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The mission of the IJISPM - International Journal of Information Systems and Project Management - is the dissemination of new scientific knowledge on information systems management and project management, encouraging further progress in theory and practice.

The IJISPM publishes leading scholarly and practical research articles that aim to advance the information systems management and project management fields of knowledge, featuring state-of-the-art research, theories, approaches, methodologies, techniques, and applications.

The journal serves academics, practitioners, chief information officers, project managers, consultants, and senior executives of organizations, establishing an effective communication channel between them.

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The journal content provides relevant information to researchers, practitioners, and organizations, and includes original qualitative or qualitative articles, as well as purely conceptual or theoretical articles. Due to the integrative and interdisciplinary nature of information systems and project management, the journal may publish articles from a number of other disciplines, including strategic management, psychology, organizational behavior, sociology, economics, among others. Articles are selected for publication based on their relevance, rigor, clarity, novelty, and contribution to further development and research.

Authors are encouraged to submit articles on information technology governance, information systems planning, information systems design and implementation, information technology outsourcing, project environment, project management life-cycle, project management knowledge areas, criteria and factors for success, social aspects, chief information officer role, chief information officer skills, project manager role, project manager skills, among others.

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Editorial

The mission of the *IJISPM - International Journal of Information Systems and Project Management* is the dissemination of new scientific knowledge on information systems management and project management, encouraging further progress in theory and practice.

It is our great pleasure to bring you the second number of the ninth volume of IJISPM. In this issue, readers will find important contributions on hybrid intelligence, innovation in digitalization projects, career dynamics of IT professionals, and stakeholder engagement in projects.

The first article, "Hybrid Intelligence: to automate or not to automate, that is the question," is authored by Wil M.P. van der Aalst. According to the author, there used to be a clear separation between tasks done by machines and tasks done by people. Applications of machine learning in speech recognition (e.g., Alexa and Siri), image recognition, automated translation, autonomous driving, and medical diagnosis have blurred the classical divide between human tasks and machine tasks. Although current Artificial Intelligence (AI) and Machine Learning (ML) technologies outperform humans in many areas, tasks requiring common sense, contextual knowledge, creativity, adaptivity, and empathy are still best performed by humans. Hybrid Intelligence (HI) blends human intelligence and machine intelligence to combine the best of both worlds. Hence, current and future Business Process Management (BPM) initiatives need to consider HI and the changing boundaries between work done by people and work done by software robots. Consider, for example, the success of Robotic Process Automation (RPA), which demonstrates that gradually taking away repetitive tasks from workers is possible. In this viewpoint paper, van der Aalst argues that process mining is a key technology to decide what to automate and what not.

The title of the second article is "An examination of the preconditions of learning to facilitate innovation in digitalization projects: a project team members' perspective," and it is authored by Bertha Joseph Ngereja and Bassam Hussein. In the modern business environment spearheaded by digitalization, organizations are faced with the challenge of maintaining a competitive edge despite constant dynamic changes. Organizations, therefore, have to adopt new, improved and modern ways of doing things. This can be achieved through proper knowledge management within the organization, which is an antecedent of innovation. Innovation is one of the crucial means for tackling the digitalization challenge as it enables organizations to maintain their competitive edge. Although extant studies have extensively studied learning in projects, there is a lack of concrete examples of the correlation between learning and improving innovation in the digitalization context. This article is based on a qualitative study aimed at examining the organizations' preconditions of learning in achieving innovation in digitalization projects focusing on the perspective of the project team members. The findings revealed two viewpoints regarding the perception of learning for innovation. The preconditions for learning for innovation in digitalization were also identified.

The third article, authored by Catherine Cabot and Stéphane Gagnon, is entitled "Understanding the career dynamics of IT professionals in digital transformation times: a systematic review of career anchors studies." The concept of career anchors has long been a reference model to guide Human Resources Management (HRM) practices within the IT discipline. However, as the digital transformation phenomenon grows increasingly disruptive, the misalignment of human resources is becoming more apparent as IT professionals are faced with mixed job demands requiring multidisciplinary skillsets. Along with the lack of workforce diversity and high turnover rates, these HRM challenges are impacting career dynamics and talent management practices. A systematic literature review of 20 empirical studies reveals three broad themes: debunking the dual-ladder construct of traditionally opposing technical and management career paths, fostering a diverse workforce through a variety of demographic profiles, and understanding the response strategies of IT professionals. While career anchors proved to be a useful model, it falls short in the context of the current structural changes of professional career choices and talent requirements, which requires a more diverse and

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dynamic model. This finding leads to a new research agenda emphasizing the study of Business Technology Management (BTM). This new concept refers to an emerging transdisciplinary profession, uniting Project Management (PM), IS, and IT competencies within a common body of knowledge for leading digital transformation projects.

"Using Theory of Change to evaluate the role of stakeholder engagement towards socially desirable outcomes in ICT research projects" is the fourth article and is authored by Tilimbe Jiya. ICT research projects are important in generating breakthrough technologies that translate into solutions for numerous societal grand challenges through research and innovation. However, to ensure that such solutions are socially desirable, there is a concerted drive for the engagement of different stakeholders, including industry, academia, the public, and government. In the face of the growing recognition of stakeholder engagement in ICT research projects, particularly as part of responsible research and innovation, there is a limited discourse on how its consequence could be evaluated. This paper suggests and uses a Theory of Change approach to evaluate the value of stakeholder engagement on the attainment of socially desirable and responsible outcomes in projects, particularly ICT research projects. Using a multi-case study approach, the paper appraises the value of stakeholder engagement in ICT research projects by elucidating the linkages between stakeholder activities and socially desirable outcomes.

We would like to take this opportunity to express our gratitude to the distinguished members of the Editorial Board, for their commitment and for sharing their knowledge and experience in supporting the IJISPM.

Finally, we would like to express our gratitude to all the authors who submitted their work for their insightful visions and valuable contributions.

We hope that you, the readers, find the International Journal of Information Systems and Project Management an interesting and valuable source of information for your continued work.

The Editor-in-Chief,

João Varajão

University of Minho

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João Varajão is currently a professor of information systems and project management at the *University of Minho*. He is also a researcher at the *ALGORITMI Research Center* at the *University of Minho*. Born and raised in Portugal, he attended the *University of Minho*, earning his Undergraduate (1995), Masters (1997), and Doctorate (2003) degrees in Technologies and Information Systems. In 2012, he received his Habilitation degree from the *University of Trás-os-Montes e Alto Douro*. His current main research interests are related to Information Systems and Information Systems Project Management success. Before joining academia, he worked as an IT/IS consultant, project manager, information systems analyst and software developer, for private companies and public institutions. He has supervised more than 100 Masters and Doctoral dissertations in the Information Systems field. He has published over 300 works, including refereed publications, authored books, edited books, as well as book chapters and communications at international conferences. He serves as editor-in-chief, associate editor and member of the editorial board for international journals and has served on numerous committees of international conferences and workshops. He is the co-founder of CENTERIS – Conference on ENTERprise Information Systems and ProjMAN – International Conference on Project MANagement.

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Hybrid Intelligence: to automate or not to automate, that is the question

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Hybrid Intelligence: to automate or not to automate, that is the question

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Viewpoint

Abstract:
There used to be a clear separation between tasks done by machines and tasks done by people. Applications of machine learning in speech recognition (e.g., Alexa and Siri), image recognition, automated translation, autonomous driving, and medical diagnosis, have blurred the classical divide between human tasks and machine tasks. Although current Artificial Intelligence (AI) and Machine Learning (ML) technologies outperform humans in many areas, tasks requiring common sense, contextual knowledge, creativity, adaptivity, and empathy are still best performed by humans. Hybrid Intelligence (HI) blends human intelligence and machine intelligence to combine the best of both worlds. Hence, current and future Business Process Management (BPM) initiatives need to consider HI and the changing boundaries between work done by people and work done by software robots. Consider, for example, the success of Robotic Process Automation (RPA), which demonstrates that gradually taking away repetitive tasks from workers is possible. In this viewpoint paper, we argue that process mining is a key technology to decide what to automate and what not. Moreover, using process mining, it is possible to systematically monitor and manage processes where work is distributed over human workers and software robots.

Keywords:
Hybrid intelligence; data science; process science; machine learning; business process management.

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1. Introduction

Machine Learning (ML) and Robotic Process Automation (RPA) have lowered the threshold to automate tasks previously done by humans [5,7,10,11,17,23]. Yet organizations are struggling to apply ML and RPA, effectively causing many digital transformation initiatives to fail. Process mining techniques help to decide what should be automated and what not. Interestingly, most processes work best using a combination of human and machine intelligence. Therefore, we relate *Hybrid Intelligence* (HI) to process management and process automation using RPA and process mining.

As Niels Bohr once said “It is difficult to make predictions, especially about the future” and, of course, this also applies to process management and automation. In 1964, the RAND Corporation published a report with predictions about technological development based on the expectations of 82 experts across various fields [5]. For 1980, the report predicted that there would be a human-crewed landing on Mars, and families would have robots as household servants. We are still not any way close to visiting Mars, and 40 years later, we only have robot vacuum cleaners. For 2020, the expectation was that we would breed apes and other animals to carry out our daily chores. None of this happened.

When it comes to predictions about Artificial Intelligence (AI), we can witness periods with great optimism and periods with great skepticism (called “AI winters”). In 1950, Alan Turing introduced the well-known Turing test centering around the following question: Can a human evaluator distinguish between a human and a machine using only natural language conversations? This question is still controversial and triggered questions like: Can a machine have a mind, mental states, and consciousness in the same way that a human being can? Independent of this philosophical debate, we can see that more and more tasks are taken over by software trained based on examples. Alan Perlis wrote in 1982 “A year spent in Artificial Intelligence is enough to make one believe in God” and, indeed, it is amazing how AI technology can recognize images and sound, translate texts, and play games like Go and chess without using a predefined strategy. However, there are still many tasks that are too difficult for AI. In 2015, Elon Musk stated that “The Tesla that is currently in production has the ability to do automatic steering autopilot on the highway. That is currently being beta tested and will go into a wide release early next month. So, we are probably only a month away from having autonomous driving at least for highways and for relatively simple roads. My guess for when we will have full autonomy is approximately three years.” In 2016, Turing award winner Geoffrey Hinton stated that “it is quite obvious that we should stop training radiologists” expecting that image recognition algorithms would outperform humans very soon. However, we are still driving our cars, and there is still a shortage of human radiologists. In short, we still need humans to do many tasks despite the amazing progress in AI and ML.

In this viewpoint paper, we focus on the question "To Automate or Not to Automate?" thereby linking Hybrid Intelligence (HI) [1,2,12,15], Artificial Intelligence (AI), and Machine Learning (ML) [9,13,16] to Business Process Management (BPM) [3,18] and Robotic Process Automation (RPA) [4,17,23]. This question is highly relevant because there is consensus that AI/ML will dramatically change the workplace [5,7,11]. Figure 1 shows the results of a PwC study based on OECD data collected in the context of the Program for the International Assessment of Adult Competencies (PIAAC) of the Organization for Economic Cooperation and Development (OECD) [7]. Recalling Niels Bohr’s quote and the RAND Corporation report mentioned before, one should take such analyses with a grain of salt. Nevertheless, it is worthwhile to try and identify jobs that might be of high risk of automation. The PwC study anticipates three waves of automation until mid-2030: (1*) algorithm wave* (early 2020s), (2) *augmentation wave* (late 2020s), and (3) *autonomy wave* (mid 2030s) [7]. The first wave focuses on the automation of simple computational tasks and analysis of structured data in areas like finance, insurance, information, and communications. This wave is already a reality considering, for example, the closing of local banks in most countries. The second wave focuses on the automation of repeatable tasks such as filling in forms, communicating, and exchanging information using technologies such as RPA. The third wave will automate of physical labor and problem-solving in manufacturing and transport. Figure 1 shows the expected impact of the three waves. For sure, the three automation waves will disrupt labor markets. Initially, mostly administrative work (e.g., in banking and insurance) is impacted, but over time, also a substantial fraction of physical labor will disappear. For example, autonomous vehicles will soon become a reality in transportation, storage, manufacturing, and construction.

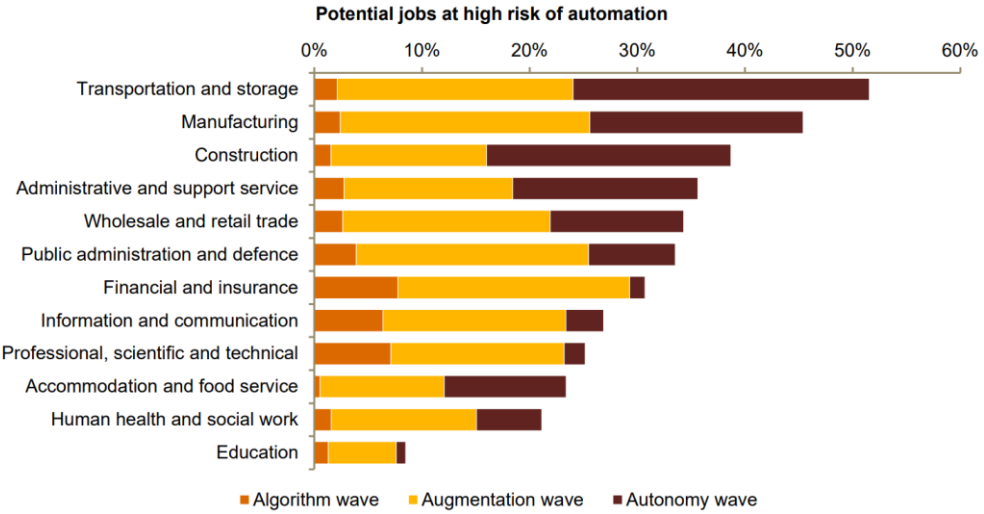

Figure 1: PwC analysis of the PIAAC OECD data predicting the proportion of existing jobs that may disappear due to automation by the mid-2030s in three overlapping waves [7].

Figure 2 shows the two types of automation considered in this paper. *Task automation* is limited to a single task, e.g., automatically performing a credit check or making a payment. *Process automation* considers end-to-end processes. The Purchase-to-Pay (P2P) process shown in Figure 2 includes multiple activities. Some of these activities may be automated, but independent of this, processes need to be coordinated, controlled, and continuously improved and adapted. BPM and process mining focus on end-to-end processes. For example, process mining can be used to detect performance and compliance problems. Such problems can automatically trigger corrective workflows. Both types of automation may benefit from a human-machine symbiosis where human intellect is complemented by machine intelligence. How work is divided exactly remains a challenging question in years to come (see the three waves in Figure 1).

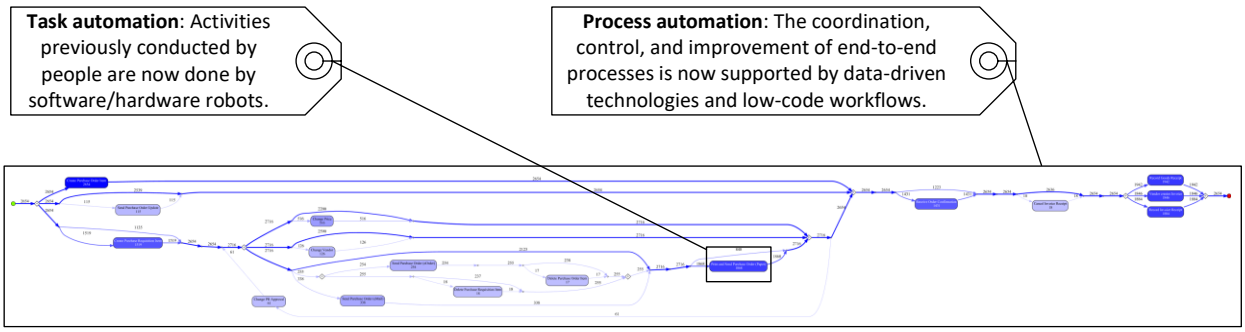

Figure 2: Two types of automation: (1) task automation and (2) process automation. Data-driven technologies such as AI, ML, RPA, and process mining can support both types of automation. However, often a combination of human intelligence and machine intelligence leads to the best results.

Hybrid Intelligence (HI) is one of the key elements in *digital transformation* initiatives, i.e., the adoption of digital technology to transform services or businesses by replacing non-digital or manual processes with digital processes or replacing older digital technology with newer digital technology. This extends beyond traditional automation and may include new types of innovation and creativity, e.g., new business models, new sales channels, new products, and new services. Such changes typically require, but also accelerate, task and process automation.

The remainder of this viewpoint paper is organized as follows. Section 2 introduces Hybrid Intelligence (HI). Section 3 provides a critical analysis of traditional BPM initiatives highlighting three main problems. Section 4 introduces RPA as a technology for task automation. Section 5 introduces process mining as a technology to make BPM more data-driven and enable new forms of process automation. Section 6 relates the different topics, advocating a convergence of HI, BPM, RPA, ML, and process mining. Section 7 concludes the paper.

2. Hybrid Intelligence

Deep Blue, a chess-playing computer developed by IBM, won its first game against world champion Garry Kasparov in 1996. AlphaGo, a Go-playing computer developed by DeepMind Technologies, defeated the best-ranked Go player Ke Jie in 2017. The more powerful AlphaGo Zero learned by just playing games against itself, but was able to defeat any human player by the end of 2017. Speech recognition software has been around since the 1950s when Bell Laboratories presented the "Audrey" system that was able to recognize the numbers 1 to 9. IBM's "Shoebox" system presented in 1962 was able to recognize 16 words. Until a decade ago, speech recognition software would not function very well. However, today we are surrounded by Amazon's Alexa, Apple's Siri, Microsoft's Cortana, Google Assistant, etc. A similar development can be seen in image recognition and many tasks that before could only be done by humans. These successes can be attributed to progress in *deep learning*, where *Artificial Neural Networks* (ANNs) having multiple layers progressively extract higher-level features from the raw input [9,16]. Although neural networks had been around for decades, these techniques started to outperform classical approaches around 2012. Today, there is a lot of excitement about the amazing possibilities of deep learning. However, also the limitations become increasingly visible, especially in organizational settings and situations with limited data or many changes.

It is not easy to clearly define terms related to "intelligence" and "learning". The "AI Effect", commonly known as Tesler's Theorem, says that "Artificial Intelligence is whatever hasn't been done yet" (actually, Larry Tesler said "Intelligence is whatever machines haven't done yet"). Tesler's Theorem shows that things that were previously seen as Artificial Intelligence (AI) are removed from the definition of AI when they become standard. When people use the term AI today, they often refer to Machine Learning (ML) based on ANNs. However, for most of its history, AI was dominated by *symbolic AI*, also known as "classical AI", "rule-based AI", and "good old-fashioned AI", and associated with expert systems and logical reasoning. In recent years, AI got increasingly associated with ML.

ML techniques are data-driven and learn from data without explicitly being programmed. We typically distinguish between training data and test data. For example, we train an ANN to distinguish dog and cat pictures that are labeled. While training, the ANN updates the weights in the internal representation until the number of incorrectly classified pictures is minimized. Then the trained ANN is used to classify test data, i.e., unseen dog and cat pictures that need to be classified correctly. Given enough training data, such an ANN may perform amazingly well in practice, although it was never programmed to do so and has no explicit knowledge of cats and dogs. DeepMind's AlphaGo Zero learned to play Go in a superior manner by just knowing the rules and playing against itself. There are many machine learning techniques ranging from classical approaches such as regression, decision trees, logistic regression, k-means clustering, and principal component analysis to support vector machines, convolutional neural networks, autoencoders, long short-term memory networks, and generative adversarial networks. Approaches can be classified into supervised learning (using labeled data, e.g., for classification), unsupervised learning (using unlabeled data, e.g., to discover unknown patterns), and reinforcement learning (finding the balance between the exploration of uncharted territory and the exploitation of current knowledge).

ML can be seen as part of *data science*, i.e., the broader interdisciplinary field aiming to turn data into real value. Data may be structured or unstructured, big or small, static or streaming. Value may be provided in the form of predictions, automated decisions, models learned from data, or any type of data visualization delivering insights. Data science includes data extraction, data preparation, data exploration, data transformation, storage and retrieval, computing infrastructures, various types of mining and learning, presentation of explanations and predictions, and the exploitation of results taking into account ethical, social, legal, and business aspects [19].

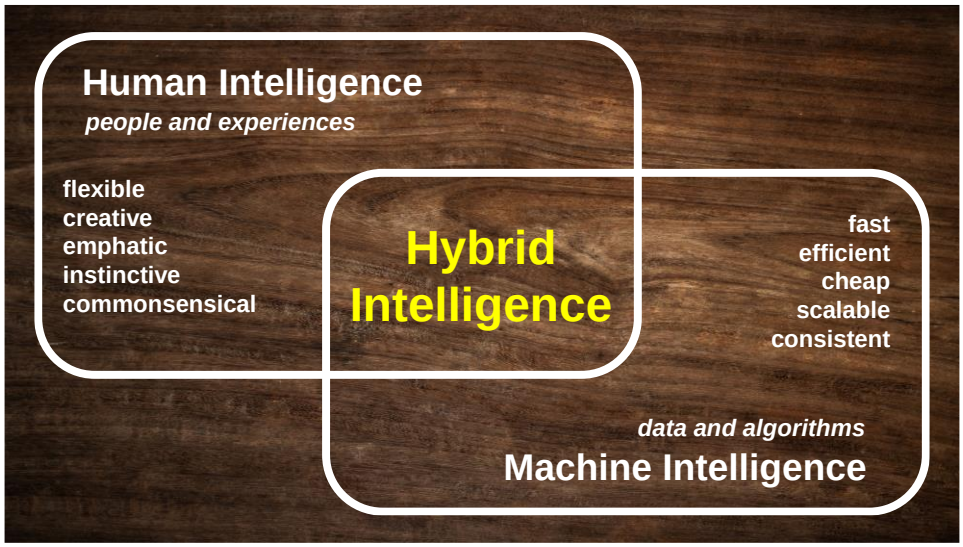

Figure 3: Hybrid Intelligence (HI) aims to combine the best of human intelligence and machine intelligence.

