transparent messaging is essential. This study contributes to the existing literature by offering a modified model of technology acceptance, specifically tailored to modern digital transformations in BPM. It also provides insights into the dynamics of employee behaviour in response to technological changes, which is crucial for leaders and managers overseeing digital strategies. Moreover, the findings emphasize the need to consider the human-technology interface, where emotional responses, trust in digital systems, and perceived control play a significant role in shaping engagement. The study acknowledges that technology adoption is not only a rational process but also deeply rooted in human values and social context. Understanding this interplay helps organizations design digital transformation strategies that align technological innovation with human-centered approaches.*

Keywords: *employee participation, innovation management, human technology interaction, organizational change, process improvement*

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INTRODUCTION

Both scientists and practitioners indicate that the low level of employee involvement in work is currently one of the most disturbing problems of the economy (Motyka, 2018). One of the areas analysing this issue is Business Process Management (BPM), which is understood as a systematic methodology aimed at enhancing the efficacy of the processes utilized by organizations to accomplish tasks, cater to customer needs, and foster value creation (Tucci, ND). The implementation and understanding of BPM exhibit significant variation across organizations, influenced by factors such as organizational size, process maturity level, technological advancement, corporate culture, and available resources. The application of BPM can range from focused interventions targeting the optimization of a single process, like onboarding a new client, to comprehensive organizational transformations necessitating the adoption of fundamentally new procedural frameworks. The effectiveness of BPM initiatives is largely depending upon an organization's ability to recognize and leverage the potential benefits of process optimization.

According to IBM (https://www.ibm.com/topics/business-process-management), business process management (BPM) can be categorized into three primary types: integration-centric, human-centric, and document-centric, each serving distinct operational functions within an organization. The first one, integration-centric BPM, is characterized by its focus on processes that necessitate minimal human intervention, relying instead on application programming interfaces (APIs) and mechanisms to facilitate the seamless integration of data across various systems. Examples of such systems include Human Resource Management (HRM) and Customer Relationship Management (CRM), where the automation and synchronization of data are pivotal. In contrast, human-centric BPM emphasizes the necessity for human interaction, particularly in scenarios that require approvals or decision-making (Fdez-Olivares et al. 2010). This approach enhances accountability and oversight throughout the procedural workflow. And finally document-centric BPM revolves around the management and processing of specific documents, such as contracts, which are critical to the procurement processes of companies. This type of BPM addresses the need for documents to undergo various stages of form completion and approvals, facilitating the establishment of agreements between clients and vendors through a structured and traceable process.

It seems that this division has been merged again by the ongoing digital transformation of enterprises. **Digital transformation** captures the utilization of digital technologies to either modify existing traditional and analogue processes or develop new ones, in response to changing market dynamics and customer expectations (What is digital transformation?, 2024). This transformation fundamentally redefines the management and operational methodologies of businesses, as well as the mechanisms through which value is carried to consumers. Research demonstrates that the implementation of artificial intelligence technologies in organizational contexts requires careful consideration of both technological capabilities and human factors, with performance outcomes significantly influenced by the integration of these elements (Angammana & Jayawardena, 2022). It also means a technological adoption, which causes a cultural shift that forces organizations to question existing patterns, engage in frequent experimentation, and accept some failures. The primary objective of digital transformation is to build a competitive power through the strategic implementation of

technology at scale, often aiming to enhance customer experiences and reduce operational costs. However, it should be assumed that digital transformation must simultaneously concern the processes of integration of enterprise functions (integration-centric BPM), human processes (human-centric BPM) and document-related processes (document-centric BPM). None of these areas can be ignored. Subsequently, digital transformations can apply to all processes that take place in enterprises. Each digital transformation initiative should be characterized by its goals; however, the primary goal of such actions is to enhance existing processes.

Currently, it is possible to identify digital solutions used in different areas of the enterprise, for example:

1) production companies use IoT tools to supervise and optimize manufacturing processes, improve supply chain management, and enhance product quality through real-time data collection; services companies use cloud platforms for flexible, scalable access to computing resources, data storage, and software applications, enabling remote work (Taj et al., 2023); 2) in other service sectors, like real estate, education, or healthcare, Virtual and Augmented Reality can be used to enhance the customer experience by providing immersive interactions, simulations, and visualizations; 3) AI-powered chatbots can be deployed on websites and social media platforms to provide instant customer service, and engagement; 4) cloud-based platforms, such as Google Drive or Dropbox, allow for the storage, sharing, and collaborative editing of documents, spreadsheets, and presentations, among employees. These are examples of digital solutions currently existing or being implemented in almost every enterprise. Their implementation and subsequent successful use always depend on the acceptance and commitment of employees (Murawski and Bick, 2017).

The successes of using these solutions in companies depend on employees at various levels, because only employees possess the cognitive abilities to set goals, make decisions, or learn from experience. Moreover, this success depends on engaged employees, who are more likely to embrace new technologies and adapt to the digital changes implemented within the company. Every change, however, can face resistance, especially when it disrupts established workflows and requires new skills. Therefore, engaged employees, who feel valued and are aligned with the organization's goals, are crucial when it comes to implementing changes. This is due to the fact that they are more likely to understand the reasons behind the digital transformation and, hence, less likely to resist it. Therefore, **the goal of the article is to define factors determining employee involvement in the digital transformation of business processes**. In relation to this goal, **4 hypotheses** have been formulated – they are given in the Methodology section.

While BPM focuses on process improvement, digital transformation aims at fundamental changes, requiring research on new process management approaches, including agile processes and infrastructure flexibility. That is why the stated hypotheses are related to the main research question: Which factors determine employee involvement in the successful digital transformation? Such a question is crucial because employees who are involved in day-to-day operations possess valuable knowledge and expertise about the processes they manage. Their insights can help identify process inefficiencies and opportunities for improvement that might not be apparent from a top-down perspective. But what is the most important, for digital transformation initiatives to be successful, they must be widely adopted across the organization. Finally, digital transformation often requires significant changes in

how processes are executed and how employees perform their jobs. Therefore employee involvement is essential for effective change management, as it helps to address concerns and resistance to change, ensuring more efficient transition.

LITERATURE REVIEW

Hajo A. Reijers, in his well-known work ‘Business Process Management: The evolution of a discipline’ (2021) writes, that BPM is so essential because managing processes from start to end ensures better efficiency and faster achievement of goals, therefore organizations that monitor and refine their business processes tend to outperform those that do not. Managing a business process is complex, as it often involves various departments, specialties, locations, management tiers, and other organizational divisions. Moreover, achieving effective management requires a thorough understanding of the process steps, the individuals involved, the data exchanged and processed, and the technologies used at each stage (Reijers, 2021). By optimizing and aligning these factors, an organization can enhance its product or service output, for instance, by accelerating the process, increasing efficiency, or reducing its environmental impact. The literature on BPM predominantly focuses on process models, especially the control-flow perspective, while other aspects like resources, data, time, and functions get less attention (van der Aalst, et al., 2016). This emphasis presupposes that better models will automatically lead to better processes, a notion that is questioned for several reasons, including the potential disconnect between models and reality, and the limited use of these models in actual process automation within organizations. Consequently, the argument is made for prioritizing process improvement over model perfection, suggesting that the utility and detail of process models should align with their intended purpose, such as automation or identifying redesign opportunities for efficiency gains.

Introducing changes in process management is often indicated as a key factor in market success. For example, research by Thomas (2020) shows that organizational innovation and creative outcomes stem from various challenges, including market volatility, diverse environmental factors, and competitive demands for uniqueness. Firms introducing digital integration across management, systems, and data gain a competitive edge. This approach merges various operational and technological areas, creating new opportunities, business models, and strategies. Fully integrating digital and business strategies leads to synergistic benefits, enhancing a company's adaptability, innovation, and resilience against competitive pressures.

It seems that the aspect of market competitiveness occurs very often in relation to process management. Truong, Nguyen-Duc, and Van (2023) write, that in the last decade, organizations have increasingly focused on effective management processes to stay competitive. This has led to a reliance on enterprise information systems for managing information and automating tasks. BPM plays a key role in integrating these systems into cohesive teams, enhancing operational efficiency and responsiveness to market changes. Despite BPM's recognized importance, there is a research gap in its application to digital transformation, which involves integrating digital technology into all business aspects.

BPM is an extremely important concept of business management enabling effective implementation of changes, which is emphasized by authors such as Dumas, LaRosa,

Mendling and Reijers (2015), who claim that BPM acts as a junction where diverse perspectives converge. Business managers gravitate towards BPM for its proven track record in enhancing organizational efficiency, ensuring compliance with regulations, and elevating the quality of services. Industrial engineers view BPM as a chance to apply established optimization methods from manufacturing to service-oriented organizations. Moreover, Information Technology (IT) professionals value BPM for offering a common language that facilitates communication with business stakeholders. Additionally, the advent of business process automation technology enables IT experts to deploy and manage IT systems in a manner that aligns with business leaders' vision for the company. Essentially, BPM bridges various disciplines, functioning as a crucible that blends distinct communities together. Although BPM is a complex area, it can be defined as – quoting Wil, Aalst, Hofstede, and Weske (2003), the authors of 'Business Process Management: A Survey'

> – *Supporting business processes using methods, techniques, and software to design, enact, control, and analyze operational processes involving humans, organizations, applications, documents and other sources of information.*

As one can see in the definition provided, the BPM connects people and technology. There is no doubt that business has been undergoing intense technological transformation in recent years. This transformation involves employing digital tools such as cloud computing, robotic process automation, workflow management software, BPM software, artificial intelligence, and low-code development platforms. These technologies aim to optimize processes, increase efficiency, and elevate customer service experiences (Verhoef et al., 2021).

Authors such as Davis (1989), Venkatesh and Davis (2000), Marler and Dulebohn (2005), Lok (2015) or Tamilmani (2021), try to explain, how users come to accept and use a technology, and indicate two main factors: 1) perceived usefulness, which refers to the degree to which a person believes that using a particular technology will enhance his or her job performance. In other words, when a technology is perceived as useful, an employee is more likely to accept and use it; 2) perceived ease of use, which refers to the degree to which a person believes that using a particular technology will be free of effort. So, if a technology is perceived as easy to use, it is more likely to be accepted and used by employees. This Technology Acceptance Model (TAM) stems from the Theory of Reasoned Action, described by Fishbein and Ajzen (1975), and assumes that users are rational and make systematic use of the information available to them when forming their judgment about technology acceptance. Nowadays this basic 2-factors approach has many extensions, encircling different types of users, organization, technology, task types, time of performance, and different locations. One of the advanced models is Unified Theory of Acceptance and Use of Technology (UTAUT), developed by Venkatesh, Morris, Davis, and Davis in 2003. UTAUT integrates elements from other models, including TAM, proposing that four key constructs - Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions - are the primary determinants of usage intention and behaviour (Venkatesh & Davis, 2000). This model also has its variants and extensions (Bouvier, Hwang & Hwang, 2024; Tamilmani et al., 2021).

One of the core concepts in this article is engagement, which can be understood as an aspect of the relationship between an employee and the organization or work performed, as

well as identification with work (Jarecki and Młokosiewicz, 2017). By engagement, according to Kenneth and Walter (2020), we mean the energy and thoughts that an employee puts into his or her work. Engagement is essential because when people are engaged in their work, they take steps to ensure that actions performed are effective in achieving goals. Moreover, engaged and satisfied employees demonstrate extra-role behaviours that go beyond the duties and requirements of employment (Veseli and Çetin, 2024.) According to the mentioned authors, the work engagement profile refers to four elements:

1) The feeling of meaningfulness – an employee has the chance to work towards a significant goal.
2) The feeling of autonomy – an employee has the ability to choose tasks that resonate with his skills and to carry them out in a manner he finds suitable.
3) The feeling of competence – an employee can effectively execute the tasks he has selected.
4) The feeling of advancement – an employee has a feeling that he makes progress towards achieving task objectives (Kenneth and Walter, 2020).

