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Conceptualising Management of Artificial Intelligence in Terms of People, Process, Data and Technology

Sahber Monshizada
University of Canberra, sahber.monshizada@canberra.edu.au

Hamed Sarbazhosseini
University of Canberra, hamed.sarbazhosseini@canberra.edu.au

Masoud Mohammadian
University of Canberra, masoud.mohamadian@canberra.edu.au

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Full research paper

Sahber Monshizada
Faculty of Science and Technology
University of Canberra
Australia
Email: sahber.monshizada@canberra.edu.au

Hamed Sarbazhosseini
Faculty of Science and Technology
University of Canberra
Australia
Email: hamed.sarbazhosseini@canberra.edu.au

Masoud Mohammadian
Faculty of Science and Technology
University of Canberra
Australia
Email: masoud.mohammadian@canberra.edu.au

Abstract

Artificial Intelligence (AI) is an area of organisational activity that attempts to build human intelligence and intelligent behaviours into information and computer systems. As a domain of study AI is characterised by, diverse opinions as to its nature, and an industry approach with limited research reporting the outcome of proposed frameworks in areas such as urban innovation, good society, and management in public industry.

In this paper, we examine the use of people, process, data, and technology (2PDT) as a possible means for bringing structure to the study of the AI domain. We demonstrate its effective use in the formulation of research questions, research design, data collection, and analysis.

We argue that AI is a domain of interest to the information systems discipline and that formulation of 2PDT seems to offer a useful conceptual framework examining this phenomenon.

Keywords Artificial Intelligence, People Process Data Technology (2PDT) Framework, Research Design

1 Introduction

Research points out that organisations implementing Artificial Intelligence (AI) are facing numerous challenges. Examples of these challenges include lack of experience and skills to leverage AI (Desouza 2018; Ichishi and Elliot 2019), effectively managing information security (Choudhary et al. 2020; Wirtz et al. 2019), and data availability (Desouza et al. 2020; Sun and Medaglia 2019). The challenges presented by researchers impact the end result and successful implementation of AI within organisations. Recent research has mostly focused on identifying the AI challenges with little research on exploring how organisations can successfully exploit AI by overcoming these challenges. This research aims to investigate the following question – how can organisations manage AI from a non-technical perspective to increase the successful delivery of AI projects?

This paper aims to investigate AI from an Information Systems (IS) perspective whereby people, process, data, and technology (2PDT) have been proposed with the aim of bringing structure to the study of AI management. We claim that the rigour and completeness of this framework brings visibility and provides structure to examine AI management. This paper has been adapted conceptualising an approach outlined in McDonald and Sarbazhosseini (2013) where authors conceptualised project portfolio management based on information systems concepts. A systematic literature review of the domain highlights that the study into conceptual frameworks for the management of AI appears to be a recent focus for researchers. Nevertheless, their existence highlights their usefulness in attempting to bring structure and standardisation within the domain.

This paper proceeds as follows. It first discusses the AI domain and outlines a need for conceptualising AI management. It then develops the 2PDT framework and applies it to underlie the research design. Lastly, we conclude with some preliminary findings from a conducted pilot study.

2 Literature Approach and Systematic Review

A systematic literature review (Webster and Watson 2002; White and Schmidt 2005) has been carried out and this process (see Figure 1) involved accessing relevant databases (i.e. ACM Digital Library, Google Scholar, Scopus), journals (i.e. MIS Quarterly, Elsevier Artificial Intelligence Journal), and industry sources (i.e. Australian Government, Deloitte, IBM). 65 articles relevant to the research question were selected, relevant information from them was extracted, summarised, and analysed.