Hybrid Intelligence (HI), sometimes also called *Augmented Intelligence*, emphasizes the assistive role ML, i.e., deep neural nets and other data-driven techniques are there to enhance human intelligence rather than to replace it (just like telescopes are there to enhance human vision). Dellermann et al. [2] define Hybrid Intelligence (HI) as "the ability to achieve complex goals by combining human and artificial intelligence, thereby reaching superior results to those each of them could have accomplished separately, and continuously improve by learning from each other".

Figure 3 illustrates that *Hybrid Intelligence* (HI) combines both two forms of intelligence:

- *Human intelligence* is about people and experiences and can be characterized by terms such as flexible, creative, emphatic, instinctive, and commonsensical.
- *Machine intelligence* is about data and algorithms and can be characterized by terms such as fast, efficient, cheap, scalable, and consistent.

HI aims to combine the best of both worlds. The spectacular developments in ML have extended the reach of software and hardware robots. Once a robot is able to perform a repetitive task at a similar level of quality, it is often also more cost-effective. The rise of the "platform economy" has accelerated this. Transaction platforms that match supply and demand (e.g., Amazon, Alibaba, Airbnb, Uber, and Baidu) and technology platforms (e.g., Microsoft's software platform and the App stores of Google and Apple) have the characteristic that they grow very fast and that, in the end, often one winner remains (due to the traditional economy of scale, low marginal costs, and network effects). Due to these platforms new technologies can be adopted fast at a global scale. However, humans still have unique capabilities. Consider, for example, disruptive events like the COVID-19 pandemic where one is confronted with completely new challenges that require flexibility, creativity, and intuition. People have the ability to transfer experiences from one problem domain to another. Moreover, empathy (i.e., the capacity to understand or feel what another person is experiencing) and ethics (i.e., reasoning about moral concepts such as good and evil, right and wrong, virtue and vice, justice and crime) require human intelligence [21]. In HI, human intelligence and machine intelligence complement each other.

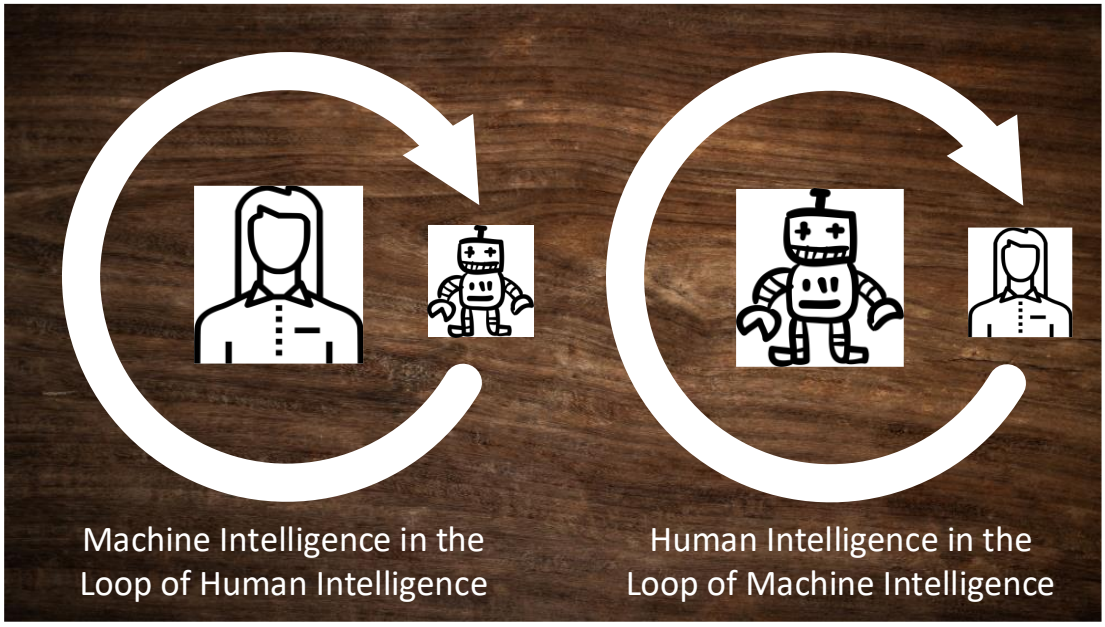

Figure 4: Human in the loop or machine in the loop?

Figure 4 shows how human intelligence and machine intelligence can be combined. The left-hand side shows the traditional use of AI/ML in organizations. AI/ML is used to provide decision support or assist in performing repetitive tasks. For example, a data-driven sales forecast supports decision-making in logistics and production, or ML algorithms help to speed up standard routines of image acquisition in radiography. The human is in control, and AI/ML is used as a tool. The right-hand side of Figure 4 shows the opposite situation. Machine intelligence is used to automatically processes cases without human intervention. However, the machine can call the human for help in exceptional cases. For example, credit scoring or X-ray diagnostics are performed automatically, but boundary cases are evaluated by human experts.

The interplay between human intelligence and machine intelligence may lead to new insights. AlphaGo showed human players new strategies for playing Go, as has been acknowledged by the world's leading Go players. Shi Yue said "AlphaGo's game last year transformed the industry of Go and its players. The way AlphaGo showed its level was far above our expectations and brought many new elements to the game." Zhou Ruiyang said "I believe players more or less have all been affected by Professor Alpha. AlphaGo's play makes us feel more free and no move is impossible to play anymore. Now everyone is trying to play in a style that has not been tried before." This example shows that humans can learn from machines. This also applies to operational processes e.g., in healthcare or sales. Therefore, organizations need to embrace HI and actively manage the constantly shifting distribution of work between workers and robots.

3. Business Process Management: a critical analysis

In this paper, we focus on the relation between HI and *Business Process Management* (BPM) [3,18], considering new technologies such as ML, RPA, and process mining.

Already in the 1970s, people like Skip Ellis and Michael Zisman worked on so-called office information systems, which were driven by explicit process models. Systems such as Officetalk and SCOOP can be seen as early Workflow Management (WFM) systems. However, it took another 15 years until WFM technology was ready to be applied on a large scale. In the mid-nineties, many commercial WFM systems were available and there was the expectation that

WFM systems would be an integral part of any information system. Many people, including the author, expected that these systems would become as common as database management systems. However, this did not happen. WFM systems were succeeded by Business Process Management (BPM) systems that were broader in scope, but were also never widely adopted. Examples of BPM systems include the software products from Pegasystems, Appian, IBM, Bizagi, Oracle, Software AG, TIBCO Software, Bonitasoft, Kofax, and Signavio. However, despite the availability of WFM/BPM systems, process management was never subcontracted to such systems at a scale comparable to database management systems. Actually, a few years ago, many considered the area of Business Process Management (BPM) to be dead. Organizations associated BPM with making process models rather than diagnosing and improving processes. There were three main reasons for this skepticism:

- Applying WFM/BPM technology was rather *expensive*. Processes are hardcoded in application software or not supported at all. Many processes also use software from different vendors, making a seamless integration difficult and time-consuming.
- Although the "M" in WFM and BPM refers to "Management", the focus is on modeling and automation rather than management. Traditional WFM/BPM systems fail to learn from the event data they collect.
- Real-life processes are more *complex* than people like to believe. The well-known 80-20 rule applies to processes, i.e., 80% of all cases are rather simple, but explain only 20% of the complexity of the process. The remaining 20% of cases tend to be neglected by software and management, but consume 80% of the resources of an organization.

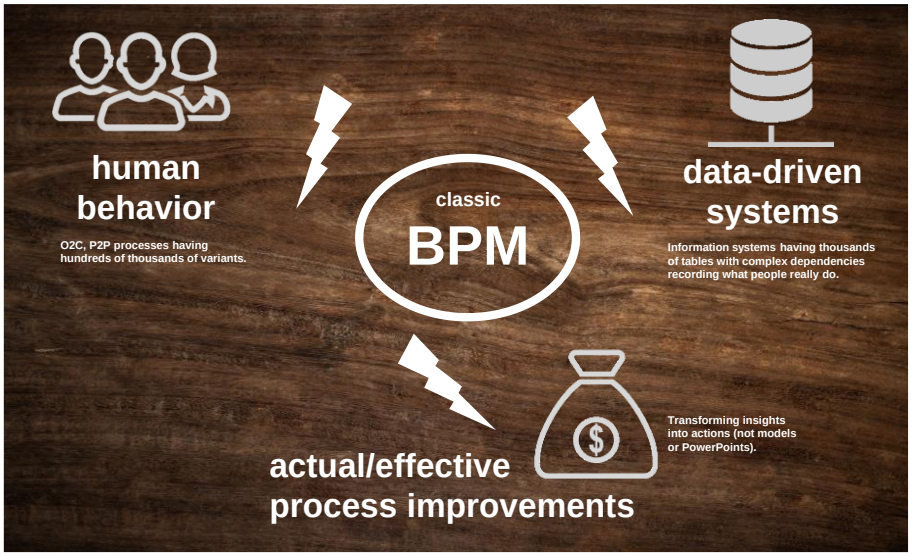

Figure 5: Old-school BPM tends to be (1) unable to capture human behavior, (2) unable to deal with the complexity of real-life systems, and (3) unable to realize actual improvements.

Figure 5 hypothesizes about possible reasons for the limited success of traditional WFM/BPM systems and approaches. Human behavior and information systems tend to be oversimplified, leading to a disconnect with reality. Moreover, it is often impossible to show that the process actually improved. In the remainder of this section, we elaborate on each of the three problems highlighted in Figure 5.

3.1 Inability to capture human behavior

Simple processes such as Order-to-Cash (O2C) and Purchase-to-Pay (P2P) tend to be much more complicated than expected. It is not uncommon to find thousands of process variants, i.e., unique ways of executing O2C or P2P processes (just considering the ordering for activities). Some of these variants may be undesirable. However, deviations often have good reasons. People are adapting to contextual factors, not present in the process model. It is also very difficult to create simulation models that exhibit the real behavior of an organization. It is possible to create so-called "digital twins" of highly-structured production processes. However, in processes where human actors are in the lead and where people need to distribute attention over multiple processes, it is still impossible to create meaningful "digital twins" that have an acceptable predictive value. These difficulties show why traditional WFM/BPM systems and approaches failed. Assuming that reality can be captured in the form of a BPMN (Business Process Model and Notation) and implemented using a WFM/BPM system is a recipe for disaster.

3.2 Inability to deal with the complexity of real-life systems

Moreover, real-life information systems are more complicated than stakeholders like to think. When making process models and talking about new systems, people tend to underestimate the complexity of the underlying data. Standard systems like SAP's S/4HANA contain hundreds of thousands of tables. Of course, a typical organization uses only a subset of these tables. However, it shows the complexity of real-life information systems. Data related to one process may be scattered over dozens or even hundreds of tables connected through primary key and foreign key relationships. Although relational databases are well-understood and more structured than NoSQL-based non-relational databases, these cannot be described using a UML class diagram and BPMN model. Nevertheless, many WFM/BPM vendors suggested that it would be easy to replace existing systems using a properly configured WFM/BPM system. This is, of course, not the case. It is very naïve to think that existing systems can be replaced easily. There are numerous examples of failed ERP systems implementations that drove companies into bankruptcy (e.g., Shane Co., American LaFrance, FoxMeyer Corp., etc.). These bankruptcy cases had in common that people underestimated the complexity. The author has witnessed numerous organizations that selected a WFM/BPM system that never went into production. Therefore, it is important to try and realize process improvements while keeping the existing information systems. RPA (see Section 4) builds on top of existing information systems while automating repetitive work.

3.3 Inability to realize actual improvements

The third problem highlighted in Figure 5 is the limited ability to provide actionable results. Making process models, organizing workshops/meetings, and implementing new information systems do not necessarily lead to process improvements. Some of the larger organizations have invested in creating repositories of process models. However, such repositories become outdated quickly and do not necessarily impact the operational processes. Actually, most workers are not aware of their existence. Wallpaper-sized BPMN models that aim to be close to reality are too abstract because they are not connected to the actual data, and stakeholders can always question their validity. Process mining (see Section 5) addresses this by showing continuously updated process maps that show the current situation.

The problems highlighted in Figure 5 explain why organizations embraced RPA and process mining during the last decade. Both helped to revive the interest in BPM. RPA can be used to automate routine work that would normally not be cost-effective. Process mining plays a key role in deciding what to automate and how. Moreover, process mining helps to capture the actual end-to-end processes while acknowledging their complexity and focusing on the real problems.

4. Robotic Process Automation: focusing on individual tasks

Robotic Process Automation (RPA) has lowered the threshold for process automation [23]. Repetitive tasks done by people are handed over to software robots. For RPA, there is no need to change or replace the pre-existing information systems (e.g., SAP). Instead, software robots replace users by interacting directly with the user interfaces normally operated by humans. RPA can be seen as "the poor man's workflow management solution" because it is often much cheaper than traditional automation [23]. Figure 6 show the main idea of RPA. In most organizations, one can easily find people whose main job is to connect information systems using copy-and-paste actions and simple repetitive tasks. These provide the required "glue" between applications and the outside world. Despite the repetitive nature of the work, it is not cost-effective to replace the information systems used. Systems may be provided by different vendors and may be too old to change (legacy software). Therefore, it is cheaper to copy-and-paste address information or send e-mails manually. RPA does not aim to change the existing systems but take over the repetitive work of people. It is a form of automation using software robots (bots) replacing humans.

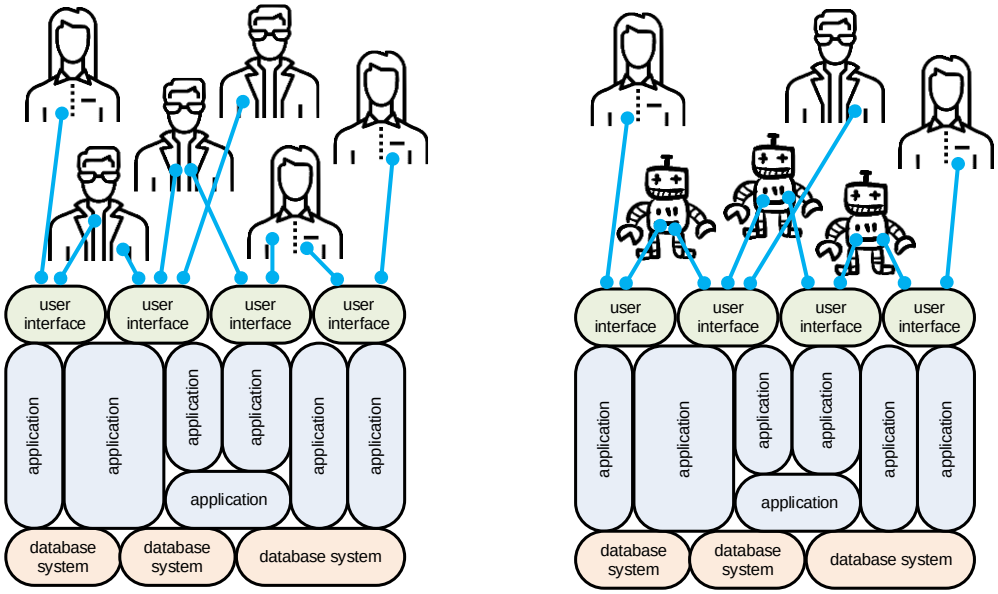

Figure 6: In many organizations, humans are the glue between applications and the outside world (left). This leads to repetitive tasks that can also be done by software robots without changing the underlying information systems.

The three main RPA vendors are UIPath (founded in 2005), Automation Anywhere (founded in 2003), and Blue Prism (founded in 2001). Other vendors include Workfusion, Kryon Systems, Softomotive, Contextor, EdgeVerve, Nice, and Redwood Software. The key difference between RPA and traditional WFM/BPM is that RPA does not aim to replace existing (back-end) information systems. Instead, software robots interact with the existing information systems in the same way as humans do. In traditional WFM/BPM systems, the process is specified precisely, and the WFM/BPM system orchestrates the modeled process by implementing simple activities and calling pre-existing applications through Application Programming Interfaces (APIs). In contrast, RPA software interacts with the pre-existing applications through (graphical) user interfaces directly replacing humans, i.e., automation is realized by taking over tasks from workers directly through the user interface. A typical RPA scenario is a sequence of copy-and-paste actions normally performed by a human.

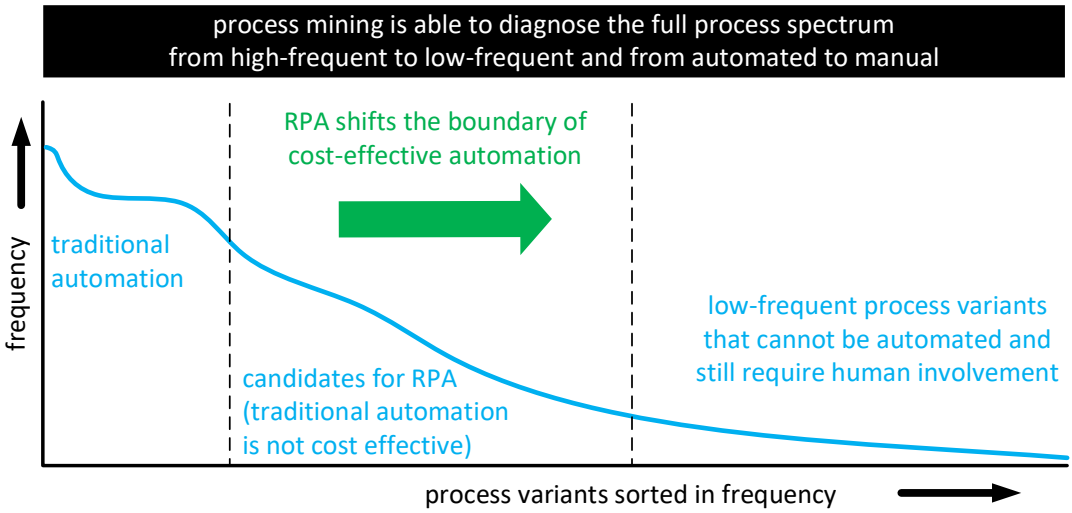

Figure 7: RPA shifts the boundary of cost-effective automation and can therefore be seen as n be seen as "the poor man's workflow management solution". Process mining complements RPA by identifying routine work and monitoring processes before and after the introduction of RPA.

Before introducing RPA, one needs to analyze the processes to be automated. Process mining can help to identify promising candidates [3,21,24]. Moreover, after RPA has been implemented, process mining can be used to monitor processes and systems even if these use a mixture of RPA, workers, and traditional automation. This is illustrated by Figure 7. The figure shows that processes and process variants can be sorted by frequency. Obviously, one would like to automate the most frequent processes and process variants first. Because traditional automation (e.g., using WFM/BPM systems or writing ABAP code to change SAP) is rather expensive, there often exist many repetitive tasks which are not automated. This corresponds to the middle of the spectrum depicted in Figure 7. After introducing RPA there are three types of tasks: (1) tasks handled by the information system using traditional automation, (2) tasks handled by software robots, and (3) low-frequent tasks still done manually. The whole can be monitored and analyzed using process mining as is discussed next.

5. Process Mining: focusing on end-to-end processes

RPA can be seen as a bottom-up activity, i.e., removing repetitive tasks. Process mining can help to identify and automatically learn such tasks [3,21,24]. However, the primary use case of process mining is the top-down analysis of end-to-end processes [19,22,23]. Process mining techniques use event data to show what people, machines, applications, and organizations are really doing. Process mining provides novel insights that can be used to identify and address performance and compliance problems. Just like spreadsheets can do anything with numbers, process mining can do anything with event data, i.e., it is a generic, domain-independent technology to improve processes. There are over 35 commercial offerings of process mining software (e.g., Celonis, Disco, ProcessGold, myInvenio, PAFnow, Apromore, Minit, QPR, Mehrwerk, Puzzledata, LanaLabs, Process Diamond, Everflow, TimelinePI, Signavio, and Logpickr), next to open-source tools like ProM, PM4Py, bupaR, and RapidProM.

All process-mining tools start from *event data*. An event log is a collection of events stored using a format like XES (xes-standard.org). An event may have many different attributes, but at least a *case identifier*, an *activity name*, and a *timestamp*. Additional attributes may refer to locations, resources, costs, transactional information, and energy consumed. Events are grouped using the case identifier and sorted using the timestamps. Hence, each case corresponds to a trace, i.e., a sequence of events. Focusing on the activity names only, these traces can be grouped into variants, i.e., sequences of activities.