When the factors mentioned above are in place, then work becomes an important source of satisfaction and fulfilment. In many ways, the four intrinsic rewards—sense of meaningfulness, sense of choice, sense of competence, and sense of progress—serve as psychological marks indicating how well the job is working for both an employee and his company. All of this is important because engaged employees perform better, experience less burnout, and stay in organizations longer (Stein et al., 2021). Contemporary research in organizational performance demonstrates that employee engagement serves as a critical mediator between management practices and organizational outcomes, with studies showing substantial improvements in performance metrics when engagement-focused strategies are implemented (Vovk & Vovk, 2024) From this perspective it should be noted that a lot depends on leaders because they are the ones who inspire and motivate their employees to exceed expected levels of performance (Maj, 2023).

From the point of view of running a business, digitizing processes entails transitioning from manual to digital operations. This conversion leverages digital solutions to modernize traditional task execution methods, including document filing, invoice processing, and inventory management. Verhoef et al. write, that there are three key external drivers forcing the need for digital transformation. First one is the Internet supported by various technologies such as smartphones, Web 2.0, SEO, cloud computing, online payment systems, and cryptocurrencies. Second is the widespread availability of big data and the introduction of cutting-edge digital technologies like artificial intelligence, blockchain, or the Internet of Things, enabling the use of this data. Thirdly, replacing more expensive human labour with robots, virtual agents, and AI. For these factors in business activity arises the need of digital resources, the need of organizational structure change, and the need for specific goals and metrics. If we assume that we have a knowledge-based economy, this fact itself causes a shift in emphasis, because knowledge-based economy has led to transformations in the nature of work, the workplace, and the workforce from simple tasks to tasks based on specialized know-how (Kanur, 2021).

Digital technologies also significantly influence consumer behaviour, granting them constant access to information and the ability to communicate. Therefore, according to Vial (2019), businesses must now anticipate changes in market expectations to maintain a strategic

edge, rather than merely reacting to them. Thus it is worth of noticing that digital changes cover not only companies' internal processes, but also external operations and their offer, which is a direct result of the changing expectations of consumers (Etienne Fabian et al., 2023).

The relationship between humans and technology is dynamic and multifaceted, shaped by both innovation and the evolving needs of society. Technology serves as an extension of human capabilities, enhancing communication, productivity, decision-making, and access to information (van Beinum, 2024). While technological advancements can lead to increased efficiency and new opportunities, they also raise challenges related to adaptation, trust, ethical use, and social impact. Ultimately, the success of any technological innovation depends not only on its functionality but also on its alignment with human values, behaviors, and expectations, making the human-technology relationship a central consideration in design and implementation processes (Bouvier et al., 2024; Hasyim & Bakri, 2024; Siderska et al., 2023).

METHODS

In the empirical part, a survey was conducted which included both quantitative and qualitative questions. The survey aimed to identify factors influencing employee engagement in the digital transformation of Business Process Management. The questions concerned, among others, issues such as: changes related to modern technologies, self-knowledge about changes and commitment, difficulties associated with digital transformation, the role of direct superiors, adequacy of communication, opinions about training, and suggestions for increasing engagement in digital initiatives.

Responses were obtained from 154 people, but from this group, 11 people indicated that they did not see any digital changes at work - so the analysis mostly concerns the answers of 143 respondents. Men constituted 43.5% of the surveyed sample, while women constituted 56.5%. The sample is characterized by a very diverse age structure because the respondents came from very different age groups, including people younger than 25 and older than 55. The sample is also diverse in terms of education, although the largest part are respondents with master's degree.

For empirical part 4 hypotheses have been formulated:

H1: Employee engagement in digital transformation is dependent on the support of direct superiors.

H2: Employee engagement is influenced by the perception that their contributions are significant to the process

H3: Employee involvement is dependent on the benefits stemming from transformation for themselves or for the entire company.

H4: A lack of information about changes diminishes the level of involvement.

The above hypotheses were tested using PLSPM (the partial least squares path modelling). Model estimation was done in WarpPLS using PLS regression as outer model analysis algorithm. PLS methodology is especially fruitful in a case of small sample sizes and non-normality assumptions for ordinal indicators. Based on minimum significant path coefficient in a model (b=0.15), significance level of 0.05 and power of 0.8 the minimum estimated sample size equals between 275 (inverse square root method) and 262 (Gamma exponential method). This sample size would be optimal. The actual sample size was 154 that

obtained too low power (1-β = 0.63), therefore, the results should be analysed with appropriate caution. As an outcome of the analysis, the stated hypotheses were verified, and a structural model showing the importance of factors determining employee engagement was created.

RESULTS

The nature of changes

In our study, 77.9% of respondents confirmed that digital changes are taking place in their companies, with 59.9% saying that they personally implement changes in their workplace. Only 7% answered that they did not see such changes, and 14% were not sure. It is significant that digital transformation mainly concerns processes, in particular document circulation, access to data, meetings and online communication. The least changes concern the devices themselves. The Fig.1 shows the nature of the changes according to the three areas: processes, technology and devices.

A culture that supports change

As mentioned, digital changes should be accompanied by a culture focused on innovation, and it seems that such a culture exists in some companies, as 29.4% of respondents stated that they often submit proposals for changes in the functioning of the company, and 13.5% stated that all submitted ideas were implemented. However, it is difficult to assume that this is the situation in most companies, because 44.8% said that they rarely suggest changes, and 25.9% said that they never report them. So about 30% of companies have a change-friendly culture.

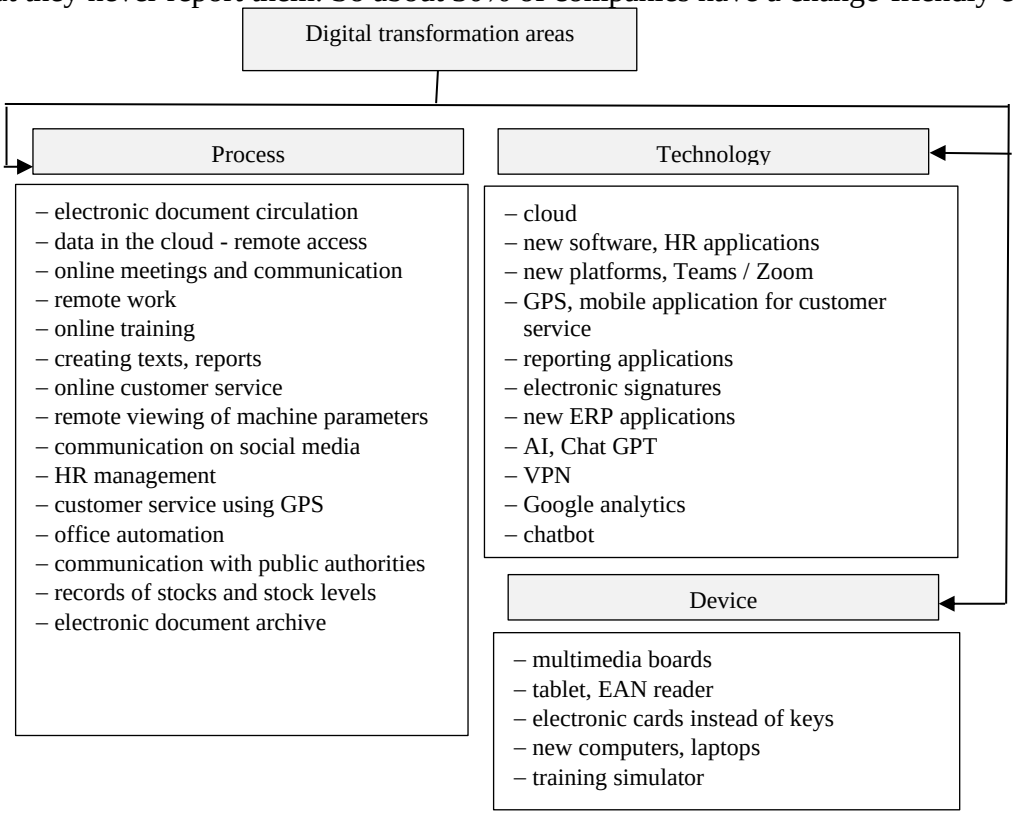

Figure 1. Character of changes. [Source: own work]

Engagement in digital transformation

Employee engagement determines the success of digital transformation, so the level of such engagement was asked. Only 16.8% of respondents rated their commitment as high. Most indications concerned average engagement (26.6%), and 11.2% rated their involvement as very low. In total, almost 35% of respondents indicated no or low involvement. Figure 2 refers to this issue.

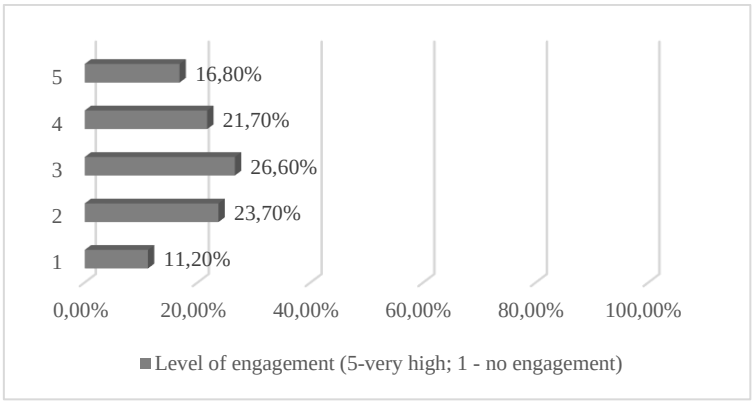

Figure 2. Engagement of employees. [Source: Own work]

Engagement determinants

A large group of respondents make their commitment dependent on factors such as: financial allowance (46.6%), the possibility of remote work (45%), or a shorter working day (32.1%). Training is also an important factor - 35% of responses indicated that training should be better adapted to the needs of employees, and 31% that generally there should be more training. It turns out that information about the benefits of implementing digital changes is important as well - benefits for the company (27.1%) and benefits for employees (23.6%) were indicated.

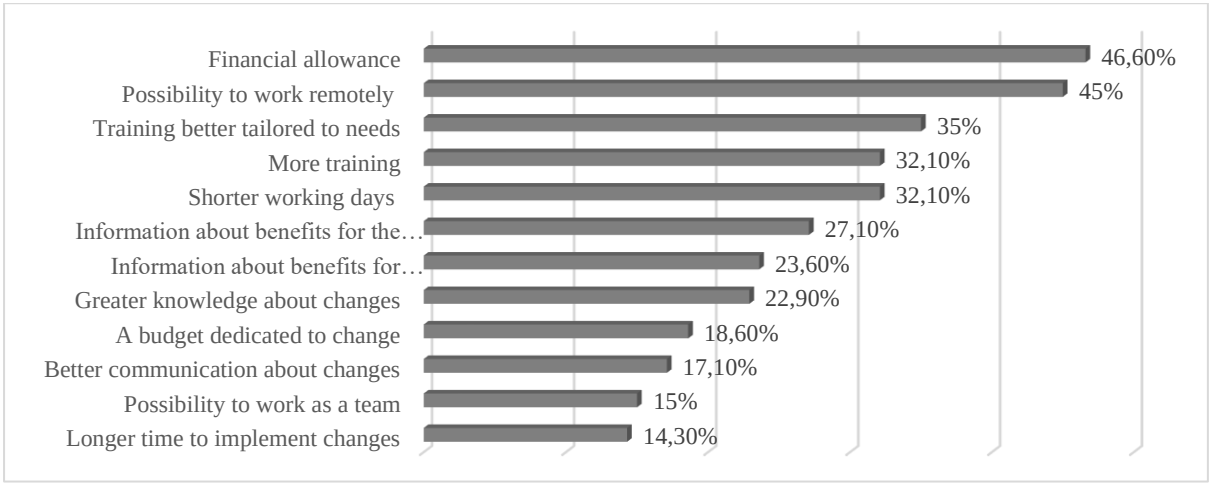

Figure 3. Incentives of engagement. [Source: own work]

Usefulness of training

Among respondents, 62.3% received training in digital transformation; this number indicates that employees are currently undergoing a lot of training and learning new things. However, 28% of this group claim that the training was insufficient. Moreover, 15.4% replied that they had not received any training but needed it. In turn, 21.7% said they did not need training at the moment.