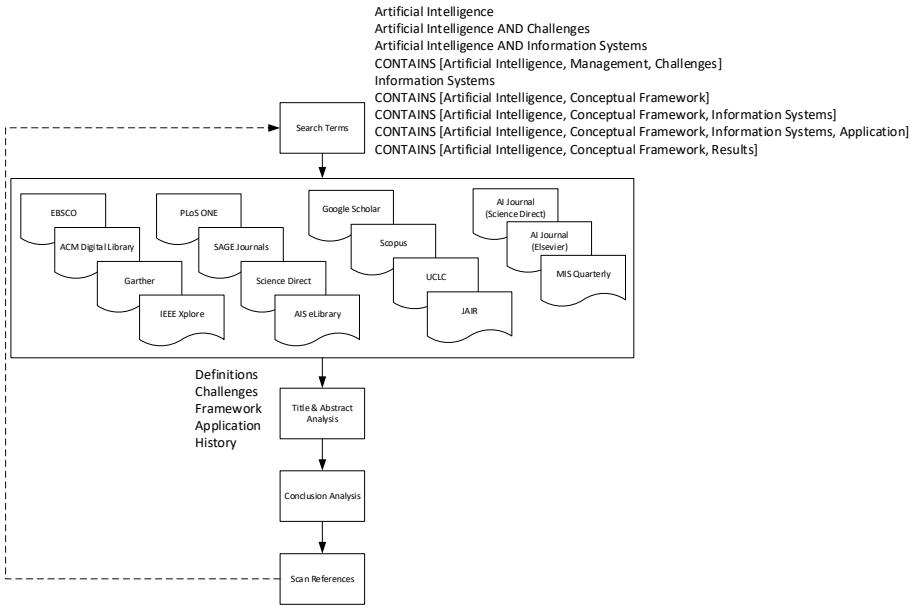

Figure 1: The Applied Systematic Literature Review Process

The keywords used in searches included Artificial Intelligence, Artificial Intelligence AND Challenges, Artificial Intelligence AND Information Systems, CONTAINS [Artificial Intelligence, Management, Challenges], Information Systems, CONTAINS [Artificial Intelligence, Conceptual Framework], CONTAINS [Artificial Intelligence, Management, Information Systems], CONTAINS [Artificial Intelligence, Conceptual Framework, Information Systems, Application], CONTAINS [Artificial Intelligence, Conceptual Framework, Results]. Of keynote is the paucity of papers in the MIS Quarterly journal, which indicates AI research papers from the Information Systems discipline are not published in this journal. Findings from the literature review are presented in the below sections.

2.1 Artificial Intelligence Theory

It may appear as a surprise to one when they come to know how far the origins of AI date back to. AI theory initially appeared in Greek mythology dating back to 850BC but under the name Automata (McCorduck et al. 1977). The literature presents a diverse set of definitions for AI (Arsenijevic and Jovic 2019; Lacheca 2018; McCarthy 2007b; Xian 2010), this research project adopts the following definition which blends these as we are content it provides a useful description covering AI's fundamental elements – AI is a broad term that covers a collection of technologies and methods (Lacheca 2018), and the science and engineering of building human intelligence and intelligent behaviours into a computer system (McCarthy 2007b; Xian 2010).

A study of the domain literature shows that historically the philosophical focus has been on how to build AI (McCarthy et al. 1955; Turing 1995), what benefits they offer (Anton et al. 2020; Desouza et al. 2020), and what areas need further development (Baldassarre et al. 2017; Desouza 2018). The first academic discussion of human-level AI is less than a hundred years old, with Alan Turing being credited to have presented it in a lecture dating back to 1950 (CSIRO Data61 2019; McCarthy 2007a; Turing 1950). By the end of that decade, many researchers began studying AI (McCarthy 2007b; McCorduck et al. 1977). However, it should not come as a surprise to learn that it appears that AI outside academia and potentially within the industry had taken place earlier. This is highlighted by the fact that the first programming language that could be used to build AI capability, named Plankalkul, was released in 1945 (McCorduck et al. 1977). The term AI is said to have officially been used by the 1955 Dartmouth research project on AI (Alsheibani et al. 2019; McCorduck et al. 1977). In scope of the project was examining how machines could mimic human learning and intelligence using a computer program.