Figure 8 illustrates the typical use of process mining using a small event log with 71,043 events, 12,666 cases, and 7 unique activities. A possible trace is the sequence <*place order, send invoice, pay, prepare delivery, make delivery, confirm payment*>. There are over 8000 cases corresponding to this activity sequence. Using process mining, one can uncover *compliance and performance problems*. Initially, process mining efforts focused on process discovery. However, over time it has become clear that process discovery is just the starting point to process improvement. One can witness an uptake in conformance checking and performance analysis techniques. Moreover, process mining is often combined with ML techniques to find root causes for inefficiencies and deviations. As was illustrated by Figure 7, event logs often follow a Pareto distribution, i.e., a few variants explain a large proportion of the event log.

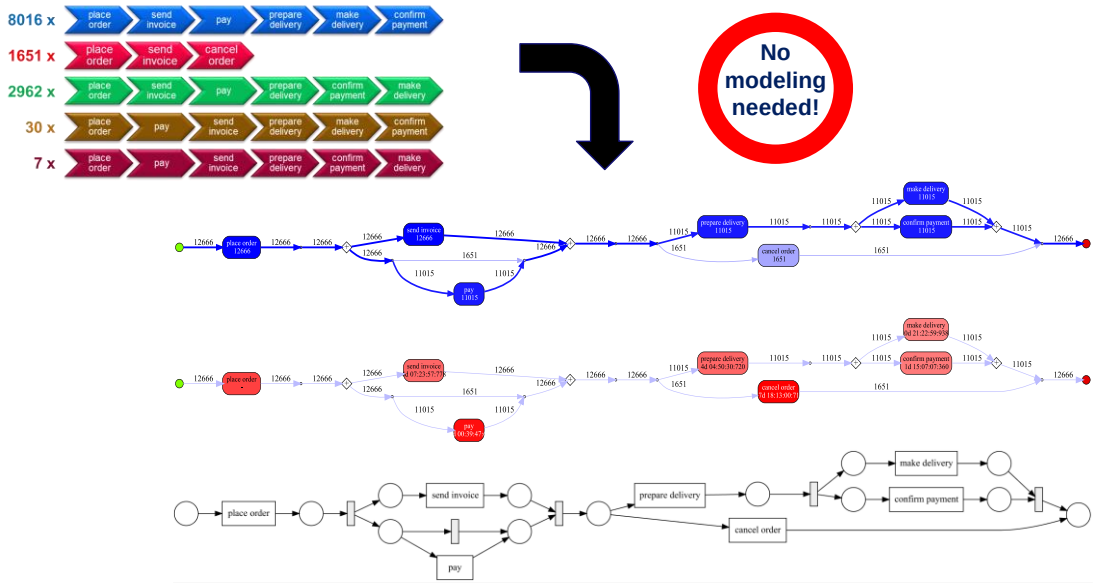

Figure 8: Event data serve as the starting point for process mining. Such data can be used to discover what the real process is, where the bottlenecks are, where the process deviates, and what the root-causes are. If there is enough data and the process is stable, then it is even possible to predict performance and conformance problems.

Figure 9 provides another, more high-level, view on process mining. Process mining starts by extracting event data from information systems. This may be quite involved since traditional process mining techniques assume an event log with a single case notion. Using object-centric process mining, this requirement can be relaxed, i.e., each event may refer to any number of objects and it is possible to discover more holistic process models [24]. However, most approaches still assume a single case notation and logs in the form of an XES file or a similar database table. Such event data are used to discover process models showing the real process. Such models can be enriched with frequency and timing information. Given a discovered or normative process model it is also possible to do conformance checking and highlight deviations. Next to visualizing conformance and performance problems, it is possible to explain and predict these. Note that process discovery and conformance checking are unrelated to mainstream AI/ML techniques. However, process mining can be used to generate standard classification problems, e.g., what are the characteristics of the cases that deviate, fail, or get delayed. This can be used to predict such problems and recommend actions.

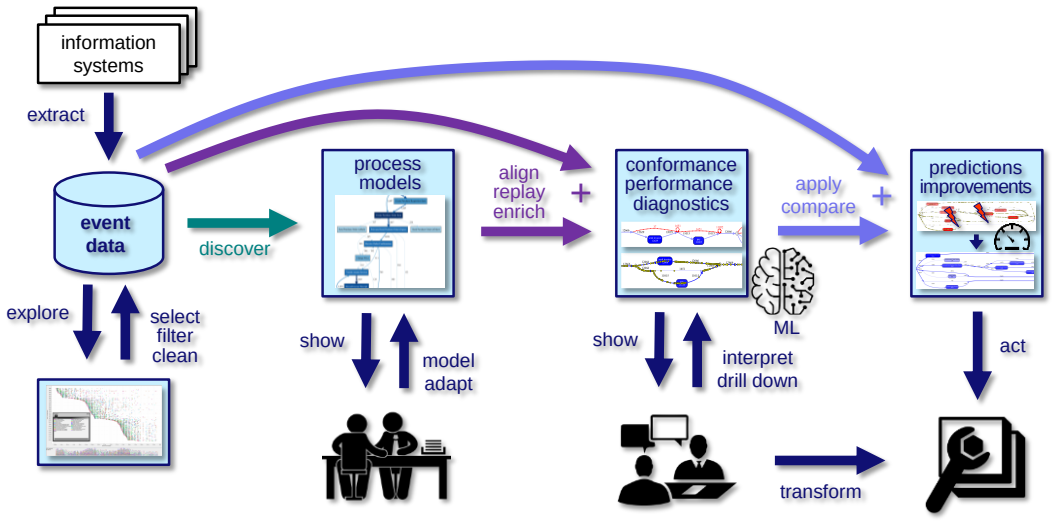

Figure 9: A high-level overview of process mining, showing also the different activities.

One can witness a shift in focus from backward-looking to forward-looking process mining [22]. Organizations are more interested in what is happing now or what is going to happen next. Backward-looking process mining can be used to fundamentally improve processes, but provides little support for the day-to-day management of processes. Therefore, event data need to be updated continuously and process-mining techniques need to be able to analyze cases that are still running. This is needed to control and influence the running process instances. Techniques for operational support (i.e., detecting compliance and performance problems at runtime, predicting such problems, and recommending actions) have been around for more than a decade. However, the challenge is to make these techniques more reliable and also trigger the actions needed.

Action-Oriented Process Mining (AOPM) focuses on automated corrections actions based on process mining diagnostics [14]. AOPM turns observed events into management actions when needed. The goal is not to support the operational process itself (that already exists in some form), but to support the management of the process. Process mining diagnostics related to compliance and performance combined with process knowledge and reinforcement learning provide the ingredients for a reactive system that automatically triggers management workflows, improving the process. The goal of AOPM is not to automate the tasks, but the management of the process. Note that, like RPA, AOPM does not aim at replacing the original information system. The acquisition of Integromat, a low-code online automation platform, by Celonis illustrates this development. Integromat provides over 500 application connectors to interact with the most widely used information systems (Salesforce, Office, Teams, Twitter, etc.). When the Celonis process mining system detects a known problem, Integromat can trigger the required corrective actions.

6. Towards the convergence of HI, BPM, RPA, ML, and Process Mining

In Section 3, we argued that old-school BPM tends to be (1) unable to capture human behavior, (2) unable to deal with the complexity of real-life systems, and (3) unable to realize actual improvements. Process mining helps to address (1) and (3) by looking at the real processes in an objective manner before and after interventions. Moreover, just like RPA process mining does not try to replace existing systems and face the complexity of real-life systems (2).

Often, a small percentage of activities account for most of the events, and a small percentage of trace variants account for most of the traces. For example, 20% of the activities may account for 80% of the events. Similarly, the 20% most frequent process variants may explain 80% of the cases. Traditional process automation focuses on the most frequent activities and process variants. Only for high-frequent activities and process variants, it may be cost-effective to automate tasks and introduce classic WFM/BPM software. Less frequent activities and process variants need to be

handled by workers that exploit human flexibility and creativity. As shown using Figure 7, RPA focuses on the middle part, i.e., routine work that is not frequent enough to be automated in the traditional sense. Process mining is a crucial technology to identify routine work that can be supported using RPA. *Therefore, we claim that process mining can be used to pick the "automation battles" that are cost-effective and feasible.*

This vision matches well with the notion of Hybrid Intelligence (HI). We should not aim for a strict divide between work done by software robots and work done by humans. Process mining can be used to detect routine work that can be automated by mimicking the behavior of workers. Rather than manually programming robots, process discovery can be used to configure the robots correctly. Part of the work formerly done by workers is now done by software robots. Process mining can be used to check whether the processes run as planned. If a software robot malfunctions due to technical glitches, exceptions, changing user interfaces, or changing contextual factors, then this can be detected using conformance checking techniques. Note that a lack of human oversight of the work produced by robots constitutes a real risk of catastrophic outcomes.

Using combinations of process mining and machine learning, it is possible to flexibly distribute work over workers and software robots. For example, tasks are initially performed by robots and are escalated to workers the moment there is a complication or exception. Similarly, workers can hand off work to robots using an "auto-complete" option. Moreover, the RPA solution may adapt due to changes in the underlying process (e.g., concept drift).

The goal of RPA is to partially automate tasks in the process, and process mining can help identify where this makes the most sense. However, RPA builds on top of existing systems ranging from SAP and Salesforce to homegrown applications. It is unrealistic to assume that RPA and ML will replace these systems. Hybrid Intelligence (HI) should not only combine human intelligence and machine intelligence; it should also do this in a complex landscape of existing systems. Hence, it is naïve to assume that process-mining results will replace existing systems handling the operational tasks. However, there are many opportunities to use process-mining results to automatically manage the process better.

7. Conclusion

This viewpoint paper discussed Hybrid Intelligence (HI) from the viewpoint of task and process automation. We started with the question "To automate or not to automate?". The question of what to automate is not new. However, with the uptake of Machine Learning (ML) and Artificial Intelligence (AI), the tradeoffs are changing rapidly. Due to advances in AI/ML, the answer to the question will change continuously. HI suggests that for many of the more challenging tasks, we will need to mixture of human and machine intelligence to get the best results. Although deep learning has had an amazing success in areas such as speech recognition, automated translation, image recognition, smart maintenance, and sentiment analysis, there are also obvious limitations. Machine intelligence tends to fast, efficient, cheap, scalable, and consistent, but also inflexible, non-creative, non-emphatic, non-instinctive, and lacking common sense. In HI, human intelligence (i.e., people having experience and domain expertise) complements machine intelligence. We introduced HI and indicated the relevance for task and process automation.

We also provided a critical analysis of traditional WFM/BPM approaches. We identified weaknesses of traditional approaches that were not data-driven while trying to replace existing systems based on process models. In hindsight, these approaches can be considered naïve for two reasons. First of all, real processes have a lot of variability due to human behavior. Simple P2P or O2C processes may have thousands of variants, and this is in stark contrast with the oversimplified models produced by humans. Second, information systems like SAP's ERP system are extremely complex with thousands of database tables. Therefore, attempts to simply replace such systems are destined to fail. Robotic Process Automation (RPA) and process mining address these limitations by better using the available data and systems. RPA builds upon existing systems by taking over repetitive tasks from humans. RPA is often used in a bottom-up manner realizing quick wins. Process mining can be used for identifying RPA opportunities. However, process mining also views processes in a more holistic top-down manner. A recent development in the field of process mining is that performance and conformance problems automatically trigger corrective workflows leveraging both the data and systems present. However, data-driven techniques should also be able to say "I do not know" or "I'm not sure" and leave decisions to people. This is the true spirit of HI where people, data, and software augment each other.

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An examination of the preconditions of learning to facilitate innovation in digitalization projects: a project team members' perspective

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Abstract:
In the modern business environment spearheaded by digitalization, organizations are faced with the challenge of maintaining a competitive edge despite constant dynamic changes. Organizations therefore, have to adopt new, improved and modern ways of doing things. This can be achieved through proper knowledge management within the organization, which is an antecedent of innovation. Innovation is one of the crucial means for tackling the digitalization challenge as it enables organizations to maintain their competitive edge. Although extant studies have extensively studied learning in projects, there is a lack of concrete examples of the correlation between learning and improving innovation in the digitalization context. This article is based on a qualitative study aimed at examining the organizations' preconditions of learning in achieving innovation in digitalization projects focusing on the perspective of the project team members. Data was collected through open-ended questionnaires with a total of 97 respondents and analyzed using NVivo qualitative software. The findings revealed two viewpoints regarding the perception of learning for innovation. The preconditions for learning for innovation in digitalization were also identified. Moreover, the immediate outcomes of learning were identified that can be utilized in assessing whether employees are actually learning given the necessary preconditions are established.

Keywords:
learning; innovation; digitalization projects; enablers; preconditions.

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1. Introduction

Learning and innovation are common terms in today's business environment. Whereas learning is considered a mediator of innovation [1], people are considered the carriers of knowledge and are consequently regarded as the drivers of innovation [2]. Learning facilitates creativity, inspires the generation and development of knowledge, and increases the ability to recognize and apply new ideas [3]. It is pivotal for organizations to create a suitable environment that will encourage individuals to learn [4] because knowledge use amplifies the performance of both individuals and organizations [5]. However, this does not imply that it is an easy task to create a learning culture, especially in a constantly changing business environment [6].

Over the past five decades, technological advancements have shaped our societies and ultimately led to the adoption of digitalization [7]. In turn, digitalization has been adopted in various business aspects, such as in optimizing processes, business models and customer involvement [8]. In such business environments, organizations face the challenges of constantly exploring new alternatives, redeploying their existing resources, and developing new capabilities and routines [9]. To unravel such challenges, organizations need to initiate approaches that expedite changes and adaptations, and stimulate improvements. Digitalization may have emerged as a crucial enabler that facilitates organizations' changes [10]. Because it facilitates the transformation of businesses, digitalization facilitates improvements and maintaining competitive advantages, subsequently enabling the creation of benefits such as productivity improvement, innovation, and cost reduction [11].

In order to remain competitive and relevant in the current changing environment, it is imperative that organizations, specifically project-based organizations, take an effort to ensure smooth acquisition, sharing and utilization of knowledge between individuals and teams. This can facilitate improvement in their performance through error reduction and the creation of novel ideas i.e., innovation. This is in line with the claim by Quinn and Spreitzer [12] that, in current business environments and due to global competitive markets and higher customer expectations, organizations require employees to accomplish more than the norm. Similarly, Roblek et al. [13] acknowledge that knowledge management is a significant factor to enable organizations to generate sustainable competitive advantage and facilitate success of digitalization projects in the current economy [14].

Hussein et al. [15], suggest that the challenges of digitalization projects are rooted in the interplay of three dimensions; (1) managing collaboration between the diverse individuals or organizational units; (2) managing the creating of new processes, products or services that create value, frequently referred to as innovation [16], and (3) managing the procurement or introduction of the digital enablers or digital technologies to create the intended novel solutions. These three dimensions constitute therefore the main efforts in managing digitalization projects and we refer to them as the pillars of managing digitalization projects.

Knowledge management is frequently identified as an important antecedent of innovation. Given the importance of innovation, multidisciplinary researches have looked for answers to the critical question *What can be done to improve innovation?* (e.g., [17], [18], [19], [20]). Knowledge handling has become a significant task in organizations [21]. Similarly, knowledge sharing is an important step in the learning process. To achieve innovation, employees need to acquire knowledge and share it within their organization [22]. This is in line with Camps et al. [23], who claim that learning processes originate from individuals' acquisition of knowledge and evolve with the exchange and integration until collective knowledge is attained.

Tohidi et al. [3] highlight innovation as influenced by organizational learning and emphasize that organizations seeking to innovate should consider strengthening their learning culture. This is in line with Ukko et al. [1], who state that innovation demands creativity, and organizational learning is the key to achieving that level of creativity. Chen and Lin

[24] suggest that for organizations to develop knowledge, there should be a dynamic environment, specific knowledge, intentional employees who possess sufficient capabilities and high levels of autonomy. Thus, the environment plays a crucial role in organizational learning. This is in line with Daemi et al. [25] who stated that the environment of an organization has potential to either support or impede the successful implementation of initiatives, models or ideas.

The huge challenge facing learning in projects involves the retention of knowledge once the project has been completed and the team has moved to other projects. In such circumstances, there is a risk that the knowledge and experience gained will be lost [9]. To avoid loss of knowledge, it is important to construct ways in which it can be retained and shared within the organization [9]. Giles and Cormican [26] suggest having a proper idea management system, such as idea banks, for easy contribution and evaluation of ideas in a collaborative manner.

The relationship between learning and innovation is more prominent in organizations with comparatively more innovative climates [27]. Organizations have a large part to play in ensuring that conditions are supportive for learning. It is important to have motivated employees, as this facilitates their independent searches for knowledge related to their tasks, hence increasing their capability to innovate [28]. According to Escrig-Tena et al. [29], a proactive behavior for the workforce is a necessary prerequisite for innovation. Organizations can also facilitate their employees' learning by investing in training and knowledge development programs to expose employees to broader perspectives, expertise and deeper insights, thus building their capacity to find creative solutions in their tasks [30]. Employees' skills, attitudes, knowledge, and competencies are generated through training and development, which then leads to improved productivity, effectiveness and efficiency in organizations [31]. Siddique and Hussein [32] found that employees were content in their jobs when they learned something new during their work. This is in line with Rhoades and Eisenberger [33] and Bassett-Jones [34], all of whom support the idea of organizations' investing in employee learning.

Van der Sluis [35] highlights the team's working climate as an important factor influencing people's creativity in their jobs. He highlights the aspects that have a positive influence on innovation as being; a favorable team climate, managerial support for learning, a challenging work environment, mentoring, and good relationships. The relationships between peers, teammates, supervisor, and subordinates must be of quality [36] in order to support creativity and innovation. When there is a good relationship between team members, problems are solved more quickly, which enhances an organization's overall performance [37].

Although we know much about the topic of organizational learning and on the preconditions that facilitate learning between projects, the current body of knowledge lacks concrete examples of the correlation between learning and improving innovation in the context of digitalization. Therefore, this article takes a bottom-up approach towards understanding the preconditions that influence employees' learning in current constant changing business environment i.e., digitalization context. Considering that the focus of this study is on how organizations can achieve innovation through employees' learning, hence use of the term '*learning for innovation'*. We examine the preconditions of organizations that facilitate employee learning in order to innovate, but with a particular focus of digitalization projects. Accordingly, we examine the conditions needed in order to improve the employees' ability to learn so they can be innovative in accomplishing their project tasks.

In addition, considering that evaluating whether learning has indeed occurred is of great value in adding quality to the learning process [38, 39], we examine the immediate outcomes that enables the team members to identify if they have learnt. To achieve this, we address the following research questions:

1. *How is learning for innovation perceived in the context of digitalization projects?*
2. *What are the enablers for learning for innovation in digitalization projects?*
3. *What are the hinderances for learning for innovation in digitalization projects?*
4. *What is the immediate outcome/evidence that makes you realize you have learnt for innovation?*

We acknowledge the existence of numerous studies on internal and external knowledge transfer in and between organizations. Moreover, the scope of this study only covers the aspect of learning for innovation during the accomplishment of projects and other organizational tasks, and therefore the focus is directly on the organizations' internal conditions and strategies for knowledge acquisition and sharing. It is important to highlight that projects studied in the context of this study are projects that have been conducted in the current dynamic business environment and therefore are characterized by a high demand of skills, competencies, technological advancement, experience and digitalization, herein referred as '*digitalization projects'*.

The remaining of this part is structured as follows; section 2 presents a theoretical background on organizational learning and introduces the concept of learning for innovation; the methodology adopted in conducting the study is described in section 3; the findings of the study are presented in section 4 and discussed in section 5; and finally section 6 concludes the study, presents the limitations and recommendations for further studies.

2. Background

2.1 Learning in the organizational context

There are many perspectives on organizational learning. However, common to all perspectives is that we cannot call anything learning if the knowledge that we gain is not exploited for a useful purpose [40]. The complexity of learning in organizations is rooted in the fact that learning is a multilevel phenomenon involving individual, group, organizational, and, at times, population levels of analysis [41]. There is general consensus in the organizational learning literature that organizational learning begins at the individual level and the acquired knowledge is propagated through groups and further to the organizational level. Duhon and Elias [42] claim that an organization knows something if just one person in it has the knowledge in question, and that organizational culture and structure enable knowledge to be reused effectively. The move from the individual learning to organizational learning is not simple. Ideally, for an organization to learn, first individuals must acquire knowledge [43], [44]. There is also broad acceptance that knowledge gained at the individual level does not become organizational learning until it is shared, integrated and institutionalized [45].