Respondents who completed the training were asked about their assessment. The issue of usefulness of training at work was rated the best - on a scale of 1-5, this feature received an average score of 3.63. The lowest scores were given to the distribution of training over time (3.22) and the support of employees after training (3.05). However, it should be noted that all aspects of the training were rated below 4, i.e. less than good. This means that a lot of training is created but it does not meet expectations.

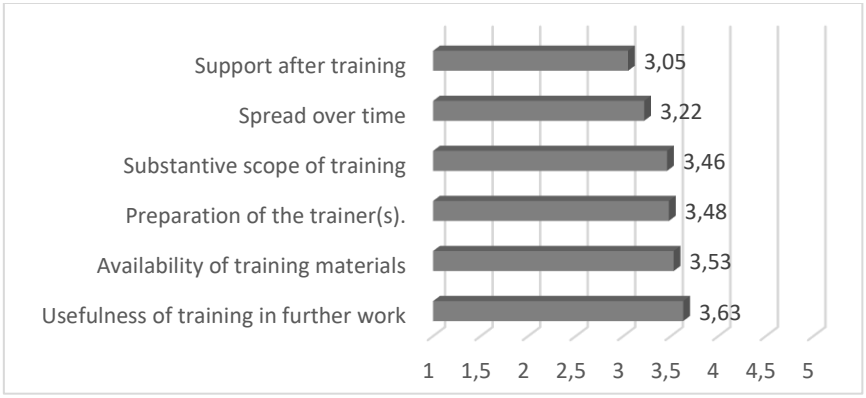

Figure 4. Evaluation of training. [Source: own work]

Verification of hypotheses

The hypotheses posed in this paper refer to: support of direct superiors (H1), the belief that employee participation is significant (H2), benefits of transformation for the entire company, (H3), and the role of information in building engagement (H4). The variables corresponding to the hypotheses were coded and then a structural model was built, using PLSPM path modelling. The advantage of WarpPLS is an ability to identify a non-linear relationship between variables, so it can be used to analyse factors that have direct impact on employee engagement.

The structural part of model with path parameters, p-values, and effect sizes (ES) is depicted in Figure 5.

The analysis shows that the model fit is acceptable. Average path coefficient (APC) = 0.247, $p < 0.001$, average R-squared (ARS) = 0.198, $p = 0.003$, average adjusted R-squared (AARS) = 0.191, $p = 0.004$, average full collinearity VIF (AFVIF) = 1.585, Tenenhaus goodness of fit index (GoF) = 0.445, Simpson's paradox ratio (SPR) = 1.000 (acceptable if >= 0.7), R-squared contribution ratio (RSCR)=1.000 (acceptable if >= 0.9), statistical suppression ratio (SSR) = 1.000 (acceptable if >= 0.7) and nonlinear bivariate causality direction ratio (NLBCDR) = 1.00 (acceptable if >= 0.7).

All constructs were based on formative measurement model with one indicator. As both independent and dependent latent variables were measured using 5-point Likert scales, the common method variance was estimated using Harman method. The first principal component in Harman method explains 41.37% of total variance and do not exceed 50%.

The results indicate that statistically significant relationships exist between: CAC-PTE, PTE-EE, CAC-PCI, PCI-EE, SDS-EE and TRA-PCP. In turn, no significant relationships were found between: CAC-PTO, PTO-EE and PCP-EE.

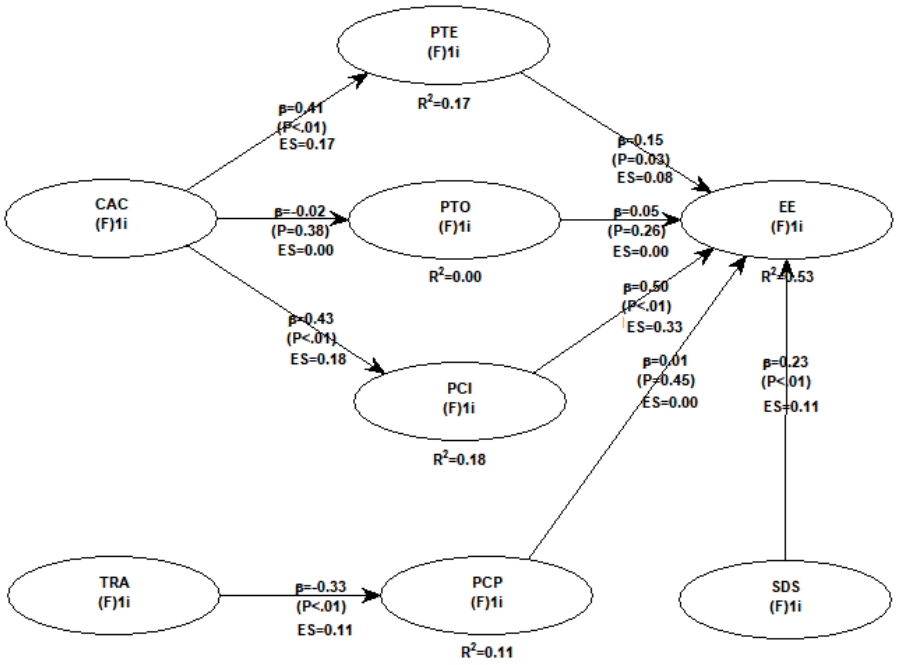

Figure 5. Estimated model parameters. [Source: Own work]

Legend:
(F) - formative indicators; 1i - number of items (one item)
(G) CAC – communication about change
PTE – perceived transformation benefits for employee
PTO - perceived transformation benefits for organisation
PCI – perceived contributions importance
EE – employee engagement
TRA - training in transformation
PCP - perceived contributions performance
SDS – support of direct superiors

Analysing the obtained results of the model estimation we may draw the following conclusions:

Referring to H1: Employee engagement (EE) in digital transformation is significantly dependent on the support of direct superiors (SDS; $\beta=0.23$, $p<0.1$). However, the effect size is rather small (ES=0.11). In other words, while there is evidence that employee engagement in digital transformation depends on the support of direct superiors, the strength of this dependency is low. This means that even though the support from direct superiors influences

employee engagement in digital transformation, it does so to a limited extent, and probably depends on other factors as well.

The vast majority of respondents have some kind of superior, only 9.2% said they have no boss. The former, assessing the role of their superiors, often said that they knew what to do when implementing changes and did not contact their direct superiors (31.2%). Often, the superior directly participates in introducing changes (22.7%), but also quite often the boss only gives orders and controls their implementation, but does not take part in the changes himself (18.4%). Interestingly, some respondents said that they knew more about the changes being introduced than their direct boss (8.4%).

Referring to H2: Employee engagement (EE) is strongly influenced by the belief that their contributions are significant (PCI) and this is the strongest relationship found in our study (β=0.5, $p<0.1$, ES=0.00). The results indicate that employees' engagement in the process is significantly boosted when they see their work as important to the success of the digital transformation. Moreover, there is also a statistically significant relationship between communication about transformation (CAC) and perception of contributions (PCI; β=0.43, $p<0.1$, ES=0.18). This means that both factors, i.e. communication about transformation and perception of contributions, significantly influence employee engagement.

Referring to H3: The hypothesis that employee involvement (EE) depends on the benefits stemming from transformation for the entire company (PTO) was not confirmed (β=0.05, p=0.26, ES=0.00). This suggests that there is no significant dependency of employee involvement in digital transformation on the perceived benefits of the transformation, either for the employees themselves (PTE) or for the entire company (PTO). Moreover, it seems that this result is negatively influenced by another factor – CAC (β= -0.02, p=0.38, ES=0.00). Therefore, it may turn out that poor communication about the transformation blocks the impact of the benefits on employee engagement.

The surveyed respondents stated that digital changes usually cover 10-50% of their tasks. The assessment of understanding the transformation goals shows that the majority understands the goals of digital transformation well - 77.5%. Only 7% of respondents indicate that the understanding of causes and goals is low or insufficient.

Referring to H4: The sum of indirect (mediation) effect for the relationship between communication about change (CAC) and level of employee engagement (EE) is significant (b = 0.275, p=0.00) with small effect size (ES = 0.143). It indicates that lack of information about changes diminishes the level of employee engagement, but the relations are significantly explained by perceived transformation benefits for employee (PTE) and organization (PTO) and perceived contributions importance (PCI).

The relationship between CAC and PCI is negative (β= -0.02), and between CAC and PTE and PCI is positive (β=0.41 and 0,43). The statistical significance of the mediation effect (p=0.00) suggests that the process through which communication about change affects employee engagement is reliable and not due to random chance. The beta coefficient (β = 0.275) quantifies the change in employee engagement for each one-unit change in communication about change, considering the mediating effects.

When asked how employees evaluate the way of communicating about digital transformation, the answers were quite varied – as it is shown in Fig. 6, it was definitely good in 11.2% of cases, and definitely bad in 7%. It seems that the way of communication in

companies is imperfect and is often not conducive to change, as ratings from 'average' to 'poor communication' accounted for a total of 57% of the ratings.

It is significant that only 11.2% of respondents rate communication about digital changes as very good. Negative assessments of communication definitely outweigh what Fig. 6 refers to.

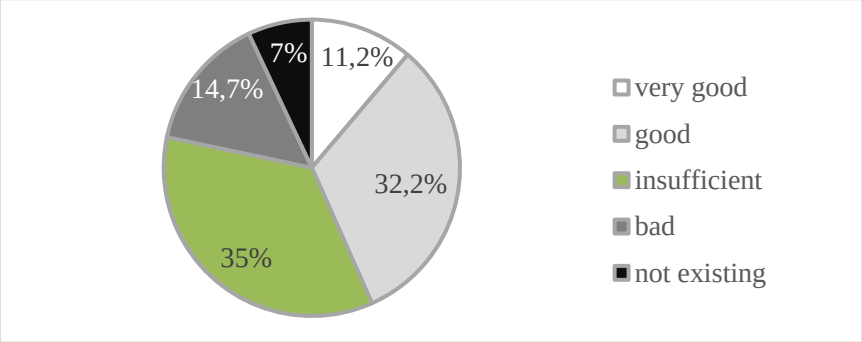

Figure 6. Assessment of communication related to digital transformation. [Source: Own work]

It is worth to notice, that non-linear relationships between PTE-EE, PCI-EE and SDS-EE exist, as well as between CAC-PTE, and CAC-PCI. The lower score of transformation benefits, perceived contributions performance and support of direct superiors tend to diminish or stabilize the employee engagement (EE) and the larger effect of engagement is observable at high score of PTE, PCI and SDS variables. Additionally, a negative effect of the TRA factor (training in transformation) on PCP (perceived performance) was also found (β= -0.33, $p<0.01$, ES=0.11). Therefore, it appears that employee performance is reduced by training.

DISCUSSION

The conducted study on digital transformation within Business Process Management (BPM) contributes to the existing literature by providing empirical evidence on the relationship between employee engagement and digital transformation. It can be stated that some findings are consistent with established theories, but others offer new insights.

When discussing the results in the context of the Technology Acceptance Models, it is evident that factors such as perceived usefulness and perceived ease of use (core to TAM) play a role in digital transformation acceptance. Thus, our results support the foundational principles of TAM, showing that employees' perceptions of the usefulness impact their engagement levels. This aligns with the work of Davis (1989), who first proposed these as key determinants of technology acceptance.

However, our findings extend beyond these basic factors by highlighting, for example, the importance of direct superior support, significance of employee contributions, and effective communication, aligning more closely with extensions of TAM. However, the UTAUT includes performance expectancy, effort expectancy, social influence, and facilitating conditions as determinants of technology use and acceptance, which factors do not fully match our model. We discover several new elements that have not been highlighted before: great importance of communication about digital transformation, which is the role of

the direct supervisor, who should communicate the task to employees. It is also worth noting that self-assessment of competences is important and influences the employee's approach to work (Tomczak et al., 2023). The common element, however, is importance of the tasks performed emerged. Also our research proves that employees are more engaged when they are convinced that their tasks are important. But, our results do not refer only to classic technology acceptance models, but also to the basic criteria that make employees engaged at work, discussed by Kenneth and Walter (2020). It turns out that employees still need a sense of meaning in their tasks, or a sense of autonomy.