Organisations want to integrate AI into their operating model to have machines complete tasks for people and give them additional time to focus on more value-add tasks. AI enables organisations to automate repetitive learning and discovery through data, add intelligence and self-learning capability to existing products, to deeply analyse more data accurately and get the most out of data (Anton et al. 2020; Department of the Prime Minister and Cabinet 2019; NSW Government 2019; Sari et al. 2020; SAS Insights 2020). AI is a fast-growing and widespread field, organisations use AI for many business processes such as fraud detection (Department of the Prime Minister and Cabinet 2019; Lacheca 2018), providing healthcare to patients (Adadi and Berrada 2018; Department of the Prime Minister and Cabinet 2019), and policy development in government (Department of the Prime Minister and Cabinet 2019). 80% of government organisations around the world are expected to apply AI into their programs by 2023. In the USA alone, nearly half (45%) of federal agencies had experimented with AI before the COVID-19 pandemic (Kaner and Jaffri 2020). AI is also a top mandate for the private sector where investment in AI exceeded US$70 billion in 2019 (Sari et al. 2020). Recent studies show that 84% of executives acknowledge the need to exploit AI (Awalegaonkar et al. 2019), and categorise AI as a 'game changer' (Kaner and Jaffri 2020) meaning it is expected to significantly change the thinking around and how Information Technology (IT) is adopted. The World Bank estimates that 57% of jobs in the Organisation for Economic Co-operation and Development (OECD) countries could be automated in the next two decades (Zhang et al. 2019).

2.2 Challenges of AI

There are several challenges that are inhibiting organisations from effective management of AI projects (Adadi and Berrada 2018; Choudhary et al. 2020; Desouza 2018; Ichishi and Elliot 2019; Lacheca 2018). While most of the AI delivery challenges are covered by both academic and industry papers, there are those that are neglected by one and not the other such as workforce management, cost-benefit, and these are discussed below:

Only industry papers identify workforce management practices, the culture of IT ownership, limited capacity for system-level redesign, and policy development. Workforce management practices refer to reviewing people management strategy including upskilling, job redesign, and hiring new skills.

Culture of IT ownership refers to the culture of government agencies to 'own' and 'develop' their own systems rather than embracing third-party vendors and the use of open-source technologies. Limited capacity for system-level redesign also refers to a challenge within government agencies to successfully introduce automation into existing processes. The final delivery challenge referred to in the Review of the Australian Public Service (Department of the Prime Minister and Cabinet 2019) recommends identifying and improving policy development.

Two challenges only identified by academic research are cost-benefit and algorithm selection. The cost-benefit challenge exists due to the nature of AI projects being explorative and innovative in nature and the time it may take to achieve benefits (Lee and Shin 2020). The algorithm challenge refers to the predicament of identifying the best algorithm to solve an organisational problem.

The AI delivery challenges that are referred to by both academic and industry papers include security, privacy, ethics, data quality, among others. A key challenge worth noting is IT project management capabilities and the recommendation to adopt agile project management approaches for AI delivery. This highlights organisations that are using non-agile or semi-agile approaches will find it difficult to achieve success. Based on these findings we are unable to identify any specific differences between academic and industry papers in areas such as culture, goals, and objectives. Both fields are overall in synchronisation in terms of the AI delivery challenges they present.

3 Justification and Need for a Conceptual Framework in AI Management

This research intends to augment on findings of existing studies that have examined conceptual frameworks for AI (Cagan et al. 1997; Floridi et al. 2018; Kumar et al. 2020; Perez-Vega et al. 2020; Petit 2017; Tsaih and Hsu 2018; Wirtz and Müller 2019; Yigitcanlar et al. 2021). The framework for Responsible Urban Innovation with Local Government AI (Yigitcanlar et al. 2021) aims to provide guidelines to assist the government in achieving responsible innovation through AI use. The authors describe the use of following a research methodology which includes a review of domain literature, research, and development of a framework. The framework contains the concepts of technology, ethics and risk which are proposed for inclusion in the 2PDT framework as areas requiring examination. Floridi et al. (2018) propose an ethical framework to support a good AI society which focuses on the ethical considerations of AI, which is one of the concepts within the proposed research. Details of the research methodology used are not given in the paper, and the framework appears to have been developed based on findings from the review of domain literature. The AI framework for public management (Wirtz and Müller 2019) proposes a conceptual framework consisting of four key layers one non-technical layer and three technical layers. This conceptual framework also contains some of the concepts which are planned to be included in the proposed 2PDT framework. These concepts include policy and technology. The paper has been written using a qualitative approach involving a comparison of theory and frameworks. The research appears to be in the early stages with the empirical examination yet to be formalised. Kumar et al. (2020) propose a framework for the health sector that uses AI to reduce the risk of infections among health care workers from pandemics such as COVID-19. This framework does not have a close relationship to the proposed research and framework given it is introducing AI to an existing process and the problems associated with effectively managing AI not considered (i.e. security, data quality). The methodology for this study included a literature review which has led to the development of a framework. It is also an initial step with further research recommended in the paper. Similarly, the conceptual frameworks for smart tourism using AI (Tsaih and Hsu 2018), for law and regulation of AI and robots (Petit 2017), for customer engagement (Perez-Vega et al. 2020), and for combining AI and optimisation in engineering design (Cagan et al. 1997), also focus on how AI can be effectively applied to an existing process. The methodology used in these studies also included a literature review which has led to development of proposed frameworks with a recommendation provided for further research.