2.2 Perspectives on learning

Although interest in the issue of learning in organizations dates back to the late 1950s, that interest grew up almost unnoticed until a sudden explosion in the late 1980s [46]. Despite a lack of a consensus on a definition of organizational learning, there is agreement on three broad perspectives that form the foundation of the definitions [47]:

- *Cognitive.* From this perspective, learning is described as a system of information acquisition, storage, retrieval, and transfer, regardless of whether knowledge is converted into actions [48]. From this perspective, learning is attained by gaining insights into and identifying associations between past actions, the effectiveness of those actions, and possible future actions. Thus, lessons learned are mainly shared understandings of organizational problems and possible remedies, and they constitute the knowledge base of the organization [49].
- *Behavioral*. This action-oriented perspective focuses on changing behaviors as a result of learning [50]. The lessons learned from this perspective are the changes that must be implemented to change individuals' or organizations' future behavior, thereby institutionalizing the lessons learned [48].
- *Social constructivist.* There are two schools of constructivism [51]. In cognitive constructivism, an individual's reactions to experiences lead to (or fail to lead to) learning. In social constructivism, meaning it is not simply constructed, but is co-constructed. The social constructivist perspective challenges the traditional idea that

learning takes place within the heads of individuals through information processing. It starts from the assumption that individuals learn through constructing knowledge in practice, and that learning is situated and occurs mainly through conversations between people within their socio-cultural settings [46]. This perspective suggest that learners are social beings who construct their understanding and learn from social interaction [52]. Hence, compared with the other two perspectives, it places stronger emphasis on socially oriented approaches to the understanding of learning and knowing.

Hussein [40] argues that each of the above three perspectives is important in order to understand how learning takes place within and between projects, as well as to understand how learning impacts organizations' rules, systems and structure. For example, the *behavioral perspective* (i.e. action-oriented perspective) of the organizational learning is useful for understanding how accumulated knowledge contributes to the implementation of changes at either the project level or the organizational level, such as through changing procedures and processes [53]. The *cognitive perspective* is useful in order to understand knowledge as a utility and how receivers of knowledge interpret, process, frame, and reframe the knowledge utility in their own contexts in order to update or modify their mental models [44]. The *social constructivist perspective* is useful to understand how learning is linked to social interaction and particularly useful to understand social processes in cooperation with the cognitive perspective of learning support learning within projects or between projects [54].

The main criticism regarding the organization learning literature is that to a large extent it is too abstract and conceptual, and does not provide concrete guidelines on how to achieve learning in organizations or to measure that achievement [55], [56]. Additionally, there are many views on organizational learning that complicate understandings of organization learning as a concept. Tsang [48] even argues that the number of definitions of organizational learning is equivalent to the number of writers on the subject.

Fiol and Lyles [50] attribute the confusion about organizational learning to the original definition provided by Simon [57], who defines organizational learning as the growing insights into and successful restructurings of organizational problems by individuals as reflected in the structural elements and outcomes of the organization itself. Simon's definition suggest that learning consists of both the development of insights, and the development of structural and action outcomes. Furthermore, the two elements often do not occur simultaneously, which makes the problem of distinguishing between them difficult. As a result of this confusion, scholars have understood organizational learning from various perspectives such as new knowledge, new structures, new systems, or mere actions, or some combinations of the aforementioned.

2.3 Learning in project-based organizations

Project-based organizations often are more customer oriented than other types of organizations, and primarily operate with short-term projects that are specific to identified customer needs [58]. Additionally, project-based organizations share some distinct knowledge and learning characteristics:

1. The projects follow a stage gate model with predefined deliverables, and predefined performance goals and specifications. Thus, the teams involved in the project have then to come up with more or less customized solutions, within a strictly limited period of time. Subsequently, individuals and teams have little time for reflecting on their own collective experiences.
2. Individuals or teams may form a knowledge silo that is not accessible to members of other projects or the wider organization.

In addition, learning in project-based organizations consist of intertwined learning activities that complicate knowledge sharing and reuse [40]:

- active experimentation, reflection, accumulation of knowledge, and probably capture of knowledge within the focal project. This type of learning activities is denoted as learning within projects [59], intra-project learning [60], project-based learning [61], or simply project learning [62];
- deliberate seeking and utilization of knowledge and experience from other individuals, other projects (even outside the organization), or from completed projects, or from the organizations' asset bases to support the learning process. This dimension of learning is denoted as learning between projects [63], inter-project learning [64], and cross-project learning [62].

Intra-project learning materializes when individuals are given the opportunity to experiment, reflect and accumulate knowledge individually or in groups while being engaged in a project. This is primarily a learning-by-doing approach and is a part of the experiential type of learning [65, 66]. Experiential learning is defined by Kolb [67] as "*the process whereby knowledge is created through transformation of experience*." Kolb's experiential learning cycle has become a widely accepted model to explain the role of experience in learning (Fig. 1). Kolb's model demonstrates that experience alone without conscious reflection is not enough [68]. Rather, reflection is needed to conceptualize experiences as insights. Only then can new insights be shared and tested in new situations that in turn lead to new experiences, and ideally the cycle repeats itself.

By contrast, inter-project learning has more to do with deliberate capture, dissemination and reuse of knowledge across projects in the organization, in order to avoid repeating earlier mistakes, to improve performance, or to avoid "reinventing the wheel". Inter-project learning is about making the knowledge gained from one project available for the next project and reusing the available knowledge in the organization effectively.

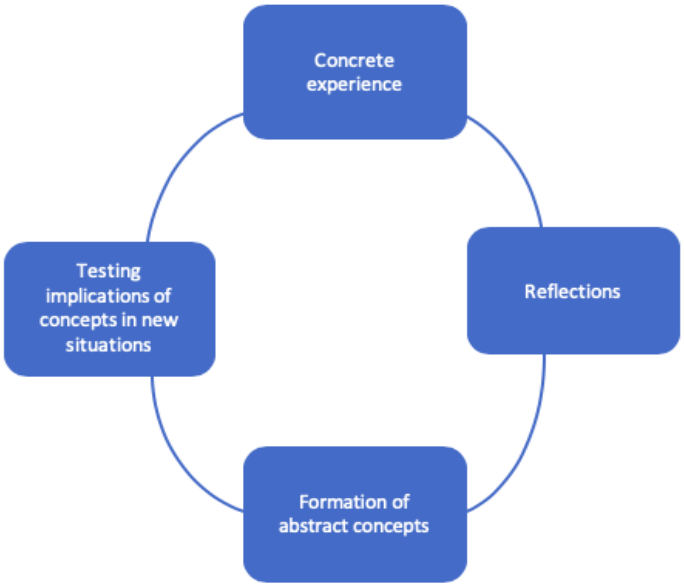

Fig. 1. Experiential learning (Kolb 1984).

2.4 Learning for innovation

With digitalization challenges facing various organization, it is imperative that they equip themselves with various capabilities including both technology and innovation related [69]. Extant studies have identified the existence of a positive relationship between learning and innovation in organizations [3, 70, 71]. A research by Tamayo-Torres et al. [70], confirmed that organizations can innovate in dynamic environments if they have a high learning capability and they further emphasize on the need to encourage learning among employees if the aim is to be innovative. Thus, for an organization to be capable of adapting to the current dynamic business environment, there must be a favorable learning environment [70].

Learning has also been found to increase employees' capabilities and competencies in their work and hence facilitates the generation of new ideas, processes, products and services [72]. As literature indicates, learning can be considered as a pre-requisite for innovation as generating new ideas requires acquiring new knowledge both from within or outside the organization, sharing the knowledge among organizational members and utilization of such knowledge to improve the nature of the existing work processes. Top management support is a crucial factor that facilitates the creation of a good learning environment because if an organization has a shared vision for instance on learning, it will tend to be more innovative [73]. Due to the positive relationship between learning and innovation, this study investigates learning as a pre-requisite for innovation and therefore adopts the term *"learning for innovation"*.

3. Method

3.1 Research sample

The aim of the study was to gain insights into project team members' preconditions for learning for innovation from projects in different organizations. Therefore, we targeted employees in several organizations who were at various levels in the organizations and actively involved in projects. There was a wide range of projects involved in the study including; information systems (IS) projects, IT projects, construction projects, administrative projects, engineering projects, product development and research projects. Furthermore, these organizations were from various sectors including manufacturing, education, oil and gas, finance, accounting and banking, engineering and health sectors. Participants were randomly selected from each sector based on work experience (i.e., working years).

The sampling frame used was from a pre-existing database that the authors had kept containing information and contacts of various organizations and professionals that they have previously collaborated in other studies. Although the pre-existing relationship of authors with the organizations and the employees facilitated easy gaining of access of the target participants, it limited the access to more participants outside the database. Furthermore, the pre-existing relationship may have influenced some of the responses and could potentially have impacted our findings. From the existing database, 120 participants were sampled.

3.2 Research approach

The questionnaire consisted of a total of four open-ended questions. The questions aimed at gaining several insights on learning for innovation in the digitalization projects. The questions were designed to collect insights on project team members' perception of learning for innovation, which pre-conditions they consider as enablers for learning for innovation and which hinder them to learn for innovation and how they are able to know if they have actually learned for the purpose of innovating. The questionnaires were sent by e-mail to each participant by the authors. The method was chosen because it enabled coverage of a wide variety of geographically spread participants. Since the participants were all professionals, both the wording and participants' ability to understand the questions was not a major concern. Rather, the concerns were the response time, response rate and the straightforwardness of the questions. To ensure that

the participants' responses would yield useful results, a pilot was conducted which led to some modifications to the questionnaire based on the feedback from the pilot. Subsequently, the questionnaire was sent to all 120 identified participants. To ensure a high number of responses, participants were assured of their anonymity. Follow ups were done through e-mail and phone for a period of one month (March 18, 2020 to April 18, 2020). A total of 97 completed responses were collected. The demographic profiles of the respondents are presented in Table 1. The data was then imported into NVIVO software where coding into relevant themes was done to facilitate performing a qualitative analysis of the data.

Table 1. Demographic profile of respondents

Age		**Work experience**		**Sector**		**Role**	
Range	**N**	**Range**	**N**	**Type**	**N**	**Type**	**N**
20 ≤ – ≤ 29	18	0 ≤ –≤ 5	31	Manufacturing	13	Project manager	21
30 ≤ – ≤ 39	71	6 ≤ – ≤ 10	49	Education	14	Project team leader	13
40 ≤ – ≤ 49	7	11 ≤ – ≤ 15	12	Oil and gas	16	Project team member	21
50 ≤ – ≤ 59	1	16 ≤ – ≤ 20	5	Engineering	19	Project coordinator	12
				Health	15	Project engineer	19
				Finance, accounting and banking	20	Project consultant	7
						Not disclosed	4
Total	**97**	**Total**	**97**	**Total**	**97**	**Total**	**97**

4. Findings

The findings of the data are presented in this section.

4.1 The perception of learning for innovation in digitalization projects

The findings indicated that the majority of participants had adequate understanding on both learning and innovation and the dependence of one on the other. Although the perceptions of learning for innovation among the project team members were fairly similar, there were two viewpoints observed. Some perceived learning for innovation as acquisition of new knowledge, or adding knowledge to what one already possesses;

"means to gain knowledge or skill in something by studying, experience or being mentored"

"is the process of gaining knowledge and skills and putting them to use in our daily lives"

Others associated it with the adoption of a new way of doing things i.e., change in behavior;

"is becoming aware of other means and ways to do what we do in an inclusive, efficient, effective and context tailored manner"

4.2 Enablers of learning for innovation in digitalization projects

When asked on what factors they considered necessary to enable their learning for innovation, four factors appeared to stand out. These were; a supportive work environment, the support of top management, the nature of a job itself, and willingness to learn.

4.2.1 A supportive work environment

Majority of the participants acknowledged that a supportive work environment is necessary to facilitate learning for innovation. For team members to learn, a welcoming environment that supports openness and sharing opinions without fear of being penalized is required. To achieve innovation, there must be an opportunity of trial and error;

"a work environment that does not penalize human error"

"a work environment that is open and allows staff to express opinions with no fear of repercussions"

4.2.2 Support of top management

There was consensus that the support of top management is crucial to enable learning for innovation in an organization. Individual effort without top management approval or support would be in vain since they are responsible for the overall strategic direction of the organization;

"through top management's approval for continuous learning coupled with efforts to create an enabling environment that enhances learning"

"my organization has a budgeted plan to ensure all employees attend different trainings relevant to their jobs"

4.2.3 Nature of the job/task

It was also observed that the nature/ type of job can have influence on people to learn for innovation. For instance, some jobs are more dynamic than others and thus require people to be highly up-to-date with the knowledge change;

"due to the nature of my job, I have to keep up with technology development and dynamics of the oil and gas industry"

However, some people are given more autonomy in their tasks to discover solutions. This facilitates them to learn more during the accomplishment of tasks;

"I learn frequently because I get the opportunity to explore and find solutions to my work-related challenges"

Some jobs are naturally more practical and therefore more engaging which facilitates learning through doing;

"I learn more through doing things in a more practical manner"

Work flexibility can also facilitate learning for innovation as it provides enough time for people to learn new things. For instance, with flexibility in work schedule, employees can attend classes or trainings online that may add value to their work;

"I have managed to learn outside work because of flexibility of my working schedule"

4.2.4 Willingness to learn

Apart from external factors, willingness to learn was observed to be another important enabler. Even if the organization provides all the other necessary enablers, if the employee is not willing then it will all be incapable of producing useful output. There was consensus among the participants on the importance of internal motivation to learn;

"the desire to do better and deliver more efficiently is what motivates me to learn"

4.3 Hinderances of learning for innovation in digitalization projects

When asked on what factors they considered hinderances to learning for innovation, factors mentioned were: internal competition among peers, leadership style that does not support learning, heavy workload, and lack of performance appraisals.

4.3.1 Internal competition among peers

The team members stated that if their peers worked in a competitive manner rather than collaborative, it was likely that learning would be hindered. This is because people tend to hide knowledge from each other instead of sharing it openly. This is a negative attitude which does not support learning among team members and the organization at large;

"skewed competition among peers leading to hiding of particular knowledge from each other"

4.3.2 Leadership style that does support learning

A leadership/management style that does not support learning is a hinderance to learning for innovation. Some participants stated that some leaders can be a hinderance if they take the credit for the work done by their subordinates;

"overshadowing bosses are a hinderance to learning"

Moreover, some participants stated that some leaders/management chose not to support continuous learning of their employees because they fear that once they become more valuable, they may opt to search for employment elsewhere for a higher pay. Although this is a possibility, it also means that there is loss of value which could be attained with more knowledgeable employees;

"top management fears that their staff would leave for greener pastures elsewhere once they are better off"

Leadership style that focuses more on results rather than employee growth does not provide opportunity for team members to learn for innovation. Team members tend to focus on doing only what is expected of them and because they do not feel motivated to learn;

"lack of staff motivation hinders them to involve in learning"

4.3.3 Heavy workload

The participants stated that having a high workload coupled with very close supervision limited their opportunities to learn;

"being overwhelmed with work load is a big hinderance towards learning for innovation"

4.3.4 Lack of performance appraisals

The team members stated that the lack of individual performance appraisals could hinder learning because being faced with learning expectations provide the challenge to learn. Having performance objectives facilitates employees to find different ways to meet and even surpass them, hence learn and innovate during the process. As stated by participant,

"poor learning plans or arrangements hinder our learning"

4.4 Immediate impact/evidence for learning for innovation in digitalization projects

When the participants were asked how they are able to know that they have learned, the results revolved around four factors; work efficiency improvement, change in behavior, problem solving ability and knowledge sharing ability.

4.4.1 Work efficiency improvement

The project team members stated that they can identify they have learned for innovation when they observe a noticeable improvement in their work efficiency. For instance, if they take less time in performing the same amount of work or they become more confident in making decisions related to their tasks;

"when I observe an increased efficiency in my work"

Some participants associated the evidence of learning for innovation with proper resource use in achieving their goals;

"when I can effectively utilize the resources to attain goals"

Moreover, we observed that recognitions from the organization are considered as evidence that they have learnt something new and utilized it differently such that it has been acknowledged;

"when I get recognition from the organization"

4.4.2 Change in behavior

Another factor that enabled the team members to identify that they have learned and are able to innovate is when they noticed a change in their own ways of working (i.e., change in behavior);

"when I am able to do things differently from before"

In addition, they expressed a noticeable change in how others view and treat them pertaining to work related tasks;

"the increasing number of people who need my consultation in their tasks"

4.4.3 Problem solving ability

The team members also stated that when they noticed an increase in their ability to solve problems encountered during the accomplishment of tasks then they know that they have learnt for innovation. Also when their confidence increases such that, they are comfortable to accomplish tasks without fully depending on others;

"when I am able to utilize what I have learnt in solving different problems in my daily tasks"

4.4.4 Knowledge sharing ability

The team members' also stated that when they are able to share knowledge with ease, it is another evidence that they have learnt for innovation. One participant said:

"I know I have learnt when I am able to execute a task and pass the same skills to someone else"

5. Discussion

The aim of this study was to examine the preconditions of learning to facilitate innovation in digitalization projects from the perspective of project team members. Numerous studies have been done on the preconditions of learning, however, not much attention has been done in the current digitalization context, which is the focus of this study.

Our study shows that project team members have a significant understanding and a positive perception towards learning for innovation. This can be attributed to both learning and innovation being commonly used terms in the digitalization context. Moreover, digitalization process facilitates learning and in turn learning leads to the success of digital transformation [14]. In addition, learning and innovation are mutually related i.e., in order to innovate, one requires to learn and through innovation, one keeps learning. This is in line with existing studies [1, 3, 27, 40, 70, 71].

Most of the preconditions found in our study are in agreement with extant studies. For example, top management support has been found to be an extremely critical factor in facilitating learning in dynamic environments [59, 73, 74], which was further proved by our study. To achieve learning for innovation, organizations cannot expect to stick to the old way of doing things. In this respect, leadership plays an important role as they are responsible for ensuring that the necessary factors are implemented [35]. For example financially through investing in trainings, socially through encouraging employees to collaborate and ask for help and strategically through encouraging managers to develop mentoring and learning schemes for their subordinates as supported by Rhoades and Eisenberger [33] and Bassett-Jones [34].

Similarly, individual willingness to learn and a supportive work environment have also been mentioned in several extant literature [4, 24, 25, 35, 40]. Moreover, existing studies suggest that the best way to ensure that new knowledge is created, is for organizations to allow room to put newly acquired knowledge into practice, which is the essence of innovation itself. One way to facilitate this is through having a favorable climate/environment that supports employee practice [35] as this may lead to errors reduction, problems solving, tackling challenges, developing creativity and enhancing motivation. Because this requires putting effort, it can only be achieved if the employees are proactive as stated by Escrig-Tena et al. [29].

The findings of this study are in line with Hussein [40] who emphasizes that for an organizational environment to be supportive of learning in organizations it must have the following characteristics:

- Encourage individuals to recognize their *own limitations and encourage individuals and teams to* seek and ask for help when needed.
- Encourage individuals/team members to avoid being trapped by old habits but to be open to new ideas and concepts.
- Encourage individuals/team members to challenge the established truths, norms and rules.
- Creating a work environment characterized by psychological safety and tolerance for mishaps in order to encourage experimentation, sharing and challenging of the rules, and to find innovative solutions encountered during project development.
- Encourage collective engagement in order to understand the perspectives of the various parties involved in a project.

However, our findings showed that the nature of the task/job as one of the preconditions for learning, that has not been mentioned in the literature reviewed for this study. It is our belief that this factor appeared in this study because of the dynamism of digitalization projects and may therefore be particularly relevant in this context. The demanding

environment compels employees to stay updated to remain valuable and competitive. Although digitalization attracts new opportunities that facilitate effectiveness and add value, it simultaneously disturbs existing operations [75], thus demands employees to continuously keep their knowledge and skills up to date.

Regarding the hindrances of learning for innovation, most factors are relevant to those in existing literature. For example, excessive workload and a leadership style that is not supportive of learning; are commonly known factors in existing literature [76-78]. However, two factors from this study were not observed in our reviewed literature; (i) internal competition among team members and (ii) lack of performance appraisals. In digitalization projects, collaboration is crucial, therefore internal competition should be highly discouraged. Similarly, appraisals are important to evaluate and determine how and where employees are adding value to the overall organizational performance.

Additionally, extant literature has shown the association between employee learning and overall organizational performance [12, 13, 37, 40]. However, our findings also revealed the immediate outcomes/evidence of learning. As mentioned earlier, practice is a significant part of the learning process if innovation is the goal. Evaluations are important because they improve the decision making process [38]. These learning outcomes can only be evaluated after new knowledge has been acquired and acted upon, and new concepts formulated and tested through practice i.e., trial and errors [67]. The improvements observed as a result of such practice are in themselves the essence of learning for innovation. This information can be useful for organizations to assess individual learning of their employees. We therefore suggest that managers/ team leaders to conduct periodic evaluations of their team members' problem-solving abilities, knowledge sharing abilities and work efficiency improvements as this may play a vital role in motivating team members to continue learning.

6. Conclusion

In this article, the preconditions for learning to support innovation in digitalization projects were investigated from the perspective of the project team members. We addressed this through four research questions and our findings revealed the following conclusions:

- The perceptions of the team members were based on two viewpoints; some members perceived learning for innovation as acquisition of knowledge, while others perceived learning for innovation as a change in behavior.
- Willingness to learn, support of top management, a supportive work environment and the nature of the job/task were identified as enablers of learning in digitalization projects. While the three former enablers can be found in several literature reviewed for this study, none mentioned the latter. Our contribution is that, since digitalization projects are characterized by constant change, the nature of the job/task compels people to learn, thus innovate.
- Internal competition from peers, lack of appraisals, leadership that does not support learning, focusing on results rather than growth and heavy workload were identified as hinderances towards learning for innovation. Whereas the latter three are quite common in existing literature, the former two are new contributions in the digitalization context.
- However, it is not sufficient to provide the preconditions for learning for innovation without a means to evaluate if the employees are actually learning. Immediate outcomes of learning were identified as; improvement in knowledge sharing ability, improvement in problem solving ability, improvement in work efficiency and behavior change.