In our case, the study diverges from the existing literature by demonstrating that perceived benefits for the employee or the organization do not directly correlate with higher engagement levels. This is important to some extent, but ultimately it does not affect engagement, so it can be assumed that the impact of these factors is short-term. This is a novel finding, as it contradicts the assumption within TAM2 and TAM3 that perceived benefits (an extension of perceived usefulness) are directly related to acceptance and use. This indicates a potential area for further research, suggesting that in the context of digital transformation, other factors may overshadow the perceived benefits.

Our research and analysis focusses on the aspect that BPM is a key area of business management enabling effective implementation of changes, as discussed by Dumas, LaRosa, Mendling and Reijers. Without a doubt, elements such as Facilitating Conditions or Effort Expectancy are important for the acceptance of modern technologies. However, behind these elements lies the need for effective communication and closeness with the superior - that was mentioned earlier - as well as the possibility of obtaining certain benefits, for example related to a different organization of the working day and the use of remote work. Therefore, we believe that our model, shown in Fig. 7, can complement the missing elements developed so far.

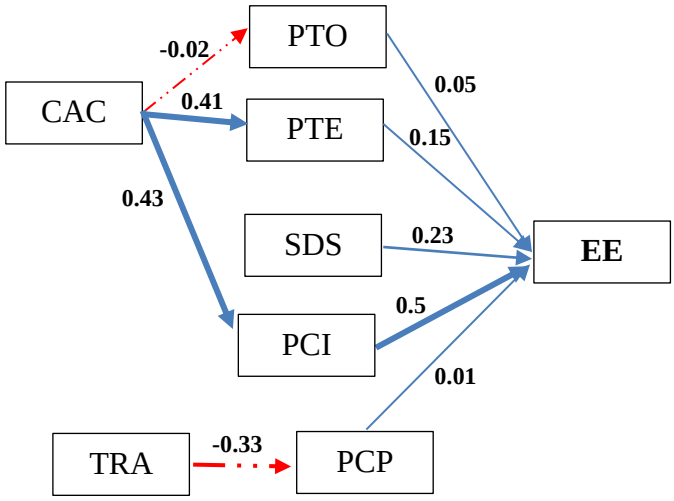

Figure 7. CECIS Model of successful digital transformation determinants from the perspective of employee engagement (dashed line - negative impact). [Source: Own work]

Legend:

CAC – communication about change
PTE – perceived transformation benefits for employee
PTO - perceived transformation benefits for organisation

PCI – perceived contributions importance
EE – employee engagement
TRA - training in transformation
PCP - perceived contributions performance
SDS – support of direct superiors

Unlike solely relying on technology acceptance models, our CECIS model integrates broader organizational behaviour and change management principles, offering a many-sided view of digital transformation processes. The acronym of CECIS takes its shape from the key factors that influence engagement:

C – communication / about transformation
E – employee / benefits to employee
CI – contributions / importance of contributions
S – superiors / role of superiors

Our findings, first of all, underscore the crucial role of the significance of recognizing employee contributions, then the direct superior support, the importance of effective communication and the mixed impact of perceived benefits. These elements resonate with and expand upon theories presented in the literature review, particularly in highlighting the importance of human-centric factors in the success of digital transformation initiatives.

Finally, the results show respondents' surprising opinions about training - 62.3% of participants reported receiving digital transformation training, so most respondents had already undergone some training. However, the evaluation of various aspects of training is far below ‘good’ which likely explains the negative impact of training on employee engagement.

As already mentioned, the findings of the study highlight several key areas of digital transformation in Business Process Management, focusing on aspects such as the nature of changes in processes, determinants of engagement, and the perceived usefulness of training. These aspects relate to the hypotheses posited in our research.

The research confirms that employee engagement in digital transformation depends on the support from direct superiors (H1), albeit the effect size indicates that while support is significant, its impact is limited, suggesting the influence of other factors as well. The study finds a strong influence of the perception that employee contributions are significant on their engagement (H2). This supports the idea that recognizing employees' contributions significantly boosts their involvement in digital transformation efforts.

Contrary to expectations, the hypothesis that employee involvement depends on the perceived benefits for themselves, or the company was not confirmed (H3), although employees indicated that their engagement could increase if they received additional pay or were able to have flexible working days. This indicates a complex relationship between perceived benefits and engagement that might be influenced by other factors such as communication effectiveness, and this requires further research. The results indicate that lack of information about changes diminishes employee engagement, underlining the importance of effective communication in digital transformation initiatives (H4). This also indicates the need for transparent and open communication when the company is undergoing transformation. This complexity is connected to the level of digital maturity of the company, which means that sometimes companies implement ad hoc activities and sometimes these are systemic ones, and then the behaviour of employees will differ (Karekla et al., 2021).

CONCLUSIONS

The goal of this study was to identify factors critical to employee involvement in the successful process of digital transformation. The study results indicate that employee engagement in digital transformation is a multifaceted issue influenced by several key factors: support from direct superiors, the perceived significance of employee contributions, effective communication, and the perceived benefits of transformation. The findings reveal also that while direct superior support is essential, its effect is relatively modest, suggesting the presence of other influential factors that require further research. The strong impact of recognizing employee contributions underscores the importance of fostering a work environment where employees feel valued and understand the importance of their work in the broader context of digital transformation.

The lack of confirmation of the perceived benefits hypothesis suggests that employee engagement is not motivated directly by benefits alone, which indicates a complex dynamic between individual motivations and organizational goals. The significant role of communication in influencing employee engagement highlights the necessity for clear, consistent, and transparent information sharing about the goals, processes, and expected outcomes of digital transformation initiatives.

The importance of effective communication and adequate information about changes, highlighted by our findings, offers a perspective that is not explicitly included in TAM or UTAUT. This suggests that for digital transformation initiatives, change management strategies including clear, transparent communication are as critical as the technological aspects themselves.

The research faced limitations due to the smaller than optimal sample size, potentially affecting the power and generalizability of the findings. Additionally, reliance on self-reported measures creates the potential for response bias, possibly skewing results. These limitations suggest that the conclusions drawn should be interpreted with caution and considered indicative rather than definitive.

IMPLICATIONS FOR RESEARCH, APPLICATION, OR POLICY

The findings of this study have significant implications for future theory, research, application, and policy in the realm of digital transformation. Future research could explore in greater depth the dynamics of direct superior support and its interaction with other factors to enhance employee engagement. Investigating the long-term effects of training on employee engagement and performance, and identifying additional motivational factors beyond the perceived benefits, could provide deeper insights into the complexities of fostering employee engagement in digital transformation contexts. The study concerned the inhabitants of Poland; in the future, comparisons could be made between different nationality groups, as well as between generations.

This research also indicates a gap in current theoretical models like TAM and UTAUT, which could be addressed by integrating change management strategies that emphasize clear, transparent communication.

From an application perspective, organizations should prioritize fostering a supportive environment, recognizing employee contributions, and ensuring effective communication to enhance employee engagement during digital transformations. This approach can help mitigate the negative impacts of suboptimal training, as identified in the study and can lead to more comprehensive and effective strategies for managing digital transformation in organizations.

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WHO BENEFITS FROM AI IN MONEY LAUNDERING IN EUROPE: THE ORGANISED CRIMINALS OR THE AML SERVICES?

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Abstract: *Artificial Intelligence (AI) has been exerting a growing influence on financial security, particularly in the area of anti-money laundering (AML). This study examines the relationship between AI adoption and AML effectiveness across selected European countries between 2017 and 2023. Employing a panel data econometric model, the analysis incorporates AI Vibrancy Scores, governance indicators, and economic variables to assess the multifaceted impact of AI integration. The findings reveal that greater AI adoption is generally associated with improved AML performance, as reflected by a statistically significant negative relationship between the AI Vibrancy Score and the Basel AML Index. However, the incorporation of a quadratic term indicates an inverted U-shaped relationship, suggesting that while moderate levels of AI adoption enhance AML outcomes, excessive integration may introduce systemic vulnerabilities exploitable by financial criminals. Governance variables – most notably the Rule of Law and Control of Corruption – emerge as key enablers of effective AI-driven AML strategies. Furthermore, factors such as public perception of AI and the presence of responsible AI governance frameworks significantly influence the success of AI applications in AML contexts. These results underscore the necessity of balanced AI policy development, robust institutional frameworks, and international regulatory coordination to harness AI's potential while mitigating its associated risks.*

Keywords: *artificial Intelligence, anti-money laundering, Basel AML Index, AI Vibrancy Score, AI Vibrancy subindexes.*

DOI: https://doi.org/10.14254/1795-6889.2025.21-1.11

INTRODUCTION

The integration of Artificial Intelligence (AI) into both money laundering processes and Anti-Money Laundering (AML) frameworks in Europe is a complex and dynamic issue. AI functions as a dual-edged sword in the realm of financial crime. On one side, financial institutions and regulatory bodies harness AI to enhance the identification and recording of illicit financial flows and improve compliance systems. AI-powered systems, particularly those employing machine learning techniques, can process vast volumes of transactional data, enabling the detection of suspicious activity with increased accuracy and reduced false positives (FCA, 2024). Conversely, organised criminal groups are increasingly leveraging AI to bypass AML controls. For instance, AI is now employed to generate fake accounts on cryptocurrency exchanges, facilitating money laundering operations that evade traditional detection mechanisms (Dale, 2024).

The rising relevance of AI in the AML domain is underscored by the development of tools such as the Napier AI / AML Index, which ranks countries based on their AI integration and financial crime compliance. Findings reveal that jurisdictions such as North America and Central Europe, which have incorporated AI more extensively, tend to experience a lower proportion of GDP lost to money laundering (Thrale, 2024). Nonetheless, the misuse of AI technologies introduces profound challenges. The same tools used to advance AML detection can also be exploited to develop complex laundering strategies, automate financial fraud, and create realistic deepfakes for deception (Dearden, 2024). This dual-use character of AI necessitates ongoing adaptation and innovation in AML approaches to keep pace with the evolving tactics of organised crime.

In this technological tug-of-war, AI simultaneously acts as both a safeguard and a weapon. While AML authorities utilise AI to fortify detection and reporting mechanisms, criminal actors manipulate the same technologies to refine their laundering techniques. The shifting balance between these forces is largely shaped by how quickly and effectively each adapts. As such, continuous empirical research and strategic policymaking are essential for AML services to maintain a technological advantage.

The broader implications of AI integration stretch beyond financial crime prevention. AI increasingly contributes to global economic development and institutional efficiency. As noted by Ioan-Franc and Gaf-Deac (2024), AI plays a crucial role in economic forecasting and stability. Neural networks, for instance, have been applied successfully to predict non-stationary agricultural outputs, facilitating more effective planning and resource distribution (Awe & Dias, 2022). Within the framework of digital transformation, Košovská et al. (2022) underscore AI's importance in reshaping accounting and financial systems, fostering transparency, reducing fraud, and enhancing long-term economic performance. However, the expansion of AI and digital technologies is not without risks. Zámek and Zakharkina (2024) caution that increasing digitisation and openness can also expose nations to new forms of economic vulnerability, a view echoed by Tiutiunyk et al. (2021), who highlight the need for updated regulatory frameworks to manage the destabilising effects of rapid technological change. As digital and AI technologies evolve, governments and institutions must collaborate to implement effective policies that balance the benefits of technological progress with the need for robust security measures.

Several studies reveal how AI has empowered criminal organisations to enhance their money laundering capabilities. AI algorithms are employed to automate illicit transactions, generate synthetic identities, and detect vulnerabilities in existing AML systems (Reshetnikova & Mikhaylov, 2023). Machine learning models enable criminals to analyse transactional behaviours and adjust operations to avoid triggering regulatory alerts (Yarovenko et al., 2024b; Yarovenko & Rogkova, 2022). Additionally, AI-generated documents and deepfakes significantly complicate fraud detection efforts (Zada et al., 2024). As Kuzior et al. (2024) note, AI-driven cyber vulnerabilities further strain AML capacities, while Yarovenko et al. (2024a) warn that the adaptability of AI could allow it to outpace traditional compliance technologies if not countered through continuous innovation.