In addition, this study has limited focus on the team members' perception on learning for innovation, further studies can be explored from the management perspective so as to compare the results and identify if there are any major differences in their perspectives.

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Understanding the career dynamics of IT professionals in digital transformation times: a systematic review of career anchors studies

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Abstract:
The concept of career anchors has long been a reference model to guide Human Resources Management (HRM) practices within the information technology (IT) discipline. However, as the digital transformation phenomenon grows increasingly disruptive, the misalignment of human resources is becoming more apparent as IT professionals are faced with mixed job demands requiring multidisciplinary skillsets. Along with the lack of workforce diversity and high turnover rates, these HRM challenges are impacting career dynamics and talent management practices. A systematic literature review of 20 empirical studies reveals three broad themes: debunking the dual-ladder construct of traditionally opposing technical and management career paths, fostering a diverse workforce through a variety of demographic profiles, and understanding the response strategies of IT professionals. While career anchors proved to be a useful model, it falls short in the context of the current structural changes of professional career choices and talent requirements, which requires a more diverse and dynamic model. This finding leads to a new research agenda emphasizing the study of Business Technology Management (BTM). This new concept refers to an emerging transdisciplinary profession, uniting Project Management (PM), Information Systems (IS) and IT competencies within a common body of knowledge for leading digital transformation projects.

Keywords:
career dynamics; information technology (IT); career anchors; human resources management (HRM); business technology management (BTM), digital transformation.

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1. Introduction

"Although the importance of project management is nowadays widely acknowledged and the evolution and importance of project-based organizations has received quite some attention in theory and practice the role and the motivation of the individual project manager is still under-researched" [1].

More than ever, research efforts are required to understand the motivations of project managers as Information Technology (IT) professionals are increasingly called up to fulfill project management (PM) roles across various organizations. Combined with the importance of project-based organizations, their roles have also greatly evolved due to the intensity of the digital transformation phenomenon. Ultimately, this has created a misalignment of human resources that is causing a talent shortage. Project success requires IT executives and hiring managers to revisit their Human Resources Management (HRM) practices and adjust them in the context of these new complex roles, ensuring more effective recruitment, retention, and talent management strategies.

The widespread digital transformation phenomenon has caused major disruptions requiring important structural changes to organizations including the need for professionals to assume new roles outside of their traditional functions [2]. Professionals with a non-IT background are faced with managing IT projects and conversely, IT professionals are expected to assist with the realization of these new IT projects [2]. This requires individuals to be proficient in multiple knowledge areas traditionally considered separate disciplines. Furthermore, digital transformation has caused organizations to shorten the lifecycle of those roles, driving professionals to change the way they think about the timeframe of their careers.

In response to digital transformation, Business Technology Management (BTM) was introduced in 2009 by the IT Association of Canada (ITAC) as a way of redefining the traditional career perspectives within technology-focused disciplines. BTM merges various business, project management and technical skills supported by core references to lead digital transformation projects within all types of organizations [3, 4]. This initiative has grown into a global community of professionals who master a broad range of integrated skillsets required by digital transformations [5].

BTM embodies a brand, a concept and a profession [5]. As a brand, BTM is a registered trademark in over 100 countries including Canada and the United States. Moreover, several Canadian academic institutions now offer a BTM program to bridge the business and IT learning curricula. As a concept, BTM promotes digital leadership from the highest strategic level of the organization to address the digital transformation [5]. As a profession, BTM includes practitioners with hybrid skillsets encompassing business, technology, and management. Since BTM blurs the traditional career boundaries of IT professionals, it has the potential to establish career paths across multiple specializations to address the talent shortage crisis. To accomplish this, research focused on career dynamics is required to shed light on the motivations of professionals that could fit within the BTM umbrella.

Accordingly, this literature review will assess to what extent existing studies of IT professionals and their career dynamics can provide insights into how HRM practices can evolve to address the misalignment of human resources in the IT discipline. The career anchors framework is the primary focus of this review as it is a widely studied model. Thus, the literature reviewed in this article focuses on the career orientations of IT professionals through the lens of the career anchors framework. The results of this study will validate the BTM initiative in the context of the digital transformation.

This article is divided into four main sections. The first section explains the misalignment of human resources in the IT profession, which include the evolution of roles in the IT sector, the lack of workforce diversity and high turnover rates. The second section provides an overview of Schein's career anchors. The third section is the heart of this article as it presents the literature review of 20 empirical studies under the umbrella of three broad themes: debunking the dual-ladder construct, fostering a diverse workforce through demographic profiles, and understanding the response strategies of IT professionals. The fourth section discusses BTM as a promising framework to model the diverse and dynamic career paths of IT professionals. The article concludes with suggestions for new research and highlights the limitations of the study.

2. The misalignment of human resources in the IT discipline

Based on the current literature, HRM challenges have emerged that appear to be causing a misalignment of human resources in the IT discipline such as the evolving roles in the IT sector, the lack of workforce diversity and high turnover rates. As these HRM challenges negatively impact recruitment, retention and talent management, individuals may find themselves in the wrong job based on their skillsets while the ideal candidates may be overlooked.

The main challenge affecting HRM is the evolution of roles in the IT discipline that have created a gap between the skills that professionals have and those that they require to undertake multidisciplinary roles. Typically, IT professionals either specialize in a technical field throughout their career or branch out into a managerial path in later career stages; indicating a potential shift in their underlying career motivations [6, 7]. However, today's professionals are increasingly faced with mixed job demands that require a blend of technical and managerial skills [7]. One reason for this evolution is the increase in project-based organizations that requires IT professionals to develop managerial skills early on to direct projects while retaining the skills to perform technical duties [1, 7].

The widespread use of digital technologies to improve organizations, industries and societies is also causing roles to evolve as IT professionals are becoming increasingly involved in digital transformation projects [2]. In fact, the digital transformation phenomenon is often cited in the literature as inducing disruptive changes to the organization, including human resources [2, 8, 9]. Digital transformation has caused various job roles to evolve according to need for new types of knowledge and skills [9]. For the non-IT professional, this means that they may have to learn new technical skills. For the IT professional, this means that they may have to understand the business strategy as was highlighted in a case study from the oil and gas industry by Kohli and Johnson [10] where Chief Information Officers and IT managers learned that they must first gain insight into the business strategy before implementing digital solutions. Therefore, a combination of skills is necessary for the IT professional to successfully take on the multidisciplinary roles available to them along their career path. Yet, it is unclear whether these evolving job demands align with the underlying motivations of the individual.

Another HRM concern is the lack of diversity in the IT workforce. While the benefits of a diverse workforce are well-known, the career dynamics of individuals with identity-based differences are not well understood. The IT sector is perceived to be a high-pressure environment where it is difficult to keep up with specialized technical skills for long periods of time [6]. This commitment conflicts with the work-life balance of older workers who prefer to spend more time with their families [6]. The desire for a healthier work-life balance may explain why some individuals transition from a specialized field to more generic management positions later in their career. Ultimately, there exists an age bias in a workforce that deals with new technologies and innovative firms, which is predominant in the IT sector [11]. To retain a progressively ageing workforce that contributes to its diversity, employers need to pay attention to the changes that may occur in the underlying motivators of individuals.

Likewise, gender equality is an ongoing problem as women represent only 26% of the IT workforce in developed countries and are reportedly earning $20K less than men [12, 13]. Pay disparity as well as discrimination and lack of advancement opportunities are some of the reasons that women choose to leave the IT sector [12]. Women face different work-life balance issues than men since most women are still primarily responsible for childcare and household duties [14]. The significant underrepresentation of women is detrimental to the diversity of the IT sector.

Furthermore, with the growing popularity of crowdsourcing platforms, consultant opportunities and startup companies, there is a shift away from the traditional career progression that is leading to higher turnover rates within the IT sector [15, 16]. In fact, LinkedIn reports that the IT sector has the highest talent turnover rate across all sectors with a turnover rate of 13.2% [17]. Several factors are thought to act as the driving force behind the high turnover rate including high demand, rising compensation and the project-focused nature of the work [7].

These issues act as career barriers from both an organizational and individual perspective, creating a misalignment of human resources within the field. From an organizational perspective, companies may struggle to recruit and retain individuals with the skills required for the job. Conversely, from an individual perspective, the jobs that are available may not match what the individual wants if it does not fulfill their career motivations and values.

3. The career anchors framework

The concept of career anchors provides a compelling framework for understanding the career dynamics of IT professionals because it provides "valuable insight into employee motivation and career development" [18]. Although the concept emerged almost half a decade ago, the career anchors model is still relevant for today's working professionals [19]. In particular, the career anchors model is widely applied in the current literature to gain insight into the underlying motivations of IT professionals; thus, it is a good model for this study.

Career anchors emerged from a longitudinal research study carried out by Edgar Schein in the 1960s and 1970s [20]. A sample of 44 male alumni from the Sloan School of Management was interviewed as students in 1961-1963 and then re-interviewed post-graduation in 1973-1974 to answer questions related to career attitude. Schein initially identified five common themes from these interviews to explain what individuals want from their careers, which he coined as career anchors [21]. Through follow-on studies, Schein eventually adapted his career anchors model to include eight career anchors that explain the underlying motivations of individuals with regards to their careers. The following describes Schein's career anchors:

- General managerial competence (GM): The individual who values management activities and roles.
- Technical functional competence (TF): The individual who values the ability to refine their technical skills.
- Entrepreneurial creativity (EC): The individual who values entrepreneurship and creativity.
- Autonomy/independence (AU): This anchor is closely linked with EC and describes the individual who values the freedom of defining their own work in their own way.
- Security/stability (SE): The individual who values certainty or tenure in their job.
- Service/dedication to a cause (SV): The individual who values work that they believe contributes value to the larger society.
- Pure challenge (CH): The individual who values challenges and overcoming obstacles.
- Lifestyle (LS): The individual who values a healthy work-life balance that meets the needs of their professional careers and personal lives.

Schein's subsequent work at the end of the twentieth century predicts that the evolution of the labour market will cause shifts in the content and structure of career anchors [19]. As technology is rapidly evolving, Schein predicts that technical experts will continue to be in demand. At the same time, general managerial competence will also continue to be in high demand, especially at the lower more technical levels where greater coordination will be required: "Team managers, project managers, and program managers will have to have general management and leadership skills above and beyond their technical understanding of the tasks at hand" [19]. This precisely describes the blend of technical and managerial skills that are required by IT professionals today.

The existing literature offers several criticisms of Schein's careers anchors framework. Feldman and Bolino [22] and Chapman and Brown [23] critique Schein's notion that individuals have only one career anchor. Rather, they argue that multiple career anchors can exist to satisfy multiple career goals. The results of the study by Chapman and Brown [23] revealed that 86% of respondents had more than one career anchor. Yet, while Schein believes that there is only one dominant career anchor defining a career path, he acknowledges that individuals can be anchored in several areas [21]. Another concern with career anchors is that the individual needs to possess the introspective ability to understand their strengths and weaknesses in order to properly identify their career anchors [22]. Moreover, the availability of jobs as well as personal constraints can severely limit the ability of an individual to make career decisions that are compatible with their career anchors [22]. However, the latter two criticisms were not tested empirically by the authors.

There are also variations of Schein's career anchors model in the literature. One variation that is widely applied in empirical studies is derived from Thomas DeLong, who identifies two additional career anchors: identity and variety [24]. The identity anchor represents the sense of belonging to a specific organization. The variety anchor represents a

preference for a wide range of challenges, which can be likened to Schein's pure challenge anchor. Moreover, DeLong separates security and stability into two distinct career anchors where the former refers to geographic security and the latter refers to organizational stability.

4. Methodology

4.1 Research Method

A systematic literature review was undertaken to collate existing empirical studies on the career dynamics of IT professionals through the lens of the career anchors framework to provide insights into how HRM practices can evolve to address the misalignment of human resources in the IT discipline. This type of review is useful for synthesizing accumulated knowledge within the IT discipline in a rigorous and standardized manner [25]. Moreover, it supports the pragmatic approach underpinning this research, which is a practical problem-solving philosophy where "what people believe to be true is what they find to be useful" [26]. With pragmatism, the researcher is not forced to choose research methods that are deeply tied with the traditionally opposing views of positivism or constructivism.

4.2 Selection of articles

The records included in this literature review had to be published in peer-reviewed academic journals, which means that books and conference proceedings were excluded as neither necessarily go through a rigorous peer-review process. In fact, peer analysis was the primary criteria for validating the quality of the article. Moreover, to be included in the review, the following selection criteria were applied: 1. article must apply the career anchors framework or a wellknown variant of the framework; 2. article must focus on the IT profession or any other related profession including but not limited to management information systems (MIS), the information systems (IS) and software/computer engineering and; 3. article must provide empirical results. Only articles published after 1974 were considered as this is when the career anchors framework emerged in the literature.

This article used the four-step method preferred reporting items for systematic reviews and meta-analyses (PRISMA): 1-Identification; 2. Screening; 3. Eligibility; 4. Inclusion. Figure 1 depicts the flowchart of the literature search, which corresponds to the four steps of the PRISMA method.

Identification: The following search phrase was used in the Scopus database: "information technology professional" OR "information systems professional" OR "project management professional" AND "human resources" AND "career dynamics". The keywords were picked to allow for the broadest possible search results to identify frameworks for understanding career dynamics other than Schein's concept of career anchors that may be widely applied in the research.

Screening: Screened 53 records. Eight records were excluded as they were either books or conference proceedings.

Eligibility: 45 articles were assessed for eligibility. 33 articles were excluded: five articles did not provide empirical results; 17 articles were focused on non-IT professions; and 11 articles did not apply the career anchors framework. Moreover, of the latter 11 articles that did not apply the career anchors framework, there was no other prevalent framework that emerged for understanding career dynamics; thus, confirming that the career anchors framework is the most widely used framework.

Inclusion: 12 articles were initially included in the review. Subsequently, a manual scan was conducted of the references included in the 12 articles and an additional eight relevant articles criteria were identified that met the selection criteria. As such, a total of 20 articles were included in the review.

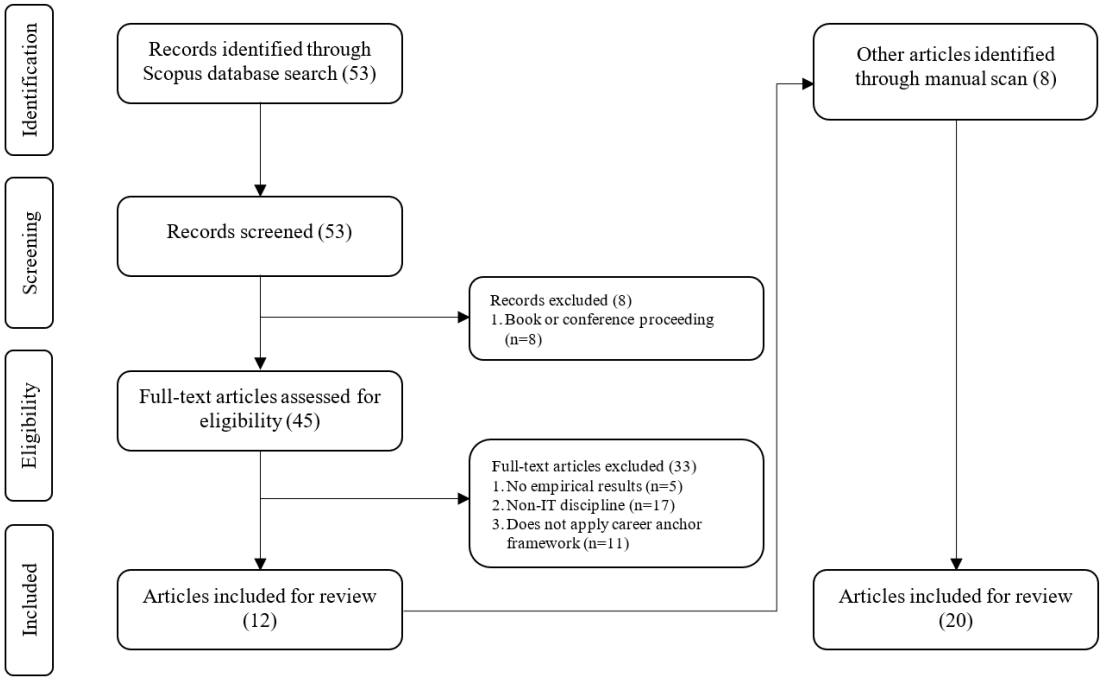

Figure 1: Flowchart of the literature search according to the four steps of the PRISMA method

5. Insights from the career anchors framework

Based on the literature review, three broad themes emerged from the literature that correspond to the HRM challenges at the core of this article: 1. debunking the dual-ladder construct; 2. fostering a diverse workforce through demographic profiles and; 3. understanding the response strategies of IT professionals. As several articles corresponded to more than one theme, the articles were matched with what was perceived to be the overarching theme intended by the author(s). Table 1 represents the 20 articles along with descriptive characteristics of the studies including year, country, participants, sample size (n) and the corresponding theme. The following describes the themes in more detail:

1. Debunking the dual-ladder construct: This theme represents five articles that are useful for guiding HRM practices that address the evolving roles of IT professionals. The studies challenge the traditionally opposing management or technical career paths. Moreover, they challenge the notion that the dominant career orientations are necessarily management or technical competencies due to the evidence that a wide range of career orientations exist.

2. Fostering a diverse workforce through demographic profiles: The bulk of the articles falls within the umbrella of this theme. A total of 11 articles shed light on the career dynamics of individuals with identity-based differences. The studies use the career anchors framework to build profiles of individuals with various demographic backgrounds, which may be useful for addressing the lack of diversity within the IT workforce. The articles are further divided into four sub-themes that represent these demographic backgrounds: students and entry-level personnel, senior personnel, gender roles and cultural diversity.

3. Understanding the response strategies of IT professionals: This theme encompasses the remaining four articles that use the career anchors framework to investigate three common response strategies of IT professionals when making decisions about their career: 1. retention is where an individual chooses to remain within the same organization; 2. turnover is where an individual will leave an organization and find a job elsewhere within their current field; and 3. turnaway involves experiencing a job change outside of one's current field.

Table 1: 20 Empirical studies of career anchors categorized by themes

Author(s)	Journal	Year	Country	Participants	n	Debunking dual-ladder	Demographic Profiles				Response Strategies		
							Entry-level	Senior	Gender	Cultural	Retention	Turnover	Turnaway
Arnold, Coombs et Gubler (2019)	International Journal of Human Resource Management	2019	Europe (Switzerland/ UK/Germany)	IT Professionals	1629						x		
C. L. H. Chang (2010)	International Journal of Information Management	2010	Taiwan	MIS Professionals	353					x			
C. L. H. Chang, Shen et Wu (2020)	Journal of Global Information Management	2020	China/Taiwan/ India/UAE/US	IT and IS Professionals	859					x			
C. L. H. Chang, Chen, Klein et Jiang (2011)	European Journal of Information Systems	2011	Taiwan	IS Professionals	10								x
C. L. H. Chang, Jiang, Klein et Chen (2012)	Information and Management	2012	Taiwan	IT Professionals	10							x	
I. C. Chang, Hwang, Liu et Siang (2007)	Journal of Computer Information Systems	2007	Taiwan	IS Students	145		x						
Crepeau, Crook, Goslar et McMurtrey (1992)	Journal of Management Information Systems	1992	United States	IS Professionals	321	x							
George et Joji (2011)	IUP Journal of Organizational Behaviour	2011	India	IT Professionals	236							x	
Huang (2008)	International Journal of Business and Systems Research	2002/ 2006	Taiwan	IS Professionals	106/ 150					x			
Hsu, Chen, Jiang et Klein (2003)	Data Base for Advances in Information Systems	2003	United States	IS Professionals	153			x					
Igbaria, Greenhaus et Parasuraman (1991)	Information Technology & People	1991	United States	MIS Professionals	464	x							
Igbaria, Meredith et Smith (1995)	Journal of Strategic Information Systems	1995	South Africa	IS Professionals	112					x			
Jiang et al. (2020)	IEEE Transactions on Engineering Management	2020	United States	IT Professionals	164	x							
Jiang et Klein (1999)	Journal of Management Information Systems	1999	United States	Entry-level IS Professionals	101		x						
Jiang, Klein et Balloun (2001)	Information and Management	2001	United States	Entry-level IS Professionals	101		x						
Jiang, Motwani et Pick (1996)	Journal of Computer Information Systems	1996	United States	IS Students	135		x						
Quesenberry et Trauth (2012)	Information Systems Journal	2012	United States	Women IT Professionals	210				x				
Ramakrishna et Potosky (2001)	Journal of Computer Information Systems	2001	United States	IS Professionals	163	x							
Ramakrishna et Potosky (2003)	Human Resource Development Quarterly	2003	United States	IS Professionals	163	x							
Wong, Fiedler et Liu (2007)	Issues in Information Systems	2007	United States	IS Students	106		x						

5.1 Debunking the traditional dual-ladder construct

At one time, technical and management positions were traditionally considered opposing career paths as one would typically hold purely technical or management positions throughout their career or switch from a technical path to a management path in later stages of their career. In either case, this dual-ladder construct considered technical and management roles to be mutually exclusive. The dual-ladder construct was also reflected in career orientations, where professionals were thought to be primarily oriented by technical or managerial preferences. Using the career anchors framework, Igbaria et al. [27], Crepeau et al. [28] and Ramakrishna and Potosky [29], [30] debunk the commonly accepted notion of the dual-ladder construct as they reveal a wide-range of career orientations that shape the career path of individuals. Moreover, with the increase in mixed job demands, Jiang et al. [7] challenge the theoretical perception that the technical and management career anchors are contradictory.