Public perceptions of AI and financial innovation also play a significant role in shaping AML outcomes. Garškaitė-Milvydienė et al. (2023) stress that user attitudes affect both the implementation of AI-driven systems and the ways in which criminals exploit emerging technologies. This reinforces the importance of public education and awareness to prevent misuse and bolster trust in financial oversight mechanisms.

Moreover, AI-enabled tools in the realm of decentralised finance and cryptocurrencies introduce additional complexity. As Máté et al. (2024) argue, AI-powered trading bots can obscure illicit financial flows by executing high-frequency transactions across multiple platforms. These innovations facilitate money laundering on a scale that may no longer require human intervention (Iskakova et al., 2025). AI has also been implicated in exploiting legal and regulatory gaps to facilitate tax evasion (Barbu et al., 2024), which further stresses the need for updated AML frameworks that align with rapidly evolving technologies.

The susceptibility of countries to AI-facilitated laundering varies according to their socioeconomic and regulatory characteristics. Yarovenko et al. (2023) highlight that weaker regulatory environments are especially vulnerable, while Letkovsky et al. (2023) demonstrate how AI can evade sector-specific rules in industries with complex financial flows. Yet AI's influence is not solely negative. In AML compliance and risk monitoring, AI allows financial institutions to process data in real time, detect anomalies, and improve decision-making accuracy (Murko et al., 2024). Predictive analytics, powered by AI, significantly reduce false positives and increase compliance efficiency (Balcerzak & Valaskova, 2024). AI is also central to enhancing regulatory reporting systems, with deep learning networks identifying hidden relationships among transactions that traditional tools might overlook (Botoc et al., 2023).

AI's contribution to financial stability has been further supported by Liu et al. (2023), who demonstrate its value in enhancing institutional competitiveness and risk forecasting. Similarly, Piotrowski and Orzeszko (2023) explore how AI-powered robo-advisors influence consumer trust and improve AML compliance. The increasing importance of AI in combating financial crime is underscored by the broader digital transformation across industries, which impacts both business operations and societal behaviours (Moravec et al., 2024). The broader digital transformation reinforces AI's role in shaping organisational behaviour across sectors, from public administration (Androniceanu, 2024) to enterprise management (Wang & Shan, 2024), underscoring its relevance to both growth and security.

Nonetheless, significant challenges remain. The effectiveness of AI-based AML tools hinges not only on technical capacity but also on high-quality data, cross-border collaboration, and regulatory harmonisation (Dobrovolska & Rozhkova, 2024a; 2024b).

Organised criminals continue to exploit jurisdictional inconsistencies and regulatory loopholes (Utkina, 2023), while ethical concerns – such as algorithmic bias, surveillance risks, and transparency – require urgent attention (Memarian & Doleck, 2024). Wright (2023) draws attention to rising cybersecurity concerns in the financial sector, and Siddiqui and Rivera (2024) examine how evolving AI applications are affecting regulatory practices, particularly in Latvia.

Ethical AI governance has emerged as a focal point in the public sector. Bian and Wang (2024) and Kabachenko et al. (2022) call for responsible AI deployment guided by transparency and fairness. These values are especially vital in AML enforcement, where algorithmic accountability is critical to ensure legitimacy and trust.

AI is also being positioned within broader global financial and geopolitical strategies. Neacsu et al. (2025) argue that AI is influencing global AML efforts and shaping power dynamics. While AI's positive role in European financial security is evident, its risks and ethical ambiguities cannot be overlooked. Höller et al. (2023) caution that unethical AI use can lead to discrimination and manipulation, especially when systems automate decisions in high-stakes domains. Ishwardat et al. (2024) further examine how organisational adherence to ethical AI practices can be encouraged through institutional design, while Burrell (2024) illustrates how AI technologies can impact public trust and psychological wellbeing – issues indirectly relevant to financial regulation through their societal effects.

In the education sector, AI is reshaping learning environments by offering adaptive and personalised experiences. Okulich-Kazarin et al. (2023; 2024) propose that non-violent AI learning tools support inclusive and efficient educational systems, a principle with parallels in the development of ethical AI systems in finance and beyond.

AI’s transformative potential is also evident in risk management. Roba and Moulay (2024) highlight the effectiveness of neural networks in financial risk assessment, while Pulungan et al. (2024) explore AI’s use in identifying corruption and laundering patterns. By analysing socioeconomic trends and behavioural indicators, AI can detect subtle risk factors that traditional models might miss. As noted by Kuzior et al. (2022), digital integration contributes significantly to AML success by improving transparency and cyber resilience. Vasilyeva et al. (2021) further support this, showing that AI applications, especially in data mining, enhance the identification of suspicious transactions. Polishchuk (2023) complements this view by positioning fintech innovations as crucial in the future landscape of AML.

AI is fundamentally reshaping the fight against financial crime in Europe. While AML services are becoming more effective through AI-driven compliance tools, criminal actors simultaneously exploit the same technologies to subvert controls. The trajectory of AI’s role in AML will depend on regulatory advances, ethical implementation, and continuous strategic innovation. Cross-sector collaboration will be vital to ensuring that AI remains a safeguard of financial integrity rather than a conduit for criminal innovation.

METHODS

This research aimed to assess the role of AI in AML efforts across selected European countries with available AI Vibrancy Score data. It assesses whether AI primarily benefits

AML services or if organised criminals exploit it to enhance money laundering techniques. The research sought to provide empirical evidence on AI's impact using statistical modelling.

Aligned with the aim of the investigation, this research tests the following hypotheses:

H1: AI vibrancy positively influences AML effectiveness in European countries with available AI data. Countries with higher AI adoption tend to exhibit lower Basel AML Index values, indicating stronger AML frameworks.

H2: The relationship between AI vibrancy and AML effectiveness follows an inverted U-shaped pattern. While moderate AI adoption enhances AML effectiveness, excessive AI adoption may facilitate financial crime automation.

H3: Stronger governance frameworks enhance AI's positive impact on AML. Countries with higher Rule of Law and Control of Corruption scores demonstrate better AML performance when leveraging AI technologies.

H4: Public opinion on AI and responsible AI governance influence AI's effectiveness in AML. Negative public sentiment toward AI and excessive regulatory burdens may hinder AI-driven AML progress.

These hypotheses guide the study's empirical investigation, comparing findings with existing literature to assess AI's role in financial security.

Research Design

This study utilises a quantitative methodology to assess the influence of AI on AML efforts in Europe. Specifically, it investigates whether AI is a tool that primarily benefits AML services or organised criminals. The study utilises a panel data econometric model to analyse cross-country variations in AI adoption, regulatory frameworks, and money laundering risks.

Data Sources

The analysis draws on multiple secondary data sources, including the Basel AML Index (Basel Institute on Governance), as the predicted variable measuring AML effectiveness. Predictors include the AI Vibrancy Score, its subindices from Stanford University, and economic and governance indicators from the World Bank. The dataset spans multiple European countries over a specified time period, allowing for a robust panel analysis.

Countries and Time Span

The analysis covers the period from 2017 to 2023 and includes European countries for which AI Vibrancy Score data is available. The study is limited to countries with complete records on AI vibrancy, governance indicators, and economic variables. These include Austria, Belgium, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, and the United Kingdom. The selection ensures comparability across nations and allows for a robust panel data analysis.

Variables and Measurement

Table 1 presents the predictors and predicted variables utilised in the study.

Table 2 states a summary of the key statistics for these variables. These statistics help to see how different countries compare and spot trends in the data.

The summary statistics in Table 2 highlight that countries differ widely in their AI capabilities, governance structures, and AML performance. These disparities suggest that a universal solution to AI-driven AML measures may not be effective and that regulatory strategies should be tailored based on each country's technological capacity and governance quality. The AI Vibrancy Score (x1) shows a wide range of values across European countries, indicating significant differences in AI development and adoption. The Basel AML Index (y1) also exhibits variation, suggesting that the effectiveness of AML measures differs across nations.

Table 1. Variables and their sources

Variable	Description	Source
	Dependent variable	
y1	Basel AML Index	Basel Institute on Governance, n.d.
	Independent variable	
x1	AI Vibrancy Score	Stanford University, n.d.
x2	GDP per capita (constant 2015 US$)	World Bank, n.d.
x3	Rule of Law: Estimate (Normalised)	World Bank, n.d.
x4	Control of Corruption: Estimate (Normalised)	World Bank, n.d.
	AI Vibrancy subindexes	
x5	R&D	Stanford University, n.d.
x6	Responsible AI	Stanford University, n.d.
x7	Economy	Stanford University, n.d.
x8	Education	Stanford University, n.d.
x9	Policy and Government	Stanford University, n.d.
x10	Public Opinion	Stanford University, n.d.
x11	Infrastructure	Stanford University, n.d.

Table 2. Summary statistics [Source: authors calculation in R Studio]

Variable	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
x1	1,2	4,03	5,74	6,186	7,97	15,68
x2	0	0,115	0,32	0,6222	0,86	4,45
x3	0,07	0,53	1,32	2,155	2,89	12,08
x4	0,000001	0,38	0,78	1,359098	1,98	4,9
x5	0,000001	0,19	0,65	1,426241	1,82	9,05
x6	0,04	0,355	0,62	1,927	1,123	78
x7	0,1	0,77	1,2	2,085	1,96	13,15
x8	2,55	8,22	13,04	14,19	18,64	46,85
y1	2,34	3,67	4,21	4,184	4,57	6,65
x9	11954	28292	44862	47815	55935	110426
x10	0,3976	0,7224	0,8054	0,7664	0,8536	0,9069
x11	0,3995	0,6613	0,8137	0,7848	0,9019	0,9805

GDP per capita (x2) varies significantly, with some countries having much higher economic performance than others. Rule of Law (x3) and Control of Corruption (x4)

demonstrate variations, highlighting differences in governance quality, which could impact AML effectiveness.

Factors like Responsible AI (x6) and Public Opinion (x10) show disparities across countries, indicating that ethical AI considerations and societal trust in AI play varying roles in different jurisdictions. Education (x8) and Infrastructure (x11) present significant gaps, suggesting that some countries may struggle to implement AI-driven AML systems effectively.

Data Analysis

The study employs panel regression models using R Studio to estimate the relationship between AI adoption and AML effectiveness. Both fixed and random effects models are estimated to control for country-specific unobservable factors. The Hausman test determines the appropriate model selection. Additional econometric diagnostics, including tests for heteroskedasticity, serial correlation, and cross-sectional dependence, ensure model robustness. Driscoll-Kraay standard errors are applied to address potential violations of classical regression assumptions.

Model Specification

The baseline regression model is specified as follows:

$$y_{it} = \alpha + \beta_1 x1_{it} + \beta_2 x2_{it} + \beta_3 x3_{it} + +\beta_4 x4_{it} + \epsilon_{it}, \quad (1)$$

Where:

y_{it} – represents the Basel AML Index for the country at the time,

$x1_{it}$ – $x4_{it}$ – are independent variables measuring AI adoption and governance indicators,

ϵ_{it} – is the error term capturing unobserved factors.

A quadratic term for AI Vibrancy Score (x1) is also included to test for nonlinear relationships between AI adoption and AML effectiveness.

Expected Contributions

This methodology provides a rigorous empirical framework to analyse the dual role of AI in AML operations. By integrating economic and governance indicators, this study provides a holistic perspective on AI's role in combating European financial crime. The findings will help solve the policy debates on AI regulation and enhancing AML strategies.

RESULTS

In the first analysis stage, the one-way individual effects within the model (fixed effects model) are estimated. This model accounts for time-invariant differences across entities (countries) by removing individual-specific effects. This method accounts for country-specific factors that remain constant over time, allowing for the isolation of the independent variables' impact on the dependent variable.

The overall model is statistically significant, as indicated by the F-statistic of 12.31 and a p-value of 2.64e-08, which is well below the 0.05 threshold. Although the R-squared suggests

that the outputs clarify a moderate amount of the variation in the Basel AML Index, the F-statistic confirms that the independent variables, when considered collectively, Exert a statistically significant impact on the predicted variable.

The random effects model using Swamy-Arora's transformation considers both cross-sectional influences and time-dependent variations, treating individual-specific effects as random variables rather than fixed constants.

The R-squared is relatively low, suggesting the model justifies only a tiny portion of the variation in the Basel AML Index. However, the overall Chi-Square test suggests that the combined consequence of the independent variables is statistically significant.

The Hausman test helps determine whether a fixed or random effects model is more suitable for panel data analysis. The null hypothesis is rejected because of the extremely low p-value (0.0001). This indicates that the fixed effects model is preferable, as there is evidence of a correlation between individual-specific effects and the independent variables.

The Pesaran CD test for cross-sectional dependence in the panel data (z = 1.4799, p-value = 0.1389) does not provide support for cross-sectional dependence at the 5% significance level. This indicates that the residuals across different countries are not significantly related, which aligns with the expectations underpinning the fixed effects model.

Similarly, the Studentized Breusch-Pagan test (BP = 2.2698, df = 4, p-value = 0.6863) fails to disprove the null hypothesis, indicating the absence of heteroskedasticity in the panel data model. This result implies that the variation of the residuals remains constant within observations, a characteristic that is favourable for the fixed effects model.

Wooldridge's test for serial correlation in fixed effects panels (F = 32.894, df1 = 1, df2 = 112, p-value = <0.0001) rejects the null hypothesis, indicating the existence of serial correlation (autocorrelation) in the panel data. Failure to justify autocorrelation may result in inefficient and biased standard errors, undermining the reliability of the regression results. Thus, employing Driscoll-Kraay standard errors is advised, as they enhance robustness against heteroskedasticity, serial correlation, and cross-sectional dependence. The fixed effects panel model results, adjusted with Driscoll-Kraay standard errors to mitigate these concerns, are displayed in Table 3.

The estimated coefficients represent the effect of each predictor on the predicted variable (Basel AML Index) while holding all other predictors constant. The standard errors have been modified to address autocorrelation, heteroskedasticity, and cross-sectional dependence, ensuring reliable inference.

A one-unit raise in the AI Vibrancy Score is linked with a 0.0288 decrease in the Basel AML Index, ceteris paribus. Similarly, a one-unit growth in GDP per capita relates to a 0.0000579 reduction in the Basel AML Index. Conversely, a one-unit growth in the normalised Rule of Law Estimate relates to a 13.613 rise in the Basel AML Index. Additionally, a one-unit growth in the Control of Corruption Estimate is linked to a 2.5441 decline in the Basel AML Index, though this cause is only marginally substantial at the 10% level.

Table 3. The outputs of the fixed effects panel model using Driscoll-Kraay standard errors to account for heteroskedasticity, serial correlation, and cross-sectional dependence [Source: authors calculation in R Studio]

```
Oneway (individual) effect Within model
Note: Coefficient variance-covariance matrix supplied: vcovSCC
Call: plm(formula = y1 ~ x1 + x2 + x3 + x4, data = pdata, model = "within", index = c("id", "year"))
Balanced Panel: n = 19, T = 7, N = 133

Residuals:
      Min.    1st Qu.     Median    3rd Qu.       Max.
-0.686290 -0.177495  0.013016  0.165502  0.836380

Coefficients:
    Estimate  Std. Error t-value  Pr(>|t|)
x1 -2.8785e-02  4.5029e-03 -6.3925  <0.0001***
x2 -5.7895e-05  1.4945€-05 -3.8738 0.0001824***
x3  1.3613e+01  2.6087e+00  5.2183  <0.0001***
x4 -2.5441e+00  1.3685e+00 -1.8591 0.0656897.
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Total Sum of Squares: 16.642
Residual Sum of Squares: 11.498
R-Squared: 0.30913 Adj. R-Squared: 0.17096
F-statistic: 77.14 on 4 and 6 DF, p-value: <0.0001
```

The AI Vibrancy Score (x1), GDP per capita (x2), and Rule of Law (x3) exhibit statistically significant effects on the Basel AML Index at the 0.001 significance level. In contrast, Control of Corruption (x4) is only marginally significant, suggesting a potential negative association with the Basel AML Index, though the statistical evidence remains relatively weak.

The model describes around 30.9% of the deviation in the Basel AML Index, which is a reasonable explanatory power for social and economic panel data. The F-statistic indicates that the predictors collectively have a statistically significant impact on the predicted variable.

Notably, in both the fixed and random effects models, the coefficient of the AI Vibrancy Score changes from positive to negative. This shift suggests the possibility of a U-shaped relationship between the AI Vibrancy Score and the Basel AML Index. To explore this potential nonlinearity, Figure 1 presents a plot visualising the relationship between these variables, with a quadratic regression line (in blue) to assess whether the association follows a U-shaped or inverted U-shaped pattern.

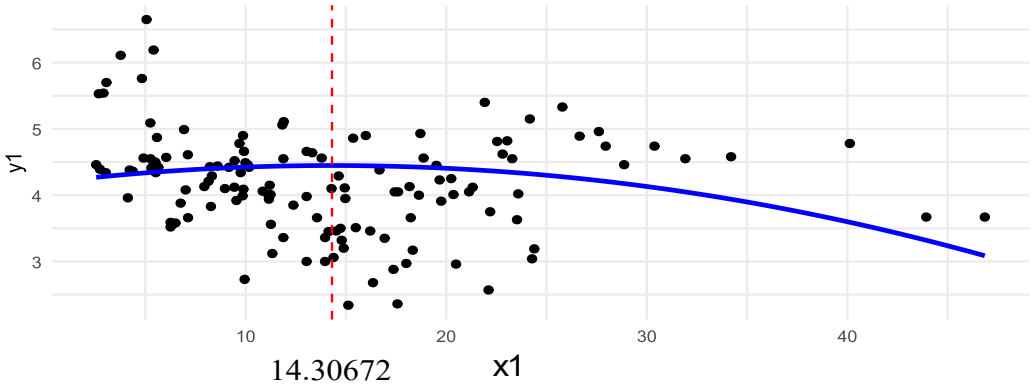

Figure 1. The relationship between the AI Vibrancy Score and the Basel AML Index [Source: authors calculation in R Studio]

The curve exhibits a downward-sloping trend as x1 increases, indicating that higher AI Vibrancy Scores are associated with lower Basel AML Index values. Rather than a U-shaped pattern, the curve follows an inverted U-shape (concave downward), suggesting that the effect of x1 diminishes as its value increases.

The red dashed vertical line represents the turning point, marking the threshold where the effect of x1 transitions from slightly positive or neutral to negative. This turning point occurs at 14.30672 on the x1 scale, implying that beyond this level of AI Vibrancy Score, the Basel AML Index declines more sharply. The data points exhibit considerable dispersion, particularly at higher levels of x1, indicating variability in the relationship at higher AI vibrancy levels.

Table 4 reports the fixed effects panel model outputs, incorporating a quadratic term for x1 to formally assess the presence of a U-shaped or inverted U-shaped relationship. The application of Driscoll-Kraay standard errors ensures robustness against heteroskedasticity, serial correlation, and cross-sectional dependence, enhancing the reliability of the estimates.

Table 4. The fixed effects panel model outputs incorporate a quadratic term for AI Vibrancy Score [Source: authors calculation in R Studio.]

Oneway (individual) effect Within model
Note: Coefficient variance-covariance matrix supplied: vcovSCC
Call:
plm(formula = y1 ~ x1 + I(x1^2) + x2 + x3 + x4, data = pdata, model = "within", index = c("id", "year"))
Balanced Panel: n = 19, T = 7, N = 133

Residuals:

Min.	1st Qu.	Median	3rd Qu.	Max.
-0.7434670	-0.1635350	0.0054556	0.1456341	0.9522636

Coefficients:

	Estimate	Std. Error	t-value	Pr(>|t|)
x1	3.6776e-02	2.7259e-02	1.3491	0.1800938
I(x1^2)	-1.2853e-O3	5.0167e-04	-2.5620	0.0117734*
x2	-4.9880e-05	1.2359e-05	-4.0359	0.0001013***
x3	1.2542e+01	2.5021e+00	5.0125	<0.0001***
x4	-3.6096e+00	1.1443e+00	-3.1546	0.0020776***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Total Sum of Squares: 16.642
Residual Sum of Squares: 10.817
R-Squared: 0.35006
Adj. R-Squared: 0.21292
F-statistic: 87.41 on 5 and 6 DF, p-value: <0.0001

The linear term of the AI Vibrancy Score is positive but not statistically significant. However, the quadratic term is negative (-0.00129) and statistically significant (p-value = 0.0118, which is less than 0.05), indicating the presence of an inverted U-shaped relationship. This suggests that as the AI Vibrancy Score (x1) increases, the Basel AML Index (y1) initially rises but eventually declines after surpassing a certain threshold.

The model explains 35.01% of the variation in the Basel AML Index, with an adjusted R^2 of 0.2129. An F-statistic of 87.41 and a corresponding p-value of <0.0001 confirm the model's overall statistical significance.

The lower bound slope (0.02112449) is not statistically significant (p-value = 0.3762162), indicating that the evidence for a classic inverted U-shaped relationship remains inconclusive. However, the significant negative slope (-0.06635444, p-value = 0.02860431)

at the upper bound, along with the significant negative quadratic term, supports the presence of a downward-sloping curve as x1 increases.

For low-to-moderate levels of the AI Vibrancy Score (x1), changes in x1 do not significantly impact the Basel AML Index (y1). However, once x1 surpasses the turning point (~14.30672), further increases in AI Vibrancy Score result in a statistically significant decline in the Basel AML Index, suggesting improved AML outcomes. The significant negative slope at the upper bound indicates that higher AI vibrancy is associated with better AML performance.

Model selection criteria further support the quadratic specification. The U-shaped model has a lower Akaike Information Criterion (AIC: -323.73 vs. -317.61), indicating a better predictive fit while accounting for model complexity. Additionally, the U-shaped model has a lower Bayesian Information Criterion (BIC: -309.28 vs. -306.05), suggesting it achieves a more optimal balance between model complexity and explanatory power. Based on both AIC and BIC, the fixed effects model with the U-shaped specification is preferred, as it better captures the variation in the Basel AML Index while accounting for the nonlinear relationship with the AI Vibrancy Score.

The extracted individual fixed effects (α_i) from the quadratic fixed effects panel model represent country-specific deviations in y1 that are not explained by the included independent variables (Table 5). These independent variables include the AI Vibrancy Score (x1, $x1^2$), GDP per capita (constant 2015 US$) (x2), the normalised Rule of Law Estimate (x3), and the normalised Control of Corruption Estimate (x4). These fixed effects allow cross-country comparisons by capturing unobserved country-specific factors that influence the dependent variable, such as institutional frameworks and policy environments. By accounting for country-specific heterogeneity, the fixed effects model ensures that the estimated effects of the independent variables remain unbiased.

Table 5. The individual fixed effects from a fixed-effects model incorporate a quadratic term for AI Vibrancy Score [Source: authors calculation in R Studio]

Country	Individual fixed effects
Austria	-1.484782
Belgium	-0.647630
Denmark	-1.120977
Estonia	-3.106627
Finland	-2.911705
France	-1.195109
Germany	-0.680832
Ireland	1.499302
Italy	1.226249
Luxemburg	2.816415
Norway	-0.360039
Netherlands	-0.594415
Poland	-0.062049
Portugal	-1.719024
Spain	-0.944857
Sweden	-1.400186
Switzerland	1.476060
Turkey	2.741532
United Kingdom	-0.830971

Certain countries, such as Luxembourg (2.816) and Turkey (2.741), exhibit positive fixed effect values, indicating that their Basel AML Index is higher than expected based on their AI Vibrancy Score, GDP per capita, and indicators of the Rule of Law and Control of Corruption. This suggests that unobserved country-specific factors may contribute to heightened susceptibility to money laundering in these nations.

Conversely, another group of countries demonstrates negative fixed effect values, suggesting that their Basel AML Index is lower than predicted given the same set of explanatory variables. For instance, Austria (-1.484782) and Estonia (-3.106627) exhibit negative deviations, indicating a mitigating effect on money laundering risks beyond what is captured by the observed variables. Among these, Estonia (-3.106627) and Finland (-2.911705) have the most considerable adverse fixed effects, implying that unobserved country-specific characteristics contribute to more favourable AML outcomes.