Studies from the early 1990s started to pay attention to the diverse career anchors that influence the career decisions of IT professionals. Igbaria et al. [27] conducted a study among 464 MIS professionals from various demographic backgrounds to examine their career orientations in relation to work experiences and job attitudes. While almost half of the population surveyed valued managerial and technical career orientations, the other half valued different career orientations such as autonomy and lifestyle integration. Likewise, around the same timeframe, Crepeau et al. [28] surveyed 321 IS personnel in a variety of industries confirming the wide variety of career anchors. The study also revealed stability as a dominant career anchor of IS personnel in addition to the management and technical anchors, reflecting a preference for job security, a stable income and retirement benefits.

A decade later, a significant shift occurs in the career anchors of IS professionals. Whereas previous studies included managerial and technical competence among the dominant career anchors, the study conducted by Ramakrishna and Potosky [29] found that only 8% of respondents with the same demographic characteristics as those in Igbaria et al. [27] valued these competencies. Instead, the findings suggest that IS professionals prefer to have geographic security and organizational stability, reflecting their preference to stay in the same geographic location and within the same firm.

Ramakrishna and Potosky [30] introduce the notion of composite career anchors, where individuals have multiple dominant career anchors. The authors examine the career anchors of 163 IS professionals to reveal that almost half of the participants maintained composite career anchors. These findings contradict Schein's career anchors framework where only a single dominant career anchor is thought to exist.

Finally, Jiang et al. [7] posit that IT professionals are now faced with mixed job demands where they must apply a blend of technical and management skills in the same position. The authors sampled 164 IT professionals in the United States (US) to determine the ideal blend of management and technical orientations that would lead to the highest job satisfaction. The results reveal that professionals prefer a moderate blend of technical and management demands. Job satisfaction is lowered when the demand is disproportionate; that is, when the blend of competencies is too low or too high.

Overall, these studies show that the career anchors framework is an effective model for challenging the traditionally opposing career paths within the IT profession and ultimately debunking the dual-ladder construct. However, while these findings are useful for understanding a collective shift in career orientations, the career anchors model falls short in providing a comprehensive understanding of an individual's career orientations as it neglects the complexity of composite career anchors and the dynamic aspect of career orientations brought on by the digital transformation. This also serves to validate the main criticism of the careers anchors model that was raised by Feldman and Bolino [22] and Chapman and Brown [23] in Section 3.

The findings of these studies are summarized in Table 2.

Table 2: Findings of the studies under the theme "debunking the traditional dual-ladder construct"

Author(s)	Findings
Igbaria et al. [27]	IT professionals hold a wide range of career anchors beyond technical and managerial competence.
Crepeau et al. [28]	
Ramakrishna and Potosky [29]	
Ramakrishna and Potosky [30]	IT professionals can hold more than one career anchor (composite career anchors).
Jiang et al. [7]	IT professionals prefer a proportionate blend of technical and management demands in their jobs.

5.2 Fostering a diverse workforce through demographic profiles

Students and entry-level personnel

Students and entry-level personnel represent IT professionals at the beginning of their career path and with many years left to fulfill their career aspirations. Chang et al. [31] propose that there exists a relationship between the career anchors of students and their job preferences. The findings revealed three leading career anchors among the 145 Taiwanese IS students that were surveyed: job security, lifestyle, and service. The findings also revealed varying preferences among different groups of students: undergraduate students value technical competence, graduate students prefer managerial competence and students undertaking a master of business administration (MBA) value lifestyle and job security. The preference for job security can be explained by the low unemployment rate in Taiwan and the value of lifestyle corresponds to the importance of family and social relationships in the Taiwanese culture.

Alternatively, Wong et al. [32] examine what motivates business students to major in IS. The results show that students believe the IS career path is unlikely to fulfill their needs when compared to the four other majors available to them: finance, accounting, marketing, and management. Marketing and management were perceived as majors more likely to achieve competency in general management, service to a cause and pure challenge. Moreover, marketing was thought most likely to lead to independence, maintaining a selected lifestyle and entrepreneurial creativity while management was considered most likely to lead to job security and stability.

Jiang et al. [33], Jiang and Klein [34] and Jiang et al. [35] focus on the career anchors of the entry-level professional and their relationship with job satisfaction. Like the studies that served to debunk the dual-ladder concept, these studies confirm that entry-level professionals also identify with many career orientations. In fact, Jiang et al. [33] found that 50% of their respondents ranked job security as their dominant anchor, which corresponds with the findings of the other studies by Crepeau et al. [28] and Ramakrishna and Potosky [30].

Another study by Jiang and Klein [34] uses a variation of Schein's career anchors construct to reveal that variety and service are significantly related to the career satisfaction of entry-level professionals. This reflects the individual's desire for a variety of job assignments and challenges as well as the opportunity for commitment to an important cause. Likewise, Jiang et al. [35] found variety to be a dominant career anchor among professionals at the entry-level stage.

Given the results of these current studies, students and entry-level personnel seem to value a variety of career anchors. The findings of the study by Wong et al. [32] offer meaningful insight to support BTM as a promising transdisciplinary academic program and profession because BTM intersects multiple disciplines including finance, accounting, marketing, management, which are areas at the core of the digital transformation roles within non-IT business units.

Senior Personnel

Unlike students and entry-level personnel, senior personnel represent individuals who find themselves towards the end of their career. Hsu et al. [36] examine the career satisfaction of senior personnel who are in the later stages of their career, which include Stage 3 (mentor) where one starts to lead junior employees and Stage 4 (sponsors) where one starts to become a leader within the organization. Limiting their research in the context of the technical and managerial

career anchors, the authors sampled 153 senior IS personnel in Stage 3 or Stage 4 of their careers and mainly between the ages of 51 and 60. The findings show that senior personnel in Stage 4 of their career tend to express a higher career satisfaction than those in Stage 3. Moreover, individuals who value management competency are most satisfied in Stage 3 as they begin to embrace their role as a formal manager or supervisor.

While the articles focused on entry-level and senior-level personnel represent a large portion of the systematic literature review results, it is surprising that no articles focused on mid-level professionals. This highlights a neglected research area in the context of career anchors studies. It may be worthwhile topic for future studies, which could serve to better understand how to retain these types of individuals.

Gender roles

Quesenberry and Trauth [37] investigate the career anchors of women within the IT workforce. Their study was conducted in two phases: a qualitative and a quantitative phase. First, the qualitative phase analyzed the interviews of an existing study conducted between 2002 and 2006 that surveyed 92 women in the US IT workforce. The goal of this phase was to better understand the relationship between female retention and occupational interventions. The quantitative phase consisted of administering a survey to another 210 women within the IT workforce between 2006 and 2007 to collect additional information that was used to shed light on career anchor variations of women and how they impact career satisfaction and turnover intentions.

The findings show that all the career anchors were present among the women participants in both phases of the study. The overall leading career anchor was lifestyle, which was identified by 28% of all the women in the study. This shows that many women value a healthy work-life balance that allows them to manage both their careers and their family. Accordingly, they value flexible work programs such as job-sharing, part-time work and virtual work arrangements.

Quesenberry and Trauth [37] note that "understanding why a woman is aligned with a particular career anchor is based on more than simply knowing her biological sex; it appears to be based on a variety of constructs including life experiences, talents and preferences" (p.469). This also includes cultural context, which is an important factor for women in IT as different types of cultural pressures may influence their career orientations.

Cultural factors

Igbaria et al. [38] published a study in 1995 to examine the career orientations of IS personnel from the perspective of a developing country. The study surveyed 112 IS professionals in South Africa to show that sense of service was the most valued career anchor.

Huang [39] conducted a longitudinal study to compare the career anchors of Taiwanese IS professionals from those of US IS professionals in 2002 and 2006. The findings revealed cultural differences where autonomy, creativity, identity, and managerial competency ranked higher in Taiwan than the US. Likewise, the study by Chang [40] in 2010 investigates the influence of the Taiwanese culture in the context of career anchors and turnover intentions. Chang [40] surveyed 353 MIS professionals in Taiwan to reveal lifestyle as the highest frequency career anchor to affect turnover. This corresponds with the sense of collectivism and the importance of family in Taiwan.

Chang et al. [41] published a study in 2020 that sheds light on how social connections affect career orientations by comparing the career anchors of IT professionals rooted in five different cultures: China, Taiwan, India, United Arab Emirates (UAE) and the US. The findings show that IT professionals value different anchors depending on their cultural identity where service is most valued in China, technical competence is most valued in Taiwan, creativity and challenge is most valued in India, learning is most valued in the UAE and lifestyle and variety are most valued in the US.

These studies show that individuals from different countries value different career anchors; confirming that cultural context influences the career orientations of IT professionals. Since cultural factors are closely intertwined with gender roles, it should be assumed that together they have a strong impact on career choices. The digital transformation phenomenon has created new roles where professionals from diverse backgrounds may find that they are a better fit than the traditional IT roles. The findings of these studies are summarized in Table 3 below.

Table 3: Findings of the studies under the theme "Fostering a diverse workforce through demographic profiles"

Author(s)	Findings
Chang et al. [31]	Job security, lifestyle, and service are the leading career anchors among IS students.
Wong et al. [32]	Students believe the IS career path is unlikely to fulfill their needs compared to other career paths.
Jiang et al. [33]	Entry-level IT professionals identify with many career orientations.
Jiang and Klein [34]	
Jiang et al. [35]	
Hsu et al. [36]	Senior personnel in later stages of their career tend to express a higher career satisfaction than those in earlier stages, especially those who value managerial competence.
Quesenberry and Trauth [37]	Women identify with a variety of career anchors as their motivations are based on a variety of constructs.
Igbaria et al. [38]	Individuals from different countries value different career anchors, which confirms that cultural context influences the career orientations of IT professionals
Huang [39]	
Chang [40]	
Chang et al. [41]	

5.3 Understanding the response strategies of IT professionals

Retention

Retention involves a career path where the individual remains within the same organization. Arnold et al. [42] study the link between career anchors and preferences for organizational career management (OCM) practices, which help to strengthen an individual's internal employability and desire to remain within the organization. The authors surveyed 1629 IT professionals from several countries in Europe and found that the link was most evident for the managerial competence and job security career anchors. Specifically, individuals who valued managerial competence most were less interested in on-the-job learning opportunities and technical skills training. In contrast, individuals who valued job security most were interested in opportunities for advancement within the company. Given the findings of this study, organizations will have to tailor their OCM practices in consideration of emerging complex digital transformation roles to maximize retention rates. They will need to be better prepared to offer learning opportunities that will appeal to the underlying motivations of IT professionals to fulfill jobs that require a mix of technical and managerial skills.

Turnover

Turnover is commonly associated with the lack of job satisfaction where an individual will leave an organization and find a job elsewhere within the IT sector. George and Joji [43] studied the link between career anchors and turnover intentions of IT professionals to better inform organizations. The authors surveyed 236 IT professionals in India to reveal that those who value job security and technical functional competence were less likely to leave an organization. Alternatively, those who value entrepreneurial creativity and general management competencies were more likely to leave the organization.

Chang et al. [44] shed light on alternative reasons for turnover intentions when career anchors are satisfied. The authors interviewed 10 IT professionals in Taiwan to reveal external factors that may disrupt the relationship between career anchors and job satisfaction such as perceived job alternatives, working relationships with coworkers and social identity.

Given the new roles and opportunities offered by the digital transformation phenomenon, turnover has the potential to translate into retention as individuals will no longer need to leave an organization to satisfy underlying career orientations such as entrepreneurial creativity and general management competencies, which were once thought to

conflict with a career path within the same organization. In fact, the evolution of roles in the IT discipline may be more supportive of the complex relationship between career anchors as described by Chapman and Brown [23] when compared to the traditional roles.

Turnaway

Turnaway involves a drastic change to the career path as an individual chooses to leave the IT profession for an entirely different profession or enters the IT profession from a different profession. Chang et al. [45] examine the career changes of 10 IS employees in Taiwan who experienced at least one job change to shed light on how career anchors can change throughout different career stages. From the participants' responses, the authors identify four patterns that are helpful for managing the IS profession: 1. IS personnel will value managerial competence more in later career stages; 2. IS personnel will consistently value technical competence throughout their career stages; 3. IS personnel will consistently value job security throughout their career stages and will value geographic security more in later career stages and; 4. IS personnel will value autonomy less in their early career stages.

The effects of digital transformation on turnaway are like those of turnover where the diversity of roles has the potential for IT professionals to satisfy a wide range of career orientations across all career stages without leaving the discipline. Moreover, the BTM framework unites resources from multiple disciplines to support the IT professional across these diverse roles. The findings of these studies are summarized in Table 4 below.

Table 4: Findings of the studies under the theme "Understanding the response strategies of IT professionals"

Author(s)	Findings
Arnold et al. [42]	Individuals who value managerial competence are less interested in on-the-job learning opportunities and technical skills training. Individuals who value job security most are interested in opportunities for advancement within the company.
George and Joji [43]	Those who value job security and technical functional competence are less likely to leave an organization. Those who value entrepreneurial creativity and general management competencies are more likely to leave the organization.
Chang et al. [44]	External factors that may disrupt the relationship between career anchors and job satisfaction such as perceived job alternatives, working relationships with coworkers and social identity.
Chang et al. [45]	1. IS personnel value managerial competence more in later career stages. 2. IS personnel will consistently value technical competence throughout their career stages. 3. IS personnel will consistently value job security throughout their career stages and will value geographic security more in later career stages. 4. IS personnel will value autonomy less in their early career stages.

6. Discussion

The findings of the systematic literature review present challenges in modelling the career paths of IT professionals, which may be overcome with the BTM framework. The dual-ladder construct is losing relevance as IT positions are growing increasingly complex; blending management and technical competencies that go beyond the traditional boundaries of the IT discipline. This can also be observed in the career orientations of IT professionals who value a wide range of career anchors beyond management and technical competencies. Figure 2 depicts the six professional roles integrated within the BTM Body of Knowledge; representing a more accurate reflection of the roles of IT professionals today.

As for students and entry-level professionals, the importance of transdisciplinary competencies also points to the need for academic curricula redesign, structured around core digital transformation roles within non-IT business units. The same perspective is reflected for senior professionals where their contribution can be leveraged to ensure an effective transition between traditional IT roles and more diverse digital leadership roles, where senior personnel is often hired. Another set of factors, such as gender and culture, have a strong impact on career choices. Thus, professionals of various demographic backgrounds may find a better fit within the new digital transformation roles and identities in

comparison to the more traditional IT roles. Finally, the traditional response strategies of professionals including retention, turnover and turnaway, have the potential to be redefined in the context of new roles and opportunities offered by the digital transformation phenomenon and the corresponding BTM framework.

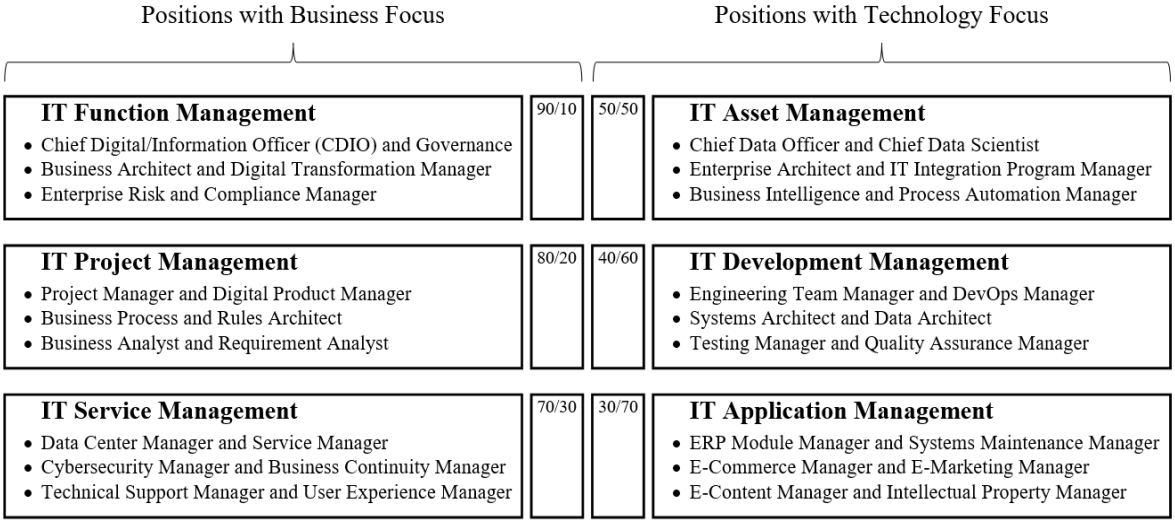

Figure 2: BTM Positions and Ratio (%) of Skills Requirement in Business and Technology [5]

These findings confirm that digital transformation has impacted IT career choices to a greater extent than is acknowledged by existing models such as career anchors. The adoption of enterprise-wide digital technologies requires multidisciplinary skills suited to lead more complex IT projects. And if the past few years are any indication, the next decade is likely to be more disruptive than the last. This is most evident in areas experiencing rapid technological change, especially artificial intelligence, cloud component engineering and born-digital service innovation such as disruptive FinTech.

The conceptual BTM framework provides an opportunity to integrate all relevant IT and digital-related knowledge and practice areas so that any professional may assess their individual and team-related competencies as well as their potential for success in new and high-risk career choices. BTM may inspire OCM and talent management practices that will provide IT and digital-related roles the conditions necessary to continuously renew oneself and perform in ever-evolving and challenging new roles.

Digital roles that involve more leadership and innovative competencies, with highly focused and self-taught technological expertise, are increasingly more appealing to IT professionals from all walks of life, including those without higher education degrees. The fact that both business and technology professionals are eligible for these higher ranking positions will no doubt cause further disruption in the OCM and talent management strategies targeting the IT professional groups. Hence, BTM can serve as a unifying conceptual framework for all IT and digital roles and underlying disciplines, providing an opportunity to facilitate the rapid transition of various professionals interested in diversifying their careers.

Disruptive technological transformations have significant consequences on IT jobs, career paths and OCM and talent management strategies. First, professionals must be proactive and invest more time than usual in keeping up to date with rapidly evolving and emerging technologies. Second, career paths are no longer linear as they must be built around various digital platforms and for shorter periods than what was previously expected. Third, while traditional IT roles such as analysts, programmers and data centre engineers remain important, they are slowly giving way to increasingly digital-related roles requiring multidisciplinary skills.

7. Conclusion and future work

This literature review examined 20 career anchors studies to provide insights into how HRM practices can evolve to address the misalignment of human resources in the IT discipline. Three broad themes emerged from the literature: 1. debunking the dual-ladder construct; 2. fostering a diverse workforce through demographic profiles and; 3. understanding the response strategies of IT professionals. While career anchors proved to be an effective model to analyze the career choices of previous generations of IT professionals, a more diverse and dynamic model may be required to understand the opportunities and challenges presented by the increasingly disruptive digital transformation.

New research is required to develop IT career models that account for the disruptive digital transformation and its structural impact on professionals and their jobs. While this study showed BTM as a promising framework for understanding the career dynamics of IT professionals faced with mixed job demands, further research is required to validate the underlying motivations of these individuals. Future studies should focus on collecting empirical data that can identify the types of professionals that fit under the BTM umbrella.

The main limitations of this study relate to the search method for the systematic literature review. First, the keywords selected to carry out the search had a significant influence on the types of articles that were uncovered. Including keywords such as “career anchors” may have narrowed the results. Yet, this would not have allowed us to validate the widespread use of the career anchors framework in understanding the career dynamics of IT professionals. Moreover, excluding keywords such as “human resources” may have provided broader search results. Second, the search for articles was carried out using the Scopus database. Other databases may have yielded different results. A combination of databases would have been useful to enrich the results of the review.

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Using Theory of Change to evaluate the role of stakeholder engagement towards socially desirable outcomes in ICT research projects

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Abstract:
Information Communication Technologies (ICT) research projects are important in generating breakthrough technologies that translate into solutions for numerous societal grand challenges through research and innovation (R&I). However, to ensure that such solutions are socially desirable, there is a concerted drive for the engagement of different stakeholders, including industry, academia, public and government. In the face of the growing recognition of stakeholder engagement in ICT research projects, particularly as part of Responsible Research and Innovation (RRI), there is a limited discourse on how its consequence could be evaluated. This paper suggests and uses a Theory of Change approach to evaluate the value of stakeholder engagement on the attainment of socially desirable and responsible outcomes in projects, particularly ICT research projects. Using a multi-case study approach, the paper appraises the value of stakeholder engagement in ICT research projects by elucidating the linkages between stakeholder activities and socially desirable outcomes. The findings from the paper could apply to other types of projects apart from ICT research projects in understanding some of the roles stakeholders play in ensuring responsible innovation as an outcome of the projects.