Countries with fixed effect values close to zero, such as Poland (-0.062049), exhibit only minor deviations from the expected Basel AML Index, suggesting that unobserved factors play a relatively minimal role in influencing their AML risk beyond what is explained by the included independent variables.

The scatter plot (Figure 2) compares the estimated fixed effects from the linear and quadratic models. Each point represents a country, with its position indicating how the fixed effects change when incorporating a quadratic term in the regression. The red dashed line represents the 45-degree line, where points lying directly on it indicate no difference between the fixed effects in the two models.

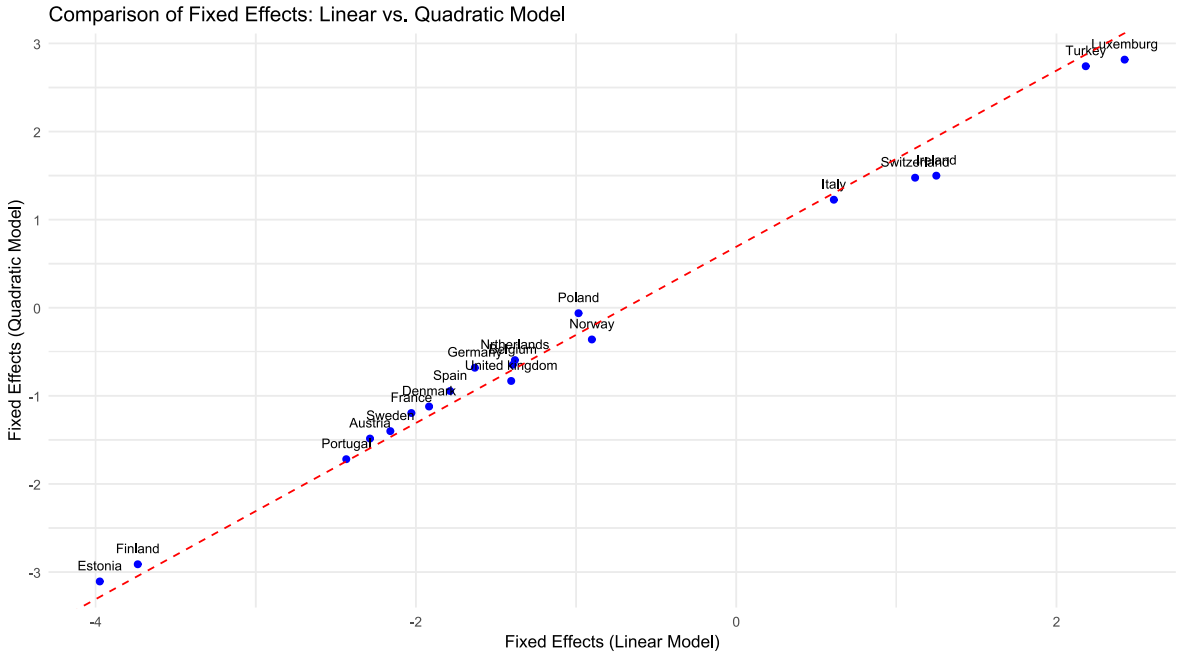

Figure 2. Comparing the estimated fixed effects from the linear model and the quadratic model. [Source: authors calculation in R Studio]

Countries positioned above the red dashed line have higher fixed effects in the quadratic model than in the linear ones. This suggests that their country-specific effects on the Basel AML Index increase when accounting for the quadratic term. Both models have the most negative fixed effects in Estonia and Finland, indicating that their unobserved factors contribute to significantly lower Basel AML Index scores (i.e., better AML performance).

Conversely, countries below the red dashed line have lower fixed effects in the quadratic model than in the linear ones, meaning their country-specific effects decrease when the quadratic term is included. Turkey, Switzerland, and Italy have high positive fixed effects, meaning their unobserved characteristics contribute to higher Basel AML Index values (i.e., worse AML performance).

Countries such as Poland, Norway, and the Netherlands have fixed effects close to zero, indicating that unobserved factors play a minimal role in influencing their AML risk beyond what the included predictors justify.

The next stage of the analysis tests how each AI Vibrancy sub-index (x5 to x11) influences the Basel AML Index (y1) by using fixed effects panel regressions for each subindex. The estimation outputs are presented in Table 6.

Table 6. One-way (individual) effect Within Models with coefficient variance-covariance matrix supplied [Source: authors calculation in R Studio]

Variable	Estimate (Pr(>|t|))	R-Squared	Adj. R-Squared	F-statistic (p-value)
x5 $x5^2$	-0.0207261 (0.6386) 0.0021520 (0.5380)	0.010867	-0.34882	3.51268 (0.16369)
x6 $x6^2$	-0.3742417*** (0.0001024) 0.0904481*** (< 0.0001)	0.15307	-0.1549	400.339 (0.00022807)
x7 $x7^2$	0.152712*** (<0.0001) -0.017457*** (2.232e-14)	0.21695	-0.067793	60.5986 (0.0037542)
x8 $x8^2$	-0.174697. (0.0738) 0.019153 (0.2255)	0.068819	-0.26979	22.8717 (0.015269)
x9 $x9^2$	0.0245731 (0.50181) -0.0134929* (0.04857)	0.14544	-0.16531	44.705 (0.0058493)
x10 $x10^2$	0.54801835*** (<0.0001) -0.00694722*** (<0.0001)	0.23413	-0.044364	425.209 (0.00020842)
x11 $x11^2$	0.0403846 (0.6301) -0.0036423 (0.6326)	0.012968	-0.34595	0.131622 (0.88147)

Note: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The findings specify that Research and Development (R&D) in AI (x5) and Infrastructure (x11) does not have a significant impact on AML risk, while AI-related education demonstrates only a weak effect. Conversely, Responsible AI (RAI) (x6) exhibits an inverted U-shaped relationship with the Basel AML Index, suggesting that its influence on AML risk varies across different levels of AI governance.

Responsible AI is evaluated through academic research output in leading AI ethics and fairness conferences, including the AAAI, AIES, FAccT, ICLR, ICML, and NeurIPS conferences. Higher conference submission rates reflect a more substantial national commitment to AI ethics, fairness, governance, and transparency. The model's results suggest that at low levels of Responsible AI governance, AML risk increases due to the absence of AI ethics frameworks. Without these frameworks, financial systems remain vulnerable to AI-driven illicit activities and lack regulatory oversight.

At moderate levels of Responsible AI governance, AML risk peaks due to several factors. Regulatory uncertainty and compliance burdens slow down AML implementation, while overregulation can hinder AI adoption for financial crime prevention. In this phase, AI ethics debates and legal frameworks often create unclear or overly restrictive guidelines, impeding the ability of financial institutions to deploy AI-driven AML tools effectively.

In contrast, at high levels of Responsible AI governance, AML risk declines significantly. This reduction is attributed to the successful integration of AI governance within financial and regulatory systems. AI-driven transparency and automation improve AML compliance at this stage, while well-defined AI ethics frameworks enhance public and institutional trust in digital financial regulations.

Developing economies often lack comprehensive AI ethics frameworks, challenging regulating AI-powered financial systems. This regulatory gap heightens vulnerabilities to money laundering activities, as financial institutions operate without clear guidelines on AI governance. The Financial Action Task Force (FATF) has detected numerous countries with significant weaknesses in AML and counter-terrorist financing measures (FATF, 2021; The Law Society, 2024).

In contrast, Western economies, particularly within the European Union (EU), have engaged extensively in regulatory efforts concerning AI ethics. The EU AI Act, introduced in 2021, aims to establish a comprehensive AI development and implementation framework, emphasising privacy, transparency, and fairness as foundational principles. However, the complexity and stringency of these regulations have introduced compliance challenges for financial institutions. The evolving nature of these regulations has delayed the adoption of AI-driven AML technologies as financial institutions struggle to navigate an increasingly intricate regulatory landscape (EPRS, 2020; Pattara, 2023).

Meanwhile, some nations have proactively developed advanced AI governance frameworks that successfully balance AI innovation with regulatory oversight. For example, Singapore's Monetary Authority of Singapore released the Artificial Intelligence Model Risk Management Paper in December 2024, providing financial institutions with detailed guidance on managing AI-related risks. Such governance initiatives enable these countries to integrate AI-driven compliance tools effectively, enhancing their capability to identify and mitigate financial crime risks (Clyde & Co, 2024).

These findings highlight the importance of a well-balanced AI governance approach. While the absence of AI-specific regulations exacerbates financial crime risks, excessive regulatory complexity may hinder AI adoption for AML purposes. Countries that successfully integrate AI ethics into financial regulatory frameworks experience lower AML risks, demonstrating the necessity of a structured yet flexible approach to AI governance.

The relationship between AI economic activity (x7) and AML risk exhibits a nonlinear pattern, initially increasing AML risk before mitigating it at higher levels of AI adoption. In regions with low AI economic activity, AML risk remains relatively low due to the limited integration of AI technologies within financial systems. This limited adoption restricts the prevalence of AI-powered financial crimes, with traditional financial crimes continuing to dominate the AML landscape. The effectiveness of manual compliance efforts and low AI hiring rates further limit criminals' access to advanced AI tools. Developing economies face infrastructural challenges and a shortage of skilled professionals, constraining AI adoption. The FATF (2021) links these challenges to operational and regulatory limitations, such as

obsolete AML/CFT compliance systems and inflexible regulatory structures. Consequently, the AML risk in these regions is predominantly driven by conventional issues such as lack of transparency and corruption.

At moderate levels of AI economic activity, AML risk reaches its peak as the increasing accessibility of AI technologies facilitates their misuse for money laundering purposes while regulatory frameworks lag behind. The proliferation of AI-powered tools enables automated fraud and synthetic identity laundering through AI-generated fake accounts and deepfake-based scams. Additionally, AI-assisted money laundering via untraceable transactions in cryptocurrencies and digital banking further exacerbates AML risks. AI-driven trading bots are increasingly employed to automate high-frequency trading activities, which can be exploited to obscure the Source of illegal proceeds through rapid and complex transactions. Cryptocurrency mixers and tumblers add another layer of complexity by pooling and redistributing funds, making it more difficult to trace their sources. This convergence of AI-driven automation and anonymisation services poses significant challenges to traditional AML compliance systems, which often struggle to match the sophistication and speed of these technologies (Merkle Science, 2022).

Fraudsters also increasingly leverage generative AI technologies to create highly realistic synthetic identities that bypass conventional identity verification processes. These AI-generated personas enable the opening of fraudulent accounts and facilitate unlawful monetary transactions. The Financial Crimes Enforcement Network (FinCEN) has reported that malicious actors are utilising generative AI to produce fake identification documents and deepfake media, allowing them to circumvent financial institutions' due diligence and verification controls. This rapid evolution in AI-generated fraud outpaces the development of traditional AML compliance measures, intensifying AML risks in the financial sector (Larson, 2024).

However, at high levels of AI economic activity, AML risk declines as AI-driven compliance tools become more sophisticated and regulatory frameworks adapt. Advanced AI technologies, such as deep learning algorithms, enhance real-time fraud detection and anomaly identification. AI-powered Know Your Customer models improve the detection of synthetic identity fraud, while regulatory technology (RegTech) solutions automate AML compliance reporting across jurisdictions. In Switzerland, financial institutions have widely adopted AI-based fraud detection solutions, with NetGuardians – a leading Swiss fintech firm—providing AI-driven services to 60% of Swiss state-owned commercial banks (The Swiss Startup News Channel, 2024). Similarly, Basu and Tetteh (2024) report that financial institutions in the UK and EU are increasingly implementing AI-powered transaction monitoring systems. These systems leverage machine learning and data analytics to identify suspicious activities more efficiently, improving the identification and prevention of money laundering. The study highlights that such AI-driven solutions enable faster processing, more accurate analysis, and improved compliance outcomes, ultimately contributing to reduced fraud and strengthened AML practices.

The effectiveness of policy and government intervention (x9) in AI-driven AML efforts follows an inverted U-shaped pattern, indicating the necessity of achieving an optimal regulatory balance. Weak AI governance creates significant vulnerabilities, allowing financial criminals to exploit regulatory gaps. The FATF (2021) has emphasised that the absence of AI-specific regulations in certain jurisdictions, particularly offshore financial

centres, facilitates cybercriminal activities. The FATF underscores the importance of comprehensive AI-focused AML measures to mitigate these risks and strengthen financial crime detection and prevention.

Conversely, excessive regulation and fragmented AI legal frameworks generate uncertainty, hindering the adoption of AI-driven AML solutions. While introducing stringent AI regulations, the European Union's AI Act (2021–2024) has faced challenges in enforcement, leading to delays in AI integration within AML systems. Gikay (2024) notes that the AI Act's elevated risk categorisation framework may be overly restrictive, potentially limiting the implementation of AI in key domains such as AML compliance. Similarly, Canada's Artificial Intelligence and Data Act (AIDA) has established stringent regulatory requirements for AI applications. Although designed to ensure responsible AI usage, these regulations have inadvertently introduced compliance challenges for financial institutions. The complexity and novelty of these requirements have created uncertainty, slowing the implementation of AI-enhanced AML measures. Research by Sheikh and Garellek (2024) further suggests that the rapid introduction of AI legislation, without clear implementation guidelines, can lead to compliance ambiguities, ultimately impeding the integration of AI technologies in financial crime prevention.

AI-powered AML systems operate most effectively within a well-structured and harmonised regulatory framework. Switzerland's Financial Market Supervisory Authority has taken a proactive approach by issuing comprehensive guidelines to facilitate the integration of AI in financial crime prevention. In December 2024, FINMA published Guidance 08/2024, which mandates that financial institutions establish robust governance and risk management frameworks when incorporating AI into their operations. This guidance addresses key risks associated with AI adoption, including model robustness, data quality, and explainability, thereby enhancing the efficacy of AI-powered anti-money laundering systems. By adhering to these regulatory principles, Swiss financial bodies can ensure their AI applications comply with supervisory opportunities, strengthening their ability to combat financial crimes while ensuring regulatory compliance (FINMA, 2024).

The relationship between public opinion on AI – measured by social media share of voice on AI, AI-related social media posts, and net sentiment in AI discussions – and AML risk follows a U-shaped pattern. Limited public discourse on AI results in low societal awareness of AI-related risks and regulatory shortcomings. In such cases, weak civil society advocacy contributes to underdeveloped AI governance, enabling unchecked AI-driven money laundering. Additionally, the absence of public pressure on financial institutions leads to the slow adoption of AI-powered AML solutions. Sampat et al. (2024) highlight that the rapid integration of AI in financial services, particularly in regions with low public awareness and weak regulatory oversight, raises ethical concerns and increases the potential for misuse. The study underscores that financial institutions may implement AI-driven systems without adequately considering transparency and accountability, further emphasising the necessity of increased public engagement and regulatory guidance to ensure ethical AI deployment in financial crime prevention.

A balanced public discourse on AI fosters transparency, regulatory pressure, and the adoption of AI-driven AML mechanisms. Public advocacy for responsible AI governance encourages governments to implement AI-centric AML policies. At the same time, financial

institutions respond to societal expectations by integrating ethical AI principles and compliance mechanisms into their operations.

However, excessive social media discourse on AI can lead to misinformation, fear, and distrust, ultimately hindering the adoption of AI-driven AML technologies. Public scepticism and resistance to AI-powered financial systems slow down technological advancements in AML enforcement, while regulatory decisions become increasingly politicised, further delaying the implementation of AI-based compliance solutions. Longoni et al. (2022) examine how consumer perceptions of AI are shaped by social media discourse, particularly regarding concerns related to AI bias, job displacement, and data privacy. Their findings indicate that exposure to negative narratives about AI on social media fosters public resistance to AI applications, including those used in AML enforcement. This resistance is primarily driven by heightened scepticism and fear, undermining trust in AI-driven financial systems. The study highlights the importance of addressing public concerns and counteracting misinformation to facilitate the acceptance and successful application of AI technologies in the financial sector.

The findings support the hypothesis that AI vibrancy significantly affects AML effectiveness in the selected European countries. The results confirm H1, showing that an increase in AI Vibrancy Score is associated with lower Basel AML Index values, indicating improved AML performance. However, the quadratic term for AI Vibrancy Score supports H2, demonstrating that the relationship follows an inverted U-shaped pattern—suggesting that while AI initially strengthens AML measures, excessive AI integration may provide tools that criminals can exploit for financial crime automation.

The governance factors provide further insight into the role of regulation in AML effectiveness. The Rule of Law (x3) coefficient is highly significant and positively correlated with AML success, confirming H3 – strong legal frameworks enhance AI's effectiveness in combating money laundering. Similarly, Control of Corruption (x4) is positively associated with AML effectiveness, albeit with a slightly lower coefficient, reinforcing that governance structures influence AI's role in AML operations. Furthermore, the study confirms H4, indicating that public opinion on AI (x10) and Responsible AI governance (x6) impact AML efficiency. Countries with a well-regulated AI ecosystem and positive AI perception tend to have better AML outcomes, while excessive restrictions or negative sentiment towards AI can hinder AML progress.

DISCUSSION

The results of this study offer important perspectives on the dual role of AI in the realm of AML and financial crime. By analysing the link between AI adoption and AML efficiency across European countries, this study builds upon existing literature and extends insight into AI's influence on financial security.

The outputs indicate that AI vibrancy has a significant, yet complex, relationship with AML effectiveness. The fixed effects model suggests higher AI vibrancy scores correlate with lower Basel AML Index values, implying improved AML outcomes. However, the quadratic model reveals an inverted U-shaped relationship, where AI initially contributes to AML effectiveness but may later enhance financial crime sophistication. This is in line with

the conclusions of Reshetnikova and Mikhaylov (2023) and Yarovenko et al. (2024b), who highlight AI's ability to automate illicit transactions and optimise money laundering tactics.

The significance of governance-related variables, such as the Rule of Law and Control of Corruption, suggests that institutional quality is critical in determining AI's impact on AML. Our results support Zámek and Zakharkina (2024) and Tiutiunyk et al. (2021), who emphasise the need for regulatory adaptation to digital transformation. However, our findings diverge from Letkovsky et al. (2023), who argue that AI primarily benefits financial security rather than criminals. The data suggests that AI-driven financial crime flourishes in countries with weaker regulatory frameworks, undermining AML efforts.

This study identifies GDP per capita as a significant predictor of AML effectiveness, reinforcing prior research by Ioan-Franc & Gaf-Deac (2024) and Košovská et al. (2022), which link digitalisation and economic growth to financial security. However, our results also show that economic prosperity alone is insufficient – without robust regulatory mechanisms, AI's benefits in AML may be counteracted by its exploitation by criminal organisations. This finding supports Yarovenko et al. (2023), who suggest that the socioeconomic context of a country influences its vulnerability to AI-driven financial crime.

One of the key findings is that Responsible AI governance (x6) exhibits an inverted U-shaped relationship with AML effectiveness. This suggests that moderate levels of AI governance may introduce regulatory complexities, delaying AML advancements, whereas highly structured AI frameworks enhance financial security. This finding is consistent with Memarian & Doleck (2024) and Gikay (2024), who caution that excessive regulation can hinder AI adoption for compliance purposes. Additionally, public opinion on AI (x10) follows a U-shaped pattern, reinforcing the work of Longoni et al. (2022), who highlight how negative AI discourse can create public distrust in AI-driven AML measures.

The study's findings suggest that AI-driven AML efforts must be continually adapted to counteract evolving money laundering tactics. The evidence supports Neacsu et al. (2025), who view AI as a geopolitical tool influencing global financial security. Additionally, Kuzior et al. (2024) emphasise that cybersecurity threats linked to AI-driven financial crime must be mitigated through international cooperation.

The findings demonstrate that AI has a dynamic and evolving impact on AML, acting as both a tool for regulatory agencies and an asset for organised criminals. While AI vibrancy enhances AML capabilities, its misuse by criminals remains a significant challenge. Future research should explore how AI regulation, financial policies, and global cooperation can further optimise AI's role in combating financial crime.

LIMITATIONS

Although this study offers important insights into the connection between AI and AML effectiveness, certain limitations must be recognised.

The investigation relies on secondary data from sources such as the Basel AML Index, Stanford AI Vibrancy Score, and World Bank governance indicators. Although these sources are widely recognised, discrepancies in data collection methods and reporting standards across countries may introduce inconsistencies. Additionally, some countries may lack comprehensive AI-related data, leading to potential gaps in the analysis.

The panel regression models assume a linear or quadratic relationship between AI vibrancy and AML effectiveness. However, AI's impact on financial crime may be more complex and nonlinear, influenced by country-specific regulatory environments, economic conditions, and technological adoption rates. Future research should explore alternative modelling methods, such as machine learning or dynamic panel models, to better capture these complexities.

AI technology evolves rapidly, and this study analyses data from a specific timeframe. As new AI advancements emerge, the effectiveness of AML measures may change. The study's findings may not fully capture how AI's role in AML will evolve in the future. Longitudinal studies with updated datasets will be necessary to track AI's impact over time.

Regulatory frameworks for AI usage in AML are still developing, and ethical concerns such as bias in AI-driven fraud detection systems remain unresolved. This study does not account for ethical dilemmas or the potential unintended consequences of AI adoption in financial security, which should be a focus of future research.

The study primarily examines European countries, restricting the generalisability of its outputs to other territories. AI adoption and AML challenges may differ significantly in regions such as Asia, Africa, and Latin America, where financial infrastructures and regulatory frameworks vary widely. Future studies should consider a broader geographical scope to assess AI's impact on AML globally.

Recognising these limitations is crucial for accurately interpreting the study's findings cautiously. Regardless of these obstacles, the study offers a strong foundation for understanding AI's role in AML efforts and highlights areas for further investigation. Addressing these limitations in future studies will help refine AI-driven financial crime prevention strategies and improve AML effectiveness.

CONCLUSION

AI is increasingly shaping financial security, presenting both opportunities for AML efforts and challenges posed by sophisticated financial crime tactics. This research aimed to judge the role of AI in AML efforts across selected European countries with available AI Vibrancy Score data. It assesses whether AI primarily benefits AML services or if organised criminals exploit it to enhance money laundering techniques. The research sought to provide empirical evidence on AI's impact using statistical modelling.

A panel data econometric model was employed to achieve this, using the Basel AML Index as the dependent variable and AI Vibrancy Score, economic indicators, and governance measures as independent variables. The study analysed data from multiple European countries over a set period, applying fixed and random effects models, Hausman tests, and Driscoll-Kraay standard errors to ensure robust results.

The findings indicate that AI adoption significantly influences AML effectiveness, with higher AI vibrancy scores correlating with lower money laundering risks. However, the relationship follows an inverted U-shaped pattern, where excessive AI adoption may also aid financial crime automation. Governance factors, particularly the Rule of Law and Control of Corruption, play crucial roles in ensuring AI's positive contribution to AML. Additionally, public opinion on AI and responsible AI governance impact AML efficiency, demonstrating

that both technological and regulatory elements must align to maximise AI's benefits while mitigating its risks.

The AI Vibrancy Score (x1) coefficient in the fixed effects model was negative (-0.0288) and statistically significant, confirming that increased AI vibrancy is generally associated with improved AML outcomes. However, including a quadratic term ($x1^2$) with a coefficient of -0.00129 suggests an inverted U-shaped dependence, meaning that while moderate AI adoption enhances AML effectiveness beyond a certain threshold, the benefits decline, and risks increase.

Moreover, the Rule of Law (x3) coefficient was highly significant (13.61), highlighting its strong positive effect on AML performance. The Control of Corruption (x4) coefficient showed a weaker but still relevant impact, reinforcing the necessity of strong governance frameworks. These results emphasise that AI alone is insufficient for AML's success—effective legal and regulatory measures are crucial in maximising AI's potential while mitigating its risks.

These insights highlight the need for balanced AI policies, stronger regulatory frameworks, and international cooperation to ensure AI remains a tool for financial security rather than a means of financial crime facilitation.

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