Keywords:
evaluating stakeholder engagement; ICT research projects; theory of change; responsible innovation; socially desirable outcomes.

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1. Introduction

In an increasingly complex world, it has now become imperative for research and innovation initiatives that aspire to change society, to have a 'theory' of how this change will happen. These initiatives more often are pushed forward through projects. Every project or initiative is based on at least one assumption or hypothesis. Such an assumption or assumptions make a 'theory' of change. Projects or initiatives that aim for a socially responsible implementation involve different stakeholders in the research, development or implementation of innovation. Such projects include those focused on Information Communication Technologies (ICTs). ICT research projects are important in generating breakthrough technologies that translate into solutions for societal grand challenges. With the engagement of different stakeholders, including industry, academia, the public and the government, the solutions are expected to be societally acceptable and desirable. It has been suggested that stakeholder engagement plays an important role in encouraging responsible outcomes of research and innovation (R&I) [1]–[3]. Despite the growing recognition of stakeholder engagement in ICT research projects, particularly as part of Responsible Research and Innovation (RRI) there is limited literature to indicate how its value can be evaluated. There is a need to understand its worth to effectively support and improve activities in R&I, particularly concerning the attainment of socially desirable outcomes. Thus, this paper addresses the research question; how can we evaluate the merit of stakeholder engagement in attaining socially desirable outcomes in ICT research and innovation projects?

Looking through the literature, there are no set models for evaluating stakeholder engagement in this regard as suggested by Smith [4]. This means that when it comes to practical fieldwork, there is not much for practitioners to base the evaluation strategy or use a guide for effective and straightforward evaluation. For example, Mark et al. [5] point out the lack of approaches or a combination of approaches that could be used in evaluation especially in social sciences and qualitative evaluations [4], [6]. Considering such suggestions relating to approaches of qualitative nature, the use of a Theory of Change, as suggested in this paper works towards addressing that gap.

There are not many approaches that are directly geared towards the evaluation of the merit of stakeholder engagement in ICT research projects. Hence, this paper proposes using a theory-based evaluation approach called the Theory of Change. As such, the paper contributes to theory and practice by enhancing analytical skills for mapping the role and merit of stakeholder engagement in supporting the attainment of responsible outcomes in ICT research projects using a Theory of Change. The paper starts by providing a theoretical background on stakeholder engagement and evaluation. This is then followed by an introduction of the method that was used to inform the present paper before discussing the findings from a multi-case study. The results and discussion of the findings include a Theory of Change for stakeholder engagement in the five case projects that were used in the study.

2. Background

2.1 Stakeholder engagement and RRI

Stakeholders are vital in ICT research projects because of their various contributions towards the implementation of research and innovation processes. The concept of a stakeholder has been covered by many authors in different disciplines such as project management and business strategy [7], [8] and concertedly, they emphasize the relevance of stakeholders in making important decisions within an entity such as a project. Historically, stakeholder concepts were inherent in the early work of system theorists, but it was a seminal publication from Freeman [9] through his contribution to stakeholder theory that brought the stakeholder concept to the forefront of academic research [10]. Freeman introduced the concept of stakeholder in a way that shifted beyond the shareholder-centric view of organisations and therefore defined, a stakeholder as 'any group or individual who can affect or is affected by the achievement of the objectives' [9, p. 46] of a particular subject such as a project or R&I.

From a responsible research and innovation perspective, stakeholders include groups or individuals such as researchers, funders, local authorities, industry players, end-users and civil society organisations (CSOs). These stakeholders are critical for the success of the R&I [11]. This line of reasoning is usually referred to as instrumental stakeholder theory [12]. Basically, instrumental stakeholder theory provides a basic rationale for stakeholders to be engaged in R&I so that

they contribute towards its direction in relation to certain aspects that affect its success such as finance, procedures and policy [12, p. 65] and the development of artefacts through processes such as user testing [13]–[15]. Of late, there has been a wave of literature on the engagement of stakeholders to contribute towards responsibility in research and innovation in projects under the notion of Responsible Research and Innovation (RRI) [16]–[19].

The notion of RRI emerged as a policy discourse at European Union (EU) level around 2011, underpinning key policy strategies and cutting across the Horizon 2020 work programme, which defines tackling societal challenges as one of its main priorities. RRI has emerged as an approach that aims to enhance the integration of science in society, specifically regarding the alignment of research processes and outcomes with the values, needs and expectations of society. There are a variety of definitions that exist in the academic discourse on RRI, and they share several aspects including an emphasis on the dimensions of anticipation, stakeholder inclusion, reflexivity and responsiveness [20]. Therefore, drawing on the review of the literature on RRI and a variety of definitions of RRI, a conclusion can be made that RRI in ICT research projects can be characterised by having stakeholder engagement with a focus on addressing societal needs and challenges. The stakeholder engagement supports ensuing research and innovation processes within ICT projects that actively engage and respond to a range of societal needs. Thus, stakeholder engagement facilitates a combined effort to anticipate potential problems, identify alternatives, reflect on underlying values and having a willingness from relevant stakeholders to act and adapt accordingly [21, p. 1164].

As such, stakeholder engagement as part of RRI is important in ICT research projects for the following reasons. Firstly, it can contribute to raising the level of discussion from an individual level to a collective or societal level aimed at considering both societal needs and implications of the project's outputs and outcomes for society [18]. Secondly, stakeholder engagement allows stakeholders to take a step back to illuminate and reflect on the underlying values that are important in ICT research projects [22], [23]. Thus, it could be claimed that stakeholder engagement can be useful in identifying, assessing and deliberating on issues that need to be reflected upon within ICT research projects.

2.2 Importance of ICT research projects

With growing societal issues, there is always a need for innovative solutions that can address them. For these solutions to materialize, ICT research projects are drivers for the ideas and processes that bring them about. In ICT research projects, new enabling artefacts and applications are emerging, which have the potential to improve society and address some of the pressing societal challenges met by society nowadays [24]. These novel technology artefacts will continue to play an important role in responding to major societal challenges such as an ageing population, health and social care, sustainable energy, inclusion, education and security. The importance of ICT research projects has been acknowledged by governments and many scholars [24]–[27]. For example, the EU has stated that ICT research is important because it enables mastering and shaping the future developments of ICTs so that the demands of society are met. In the same light scholars has pointed out the importance of ICT research projects in the development of these technologies. Some scholars have acknowledged the importance of ICT research projects in improving society wellbeing [28], economy [29], health [25], productivity [30] and of late they have been a surge of ICT research projects that are directed towards creating a sustainable environment [27], [31]. On top of this, the outcomes and outputs from these projects have an impact on social behaviours, democratic processes, economy and policies [24]. Therefore, considering the motivation of this paper, ICT research projects provides a readily available arena to explore and understand how stakeholder engagement contribute towards socially desirable outcomes in R&I.

2.3 Understanding the value of stakeholder engagement

Considering the discourse on the role of stakeholder engagement in ICT research, it is pertinent to understand its value. However, there are not many approaches that are directly geared toward such an endeavour. Hence, this paper used a theory-based evaluation approach called the Theory of Change. In general, evaluation is about generating knowledge about a phenomenon [5], that could be used for learning and improvement [5], [32]. The phenomenon or subject being evaluated is sometimes referred to as an evaluand [4]. In this paper, the evaluand is the value of stakeholder engagement in ICT research projects with regards to the attainment of socially desirable outcomes. There is a lot said about the purpose of evaluation in research projects including those related to ICT. For example, some have suggested that evaluation may be used to pose certain questions on the relative merit of a specific aspect of R&I in projects [33]. Also,

it may be used to ascertain the difference an evaluand such as stakeholder engagement is going to make, for example in R&I or society [34], [35]. Besides, evaluation can also be used to assess society's learning, change of behaviour and success towards specified goals in ICT research projects [36]. In a nutshell, 'evaluation provides evidence that an evaluand such as stakeholder engagement has achieved a particular end' [33, p. 12].

2.4 Theory of Change

One approach to evaluation is the theory-based approach (TBA) [37], [38]. There are numerous strands of TBA and their discussion is outside the scope of this paper [39], [40]. That said, this paper uses one of the strands of TBA called a Theory of Change. The basis for the theory-based approach is that the assumptions and beliefs that are fundamental to an evaluand such as stakeholder engagement can be expressed in terms of a series of causes and effects [39]. Theory of Change is defined in several ways. For instance, Weiss [39] defines a Theory of Change as 'a theory of how and why an initiative works' [40, p. 502]. On the other hand, Kubisch and Connell [41] define it as 'a systematic and cumulative study of the links between activities, outcomes, and contexts of the evaluand' [41, p. 2]. Recently, Rogers [42] defined a Theory of Change as 'an explanation of how activities are understood to produce a series of results that contribute to achieving the final intended impact' [42, p. 1]. The cross-cutting theme in these definitions indicates that the Theory of Change can be used to evaluate stakeholder engagement by determining its intended outcomes, the engagement activities expected to achieve those outcomes and the contextual factors that may affect the implementation of activities [43, p. 2].

Therefore, Theory of Change as a theory-based approach helps us understand how stakeholder engagement contributes towards an intended change or outcome. Using a Theory of Change, the evaluation not only shows how much change has occurred as a result of a project but also tells how the change occurred, therefore, highlighting areas along the line where there are failures affect the intended outcomes [41], [44], [45]. Nonetheless, a drawback of using a Theory of Change is the inability of many stakeholders to make plausible and non-contentious assumptions about linkages between their engagement activities and outcomes [46]. The feasibility of the Theory of Change is determined by the capacity of the project's stakeholders and evaluators to identify, prioritize, and then assess the key activities and contextual factors. In most cases, evaluators and stakeholders tend to look back on the evaluand and then construct convincing tales of why an outcome materialized or not.

In general, Weiss [39] and Nakrošis [47] mentions that a Theory of Change aims to describe the actual mechanisms that relate to desirable outcomes. For example, as an assumption, if stakeholder engagement is associated with increased ethical consideration in R&I within ICT research projects, the mechanism may be the 'consultation' and linkages might be the 'knowledge' and 'awareness' that the consultation provides. This kind of cause-and-effect process and the description of the mechanisms and their related outcomes are normally illustrated through the construction of models that depict how an evaluand (stakeholder engagement) work and they are used to guide the formulation of evaluation knowledge [39], [45], [48]. The Theory of Change facilitates a segmental approach in understanding the different elements of stakeholder engagement to get a full picture at the end of the process. Thus, using a Theory of Change draws attention to the key areas to focus on in evaluating stakeholder engagement in ICT research projects when it comes to producing socially desirable outcomes.

2.5 Evaluating stakeholder engagement using the RRI lens

Although extensive research has been carried out on the evaluation of stakeholder engagement in many contexts of research projects including those involved with ICT [49]–[51], no single study exists which specifically looks at the evaluation of stakeholder engagement through the lens of RRI. The RRI lens is informed by different accounts of RRI [17], [18], [20] and provide a starting point for incorporating RRI into evaluation. In these different accounts of RRI, there are cross-cutting key conceptual features that give a concerted picture of what could be regarded as socially desirable in ICT research projects.

These key conceptual features include:

- Engagement of stakeholders: ensures an acceptable and socially desirable production and uptake of the outputs and outcomes of ICT research projects in society, diverse views from stakeholders should be considered [18, p. 11].
- Openness and transparency: involves a balanced and meaningful discussion of research and its implications in order to facilitate stakeholders' understanding and examination of R&I that exists in ICT research projects [17].
- Anticipation and reflection: involves deliberating on assumptions and values underpinning R&I in support of anticipation [18, p. 13].
- Responsiveness: encourages the sensitivity to the unfolding of a diversity of value positions and the absence of a consolidated knowledge for responsible innovation processes and practices Stilgoe et al. [20].

Evaluating stakeholder engagement by using the RRI lens is necessary to understand how stakeholder engagement plays a role in the attainment of socially desirable and acceptable outcomes in ICT research. This will help in improving the implementation of responsible innovation in ICT research. Evaluating stakeholder engagement in light of RRI provides a reflection point for both theory and practice.

As pointed earlier in this paper, RRI in ICT research projects ensures that R&I activities and outcomes should be acceptable and desirable and one way of achieving such goals is by engaging stakeholder engagement to address the grand societal challenges that concern society. This then raises a need for understanding and assessing whether, and in what way the stakeholder engagement is likely to address these grand societal challenges. Many scholars [6], [52], [53] hold the view that evaluation provides an understanding of stakeholder engagement in research projects and the outcomes that result from it. Proportionately, evaluating stakeholder engagement within the context of RRI may be useful for understanding the outcomes that relate to the attainment of responsible outcomes and support framing stakeholder engagement in ICT research projects.

3. Method

3.1 Case study approach

The paper used a case study approach because it was ideal for investigating stakeholder engagement that exists in a 'real-life context within a boundary' [54, p. 23] which are the ICT research projects used as cases. The case study strategy was also ideal because it gave the participants (stakeholders) an authoritative and in-depth explication of their views on how they think or interpret their engagement in ICT research projects in light of responsible research and innovation without the researcher's control. Although the case study strategy is considered ideal, one of the argument against its use is that the findings from the case studies cannot be generalised to other contexts [55]. This was nevertheless addressed by using five cases [54] which are identified in Table 1 below. The five case projects have a variety of contextual factors for stakeholder engagement, and therefore findings could be applied to other ICT research projects that are related. Also, the issue with reliability and validity of findings from case studies [56, p. 123] was addressed by combining data sources. The data was sourced from documents, questionnaires and semi-structured interviews with participants from the case projects.

Table 1 describes the sample of the cases that were considered for the case study based on purposive sampling. Five projects out of the 10 were purposely selected to be part of the case study based on their accessibility. The selected cases were Projects D, E, F, G and I. Most importantly, the cases were selected because the contextual conditions of the cases were similar and pertinent to understanding the phenomenon under inquiry which was the role of stakeholders in ensuring that their aims were responsibly achieved. Also, these cases were selected for literal replication [57], that is, there were selected to predict similar results.

Table 1: Description of the cases

Project	Social Challenge	Aim	Accessibility
A	Health	To improve the communication channels and social connections of children with a degenerative disease through the of use Brain and Neural Computer Interface (BNCI)	**No**
B	Health	To link Brain/Neural Computer Interaction (BNCI) technologies with other novel and emerging types of ICTs. to develop technologies that would support severely disabled users	**No**
C	Health	To establish how ICT can be used for patients suffering from a chronic organ-related condition	**No**
D	Environmental degradation	To use ICTs to support environmental sustainability through energy optimization	**Yes**
E	Gender/ Education	To foster gender inclusivity in STEM subjects such as ICT	**Yes**
F	Education	To determine and improve the use of ICT in transforming education provision in secondary schools	**Yes**
G	Health impairment	To use ICT to improve hearing aid technologies	**Yes**
H	Health impairment	To exploit ICT and other technologies in assessing and treating the Autistic Spectrum Disorder in children in a more "natural" home environment where non-obtrusive techniques will be used	**No**
I	Environmental degradation	To use ICT in developing a dynamic traffic management system to improve air quality	**Yes**

3.2 Data collection and analysis

Data were collected in two phases and was analysed following an interpretivist viewpoint. This means the paper views social reality as embedded within social settings such as projects and that reality can be interpreted from subjective opinions, views and values rather than a hypothesis testing process [58].

The first phase involved 20 semi-structured interviews with purposively selected key stakeholder informants and then there was a follow-up phase which involved a further eight semi-interviews with a sample of key stakeholder informant from the first phase. Also, 50 evaluation questionnaires were given to different stakeholders that were in the case projects to understand their experiences. Documents such as project reports and web pages were also used to understand the context of the stakeholder engagement.

This paper used a hybrid thematic data analysis. With the hybrid thematic data analysis, codes were developed both inductively and deductively in Nvivo. The hybrid approach deductive codes shown in Table 2 below were used to give the researcher a starting point for the coding process. The high-level deductive codes were determined based on stakeholder theory and RRI literature.

Table 2: High-level deductive codes

Code label	**Column A**
Nature of engagement stakeholder	The form and type of stakeholder engagement activities conducted by the stakeholders that were engaged in the ICT research projects.
Rationale for engaging stakeholders	The reason and motive for engaging the stakeholders in the ICT research projects. This includes a look at their role in the research process.
Outcomes of stakeholder engagement	The results for engaging the stakeholders in the projects, particularly those that would relate to RRI
Context of stakeholder engagement	The circumstances that form the setting for the stakeholder engagement in the ICT research projects. These circumstances are those which can be fully understood and assessed.
Stakeholder identification	The process and identification process aspects of the stakeholders
RRI application	The relevance of the key RRI features as developed in the RRI literature.

Once the deductive codes were established, based on a predefined coding frame [59], they were then applied to the text in transcripts to identify meaningful fragments of text. Through an iterative cross-case data analysis, inductive codes emerged from the data that was collected through the interviews emerged. Analysis of the text at this stage was guided, but not confined, by the predefined codes. During the coding of transcripts, inductive codes were assigned to segments of data and categorised to describe a new theme observed in the text [60, p. 9]. The themes then informed the construction of a Theory of Change for stakeholder engagement in the case projects.

4. Results and discussion

This section presents a discussion of the results from a cross-case analysis of the five individual case projects including Project D, E, F, G and I. The results, analysis and discussion inform the Theory of Change for the value of stakeholder engagement in the attainment of socially desirable outcomes in ICT research projects. The section begins by presenting a construct depicting the Theory of Change in Figure 1 below and then it is followed by a discussion of the elements that are part of the Theory of Change. The Theory of Change is constructed based on the key elements for evaluating stakeholder engagement with reference to an application of RRI that were analysed using the deductive codes in Table 2 above.

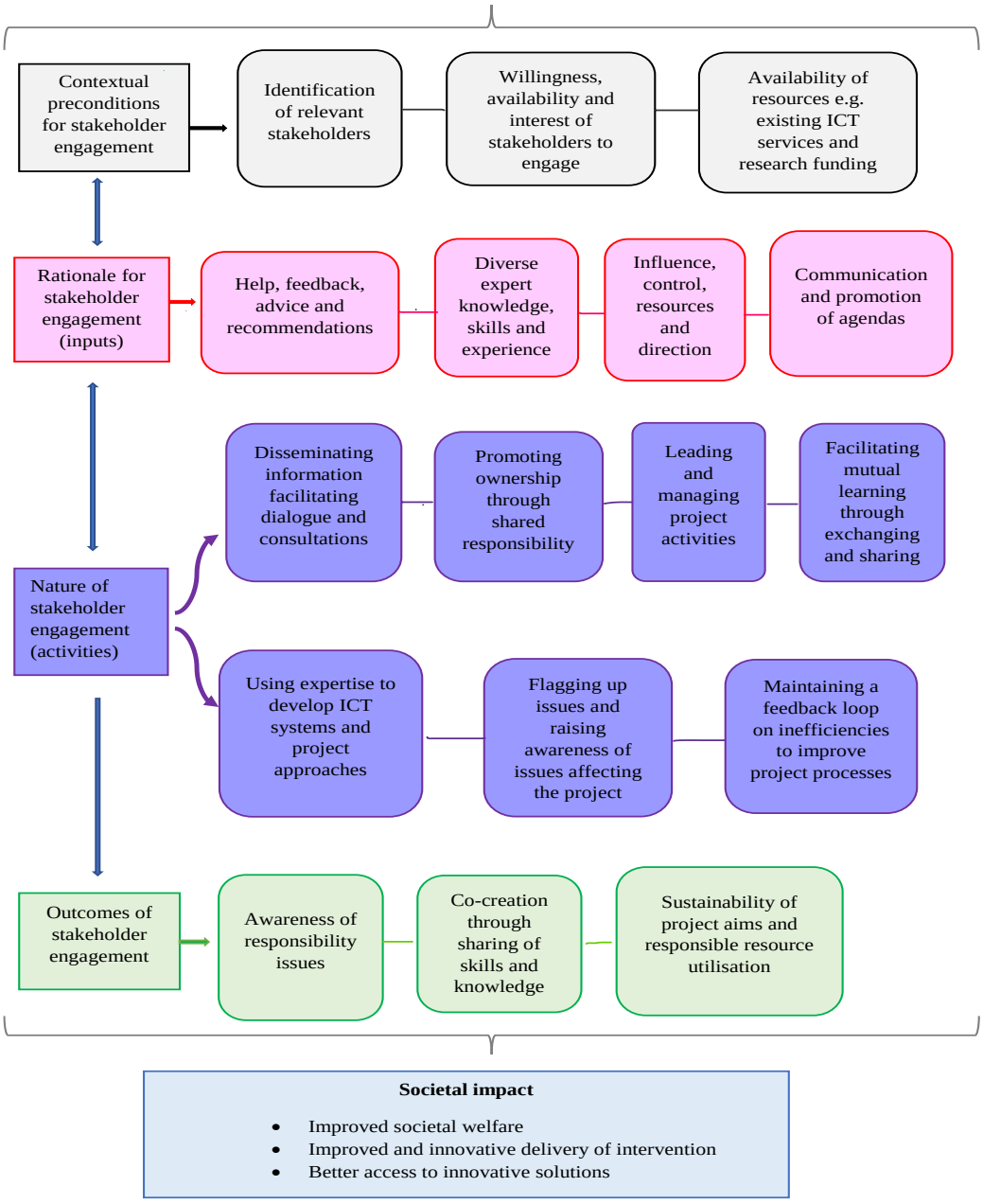

Figure 1: Theory of Change for Stakeholder engagement in ICT Research Projects

4.1 Key elements for evaluating stakeholder engagement

The elements for evaluating stakeholder engagement were realised from the theoretical and empirical insights to provide the analytical framework for constructing a Theory of Change (Figure 1). The Theory of Change was used in understanding the socially desirable outcomes of engaging stakeholders in the projects, project activities expected to achieve those outcomes and the contextual factors that influenced the activities. Thus, 17 cross-cutting themes emerged

from the five case projects. From these themes, five main common insights were derived, and they were termed key elements. The five key elements to consider when evaluating stakeholder engagement were contextual factors; identification of stakeholders; nature of stakeholder engagement; the rationale for stakeholder engagement and the outcome of stakeholder engagement. These will be discussed below.

4.1.1 Contextual factors

In all the five case projects contextual factors were very important for stakeholder engagement to be effective towards the attainment of socially desirable outcomes in the ICT research projects. This concurs with the suggestion by Connell and Kubisch [41] that contextual factors are likely to influence the effectiveness of stakeholder engagement activities and outcomes that result from those activities. As such, contextual factors are an important element to evaluate. The stakeholder engagement activities were taking place within a context of action, which was the ICT research projects. Therefore, as suggested by Stufflebeam and Shinkfield [61], it was essential to understand the different aspects of the context of action in which the stakeholder engagement was taking place. This was necessary because the lessons that were learnt from the five cases could be extrapolated to future project evaluation activities and stakeholder engagement efforts. Therefore, what was learnt in the five cases could be used to identify, prioritize, and then assess the key stakeholder engagement activities and contextual factors that are likely to influence a valuable engagement [41], [43], [44] towards the attainment of socially desirable outcomes in ICT research projects.

Principally, two main areas of focus under contextual factors emerged in all five ICT research projects and are discussed below.

4.1.1.1 Resources as an enabling factor

It was recognized that resources are a fundamental enabling factor that is necessary for stakeholder engagement to be effective. The availability of research resources was paramount in ensuring that the stakeholder engagement and its associated activities were effectively organized to carry out the scope of work that achieved beneficial change. For the stakeholder engagement to be of value, necessary resources (financial, human or material) for the stakeholders to come together and work towards specific aims were provided in some of the projects.

For example, in Project D, for the stakeholders to have a fruitful engagement, there was a provision of research funding and an existing ICT infrastructure to support the research on the ICT system that was being developed. In all five projects, the funding was accessed through research funding institutions and industry partners. In the case of the infrastructure, this was mainly important in three projects, Projects D, E and F due to the nature of their research. Also, for valuable stakeholder engagement, there was a requirement for human resources, which was crucial in ensuring that the process was efficient and effective towards achieving positive goals [62], [63].

4.1.1.2 Willingness to assume expected roles

Another important area was the uptake of expected roles by stakeholders that were engaged. Despite the expectation by the project sponsors and principal researchers to involve stakeholders that would assume different roles, sometimes the engagement was not as successful as would have been expected. From all cases, the two main issues were the appropriateness and willingness of the stakeholders to take up the different roles as part of their engagement. Core to these issues was a lack of interest by some identified stakeholders. Stakeholders that were expected to be highly engaged in the ICT research projects were prioritising other commitments. Therefore, to improve stakeholder engagement, perhaps it is necessary to make the engagement process more interesting and provide ample resources to support the stakeholder engagement process [64]. As a result, this could yield positive uptake of roles. Such positive examples of role uptake may include increased attendance of stakeholder engagement activities, providing timely feedback or constructive comments on progress and projects' deliverables.

4.1.1.3 Identification of stakeholders

The identification of stakeholders is essential for the effectiveness of the stakeholder engagement process because it helps the ICT research projects to achieve their aims by scoping which stakeholders will support the attainment of different outcomes [63], [65], [66]. In all the five ICT research projects, the identification of stakeholders for engagement was similar. The identification of relevant stakeholders for engagement was mainly based on two broad thematic categories, the process of identification and timing of the identification.

With regards to the process, in all five cases, stakeholders were identified based on existing networks. Stakeholders were mostly identified because there was someone who knew them either because of a past encounter or was known to have some experience or expertise that was relevant to the aims of the ICT research projects [66]. This was a trend in all the cases were stakeholders experience or expertise was crucial in identifying the stakeholders to take up roles (as mentioned by Bryson et al. [63]). These roles were wide enough to include those who were actively involved in research in all five cases and those who were there to represent the public interests [65] for example, researchers and end-users.

In all the five ICT research projects, stakeholders were identified ex-ante [67, p. 24] that is, the stakeholder identification took place in advance. However, it also emerged that in some of them there was an ad-hoc identification of stakeholders that is, the identification took place as the project activities progressed. In Project I, stakeholders were only identified ex-ante, and none were identified during the research. Perhaps this was due to the nature of the research that was being undertaken in the research project. The research in Project I only needed to have the stakeholders identified at the beginning and be engaged throughout the whole R&I process until the final output and outcomes were achieved. This was contrary to Project D, G and F where the identification was happening iteratively at all stages of the research process as recommended by Reed and Curzon [67].

In all the five case research projects there was a wide range of stakeholders identified. From the data collected it could be seen that there were stakeholders who were identified because of their expert knowledge as scientists, researchers and project managers. Apart from expert knowledge, some stakeholders were identified because of their experiences. These stakeholders were engaged in the research projects to share their lived experiences, values and expectations in developing or implementing desirable ICTs [1], [68]. For example, Project G engaged teachers who were not experts in ICT but were capable of bringing rich knowledge that was necessary for the effective implementation of ICTs in secondary school education. The identification of a wide range of stakeholders was ideal for matching the users' expectations and the usability of the ICT systems that were being developed or implemented in the ICT research projects [69].

4.1.2 Rationale for stakeholder engagement

One noticeable thing was that the rationale for the engagement varied according to the stage of the project and the objectives that the research projects were trying to achieve at a respective stage [63]. From the analysis of the five cases, it was realised that the main rationale for stakeholder engagement is to bring together different stakeholders to embed anticipation and reflection into practice within the R&I processes to stimulate new ways of addressing societal challenges and therefore achieve socially desirable outcomes [1], [19], [72]. In the five cases, the rationale for stakeholder engagement included the following.

4.1.2.1 Consultation

Different stakeholders were brought together to consult on how the projects could address the societal challenge that each ICT research project was focusing on respectively. Corresponding to Bryson et al. [63], stakeholders were engaged so that they could provide feedback on the different aspects of the ICT research projects. Also, there was a consultation to raise awareness of the potential responsibility issues and how they affect society [18]. As an example, in Project D building users and researchers were engaged in consultative interactions throughout the whole R&I process to develop an ICT interface that was easy to use and understand. The consultation was either conducted during promotional activities at stakeholder engagement events or through the project's dedicated online forum. Similarly, in Project F, the

rationale behind stakeholder engagement was to have consultations with an aim to bring in different perspectives from the stakeholders who had different experiences and backgrounds [73].

Regarding the socially desirable outcomes, the consultation was very supportive towards realizing them in all the five ICT research projects because it facilitated inclusiveness in the research processes. The consultation afforded the anticipation of moral concerns about the research's intended outputs including issues with potential harm.

4.1.2.2 Control and direction

Some of the stakeholders were engaged to control and direct the research projects towards the attainment of their aims in a desirable way. The control and direction were dependent on the expertise, experience and background of the stakeholders. For example, in Projects I and F, for some of the stakeholders, their engagement predominantly was in the form of directing the research efforts towards managing the implementation of a methodology and coordination of different tasks. As a result of such coordination, there was a lot of co-creation and inclusion of different perspectives from those who were engaged in the project.

4.1.2.3 Mutual learning

The other rationale for stakeholder engagement was that stakeholders should learn from each other. Learning among the stakeholders was common in all five cases. From the findings, it was established that different stakeholders were engaged, on the one hand, to share their expertise and knowledge, and on the other, to learn things that they were not aware of, or had limited knowledge about before the engagement (see [20], [66]). For example, in Project G the rationale for stakeholder engagement was that different stakeholders from industry, academia and local authority combined their knowledge to come up with a solution for improving air quality using ICT. Similarly, in Projects D, G and F, the motive behind stakeholder engagement was to bring in stakeholders other than the experts to learn and get information on the issues that were affecting the society such as seclusion because of hearing loss, reduced education performance in secondary and high carbon dioxide (CO2) emissions in buildings. These stakeholders learnt a lot through the dialogue (as mentioned by Blok [71]) that was taking place in the ICT research projects through fora, blogs and stakeholder engagement events. By being part of the dialogue, they provided feedback, knowledge and shared experiences with those who had the expertise to learn and implement the research successfully [20]. Concerning achieving socially desirable outcomes, mutual learning helped those engaged to pre-empt societal concerns and provide innovative suggestions to the dilemmas of R&I in ICT.

4.1.2.4 Resourcing

Although resourcing was not explicitly mentioned as a rationale in the interviews, it was clear from the document analysis that in all the five ICT research projects, one of the main reasons for stakeholder engagement was the provision of resources that were necessary for the implementation of the research (as suggested by Durham et al. [65]). The resources were in three forms. Firstly, the resources were in the form of materials, as was the case particularly in Projects D, E, and F. In these case projects, there was a need for the existence of ICT infrastructures to support the research. Secondly, the motive for stakeholder engagement in all five cases was the human resource it brought to ICT research projects. For example, in all the cases, stakeholders had the right skills, expertise, knowledge and experiences that were essential for different aspects of the research process. Thirdly, some stakeholders such as the local authority and industry were engaged in the ICT projects because of the financial resources that they could bring into the research. In relation to the attainment of socially desirable outcomes in the ICT research projects, each type of resources was relevant and crucial. For instance, the materials provided were crucial for providing the capacity to adapt and respond to changing circumstances [20] within the research environments in which all the ICT research projects were being implemented.

4.1.3 Nature of stakeholder engagement

In evaluating the nature of stakeholder engagement, the focus was on the activities which the stakeholders were undertaking in their respective research projects. It was important to evaluate whether the activities were relevant for attaining the socially desirable outcomes in the ICT research projects or not (see [41], [42] on Theory of Change). From the cross-case analysis, the following five different types of stakeholder activities describing the nature of stakeholder engagement emerged.

4.1.3.1 Dissemination of information

In all five cases, the stakeholder engagement provided a platform where the different stakeholders could disseminate information among those engaged in the ICT research projects. For instance, the information that was disseminated was about the intended outcomes of R&I process or the activities that were taking place as part of the research. In the case of the former, an example was given in Project D, where as part of the stakeholder engagement, stakeholders were given the information about the intended innovative solutions for solving the societal challenge of air pollution and traffic congestion. While for the latter, an example was shown in Project F in which information was disseminated as part of knowledge exchange among the stakeholders that were engaged in the ICT research project. This was very important in achieving outputs and outcomes which could be acceptable and desirable for society.

4.1.3.2 Facilitation of dialogue and consultation

In all five cases, stakeholder engagement was a good platform for facilitating dialogue and consultation on different aspects that were related to the research processes, for example, the choice of effective implementation methodologies. For example, in Project D, Project I and Project F, the respondents that were interviewed said that as part of the stakeholder engagement, there was a lot of consultation with those who would be the end-users of the ICT systems that were either being developed (as in the case of Project D and Project I) or being implemented (as in the of Project F).

Facilitating dialogue and consultative actions such as blogs and events were supportive towards achieving the different outcomes for the ICT research projects. The consultations and dialogue were an inclusive process of establishing different ways of creating possible future scenarios which could help minimize possible future negative outcomes of the research by providing viable alternatives [70].

4.1.3.3 Offering expertise

When it came to offering expertise as a stakeholder engagement activity, in all five cases, stakeholders had some form of expertise that they provided towards the research process and ultimately towards the intended outputs and outcomes of the ICT research projects. For example, in Project G, Project D and Project I some of the stakeholders were engaged to provide their technical expertise in developing ICT systems that were expected to address the societal challenges which these ICT research projects were focusing on, respectively. With respect to RRI, engaging stakeholders that offer expertise is an anticipative approach that ensures that the planned methodology and its outcome is acceptable [17]. The different expertise that is offered as part of stakeholder engagement is vital in the co-creation and responsiveness of ICT research projects to social impacts.

4.1.3.4 Providing feedback and advice

Another stakeholder engagement activity that was overarching in all five cases was the provision of feedback and advice (as suggested by Bryson et al. [63]). The stakeholders engaged in the ICT research projects provided feedback on the ICT systems that there were being developed. For example, in Project D and Project F there were fora where the stakeholders could discuss the research and its outputs, and in so doing provide feedback that was used to improve the R&I processes and in the long run the final results.

This resonates with Bryson et al. [63] who asserted that stakeholders provide feedback about alternatives and decisions on how certain processes should be carried out, for instance, to mitigate societal harm. The focus on such feedback is on

the procedures that R&I follows in the ICT research projects. This is indicative of reflection and inclusiveness in the ICT research projects, which are crucial elements for attaining socially desirable and desirable outcomes [71].

4.1.3.5 Promoting ownership

Through their engagement, stakeholders understood the need for the research their they took ownership of either the research process or the results that came from it. For instance, as part of the stakeholder engagement in Project I, information for change was provided to different stakeholders in the ICT research project. The provided information was used by the stakeholders to change perspectives on societal problems and went deeper into discussions of how the issues could be addressed using technology, and also how they could contribute toward that solution.

Similarly, in Project F, some of the stakeholders that were engaged promoted the research agenda and the outcomes that were being realised. Because of such promotion, other stakeholders were encouraged to be part of the efforts that the ICT research project was working on. In terms of achieving socially desirable goals, this is significant because it encourages mutual learning and knowledge exchange between stakeholders [15] when responding to the calls of the ICT research projects, particularly to address the societal challenge.

4.1.4 Outcome of stakeholder engagement

As suggested by Weiss [39], evaluation is about assessing the outcome of a certain activity or activities. One way of achieving this in projects is by using an approach such as a Theory of Change to identify the linkages (the rationale) between the activities (nature) of stakeholder engagement and the outcomes (in this case the socially desirable outcomes). In all five cases, there were some overarching socially desirable outcomes of stakeholder engagement in the ICT research projects and they are discussed next.

4.1.4.1 Awareness of responsibility issues

Awareness of responsibility issues is very important in building the capacity of stakeholders to adapt and respond to changing circumstances and it encourages responsible innovation in ICT research projects. Stakeholders were engaged in dialogue through consultations which provided them with information. The information provided made them more aware of the societal challenges that the individual ICT research projects were aiming to address and the responsibility issues that were related to the causes of the research. As a result, the stakeholders were able to change their behaviours and attitudes towards the respective challenges that each ICT research project was dealing with [1]. For example, in Project D, the interaction with a dashboard (ICT system) that was developed in the project, stakeholders were able to see patterns of their behaviours on energy consumption. After receiving feedback from the ICT systems, the stakeholders were discussing the results and ways of changing their behaviours through an online forum and during consultative engagement events. Thus, the awareness made the stakeholders responsive to the issues that were being flagged up by the ICT systems and also during deliberation.

4.1.4.2 Sustainability of project aims

The stakeholders that were engaged in all the five cases brought with them a variety of skills, capabilities and knowledge. Among some of the inputs from the stakeholders that were engaged in the ICT research projects, were leadership, knowledge and management of the research process. One of the things that resulted from such contributions from certain stakeholders was a better utilization of resources and knowledge that was shared during the engagement processes. As an example, in Projects D and F, stakeholders' expertise and knowledge were central to providing control and direction. Controlling and directing the research process was necessary for the sustainability of the project's aims and better resource utilization during and beyond the research through a change in behaviour and attitudes. Engaging the stakeholders in the five ICT research projects, meant that what the stakeholders co-created and learnt through their engagement had a chance to continue beyond the lifespan of the respective ICT research projects. The ICT systems that were developed (as is the case of Projects D, E and F) and those that were implemented in all the five projects were likely to be accepted by the stakeholders because they were involved in the R&I processes. With such involvement, there was buy-in across the stakeholders.

4.1.4.3 Co-creation

The stakeholder engagement process in all five of them allowed the projects to bring in different stakeholders, harness their capabilities, knowledge and potential in creating solutions to the societal challenges that each project was aiming to address. In Projects D and I, computer experts worked together with a sample of users in developing the ICT systems that they were developing so that they could come up with desirable technologies that meet the needs of society [68]. One way to ensure that the outcomes of ICT research are socially desirable is through co-creation. The reason behind this is that with co-creation, stakeholders bring together their knowledge, experiences, values and perspectives to come up with solutions that tend to be accepted by society [27], [31].

To round up, from the Theory of Change shown in Figure 1, it can be seen that for effective stakeholder engagement to take place there are contextual factors or rather enabling factors that support the engagement of stakeholders in ICT research projects [45]. Thus, for the stakeholders to contribute towards desirable outcomes of the research and innovation process, there is a need for effective identification. This entails identifying the stakeholders who will have roles that are vital for a respective ICT research project to achieve specific goals [65]. Despite the identification, stakeholders have to be interested and show a willingness to engage otherwise the identification will result in ineffective engagement [31]. On top of the stakeholders' willingness, there is a need for resources that will enable and support the engagement activities that are necessary to achieve particular outcomes including socially desirable ones.

The activities that are necessary to achieve socially desirable outcomes are based on the motives behind stakeholder engagement. These motives or rationale for stakeholder engagement are depicted by the inputs that the stakeholders provide to the ICT research projects [15], [63], [74]. These include control, feedback, expert advice and recommendations on the research and innovation process. Based on the rationale of the stakeholder engagement, the stakeholders carry out different activities that work towards achieving a range of intended and sometimes non-intended outcomes from the research and innovation process [16], [18], [20], [75]. For instance, the activities may include disseminating information, facilitating dialogue and consultation with other stakeholders, therefore, acting as a bridge and providing diverse expert knowledge and experience.

Using the Theory of Change, assumptions are made on the linkages between such activities and the desirable outcomes that result from them [42], [76]. In the case of the five cases, the Theory of Change in Figure 1, shows that as the result of the different stakeholder engagement activities some desirable goals came about. For example, through facilitating mutual learning by exchanging and sharing knowledge, there was co-creation. This resonates with the RRI discourse which advocates that stakeholder engagement can support co-creation in research and innovation [77], [78]. The co-creation helps in collectively highlighting some of the issues that may impact the research and innovation process as well as the society. Other socially desirable outcomes that result from stakeholder engagement such as responsibility through learning and reflection and awareness of the societal issues that the ICTs were aiming to address also corresponds with the reasons for having stakeholder engagement in ICT research as suggested by Jirotka et al. [17].

5. Conclusions

The paper has contributed to theory around project management, by suggesting how an approach such as Theory of Change can be used to evaluate the merit of stakeholder engagement and establish different linkages between inputs from the stakeholder engagement, favourable contextual preconditions for the engagement, the relevance of stakeholder engagement activities within the project, the rationale behind the engagement, and the attainment of socially desirable outcomes in projects. Using evaluation approaches such as the Theory of Change helps practitioners in projects to understand the value of stakeholder engagement towards the intended and non-intended socially desirable outcomes of the research and innovation process that is taking in different types of projects, including ICT research projects. In all the five key conceptual features advanced, it can be established that stakeholders are crucial within ICT research projects and therefore it is necessary to evaluate and understand their contribution towards positive outcomes of R&I within the context of RRI.

Thus, this paper contributes to practice and theory by emphasizing the vital interrelation between stakeholders and the achievement of responsible outcomes in ICT R&I. The paper guides better alignment of stakeholder engagement and

R&I processes within ICT research projects in achieving positive outcomes for the society. Using a Theory of Change as suggested in this paper could be helpful in practice to identify specific elements of stakeholder engagement which practitioners should focus on to promote stakeholder engagement towards ensuring better R&I outcomes in projects. Furthermore, the paper has shown how evaluation theory can support understanding the value of stakeholder engagement in R&I within the context of responsible research and innovation by applying it to a multi-case study of ICT research projects. Such an understanding has the potential to guide effective stakeholder identification and design of stakeholder activities that will have links to particular outcomes in projects. Despite using ICT research projects in the paper, the insights can apply to other types of projects apart from ICT research projects in understanding some of the roles stakeholders play in ensuring responsible innovation as an outcome of the projects.

5.1 Limitations of the study and future work

In most cases a Theory of Change is best constructed as and when the project is being implemented. However, due to the timing of the study, the projects' life cycles and the lack of cooperation from most project participants to take part in constructing the Theory of Change, its significant proportion was constructed retrospectively through post-project or post-phase interviews and secondary research. Some participants did not accept the invitation to partake in the evaluative study, reducing the possible number of contributions for a comprehensive Theory of Change.

Another limitation was that the sampled case projects were limited to those funded by the European Commission due to the nature of the study and therefore having a Euro-centric perspective and could be biased. The sample could be biased towards government-funded ICT research projects that are being implemented in Europe, neglecting the perspectives of those in industry and other parts of the world. Such bias could influence the results and therefore the resulting Theory of Change.

Future work could explore the role of stakeholder engagement towards socially desirable outcomes in other types of ICT projects such as those in industry and different parts of the world. Also, future studies could employ action research methodology to avoid a retrospective enquiry and provide a better evaluation of the role of stakeholder engagement in such type of projects as suggested above.

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