While these theories and frameworks exist there is a lack of empirical results from testing and application of them. Using Google Scholar's 'cited by' data from between early March and May 2021, there does not appear to be any literature on application of these frameworks. During this time author contact details in the above papers were also utilised to check with the authors if they had an opportunity to test their framework or were aware of others that may have, one response has been received confirming that particular framework had not been tested. We challenge that the completeness and rigorousness of the proposed 2PDT framework are what makes it useful in bringing structure and formulates management of AI projects.

4 Conceptualising AI Management with the 2PDT Framework

4.1 Conceptualising AI Management

Based on the systematic literature review it was important to find the building blocks to construct the 2PDT framework. Our questions being (1) what detail will the framework contain? (2) what existing IS theory can we base the framework on? We examined a catalogue of IS theories compiled by Larsen and Eargle (2015) to assist with constructing our framework, and also reviewed existing theory relating to the components of an IS (Jessup and Valacich 2008; Lyytinen and Newman 2008; Rezazade Mehrizi et al. 2019). We propose using the components of an IS for providing the categories for our framework and to group identified challenges. These components being technology, people, data, and process. We arrived here based on analysis of available theory on IS components. While we were unable to find uniformity in the theory, we did identify a positive level of correlation in how the components of IS are defined in the literature (Jessup and Valacich 2008; Lyytinen and Newman 2008; Rezazade Mehrizi et al. 2019). In summary, Rezazade Mehrizi et al. (2019) defines the following components – technology, actors, routines; Lyytinen and Newman (2008) defines the following components – technology, actors, task, structure; and Jessup and Valacich (2008) defines the following components – Telecommunications, Software, Hardware, Data, People. Additionally, the PACT (people, activities, contexts, technologies) framework used for system design (Benyon 2013), and the Information Systems Research Framework (people, organisations, technology) (Hevner et al. 2004) further support the above defined components of an IS. While there is no agreed theory for components of an IS it is evident that the theory does refer to some of the components using similar terminology, while for others a different term is used but we have taken the meaning to be the same. We have applied these theories to construct a model of IS components which will be used in this study to categorise challenges into non-technical and technical categories. We propose that an AI system is essentially an IS given the components above also make up an AI system, supported by the definition provided by Sari et al. (2020) who emphasises that implementation of AI includes work practices, task processes, technology, and data. Given that we have been unable to find standard theory describing the components of an IS we have brought the available theory together which encompasses the components mentioned below. We propose people, process, and data are non-technological components, and the technology component is where the technological elements are. The research interview questions are also grouped using these defined IS components.

4.2 2PDT Framework

Figure 2 provides an illustration of the conceptual 2PDT framework, which has been developed following analysis of AI challenges presented in the domain literature (Adadi and Berrada 2018; Choudhary et al. 2020; Department of the Prime Minister and Cabinet 2019; Desouza 2018; Desouza et al. 2020; Ichishi and Elliot 2019; Lacheca 2018; Lee and Shin 2020; Sicular et al. 2020; Sun and Medaglia 2019; Wirtz et al. 2019; Zatarain 2017). These challenges, some examples presented in the rectangle boxes, are currently impacting effective management of AI projects. They include infrastructure, interoperability, data quality, data availability, skills, workforce management, security, and use case development. Infrastructure refers to the technological capability such as systems, applications, and technical resources (Choudhary et al. 2020; Desouza et al. 2020). Interoperability refers to the challenge of disparate systems and data which make it challenging to build effective AI system solutions (Desouza 2018). The Data quality challenge means organisations must clean and model data before it can be used for AI systems. Data availability refers to all required data being captured by the source systems to enable the fulfillment of identified use cases (Ichishi and Elliot 2019; Sun and Medaglia 2019). Organisations have good ideas to be exploited by AI, but their systems need to be enhanced to capture the data they require. Skills and workforce management practices refers to the challenge of having access to the human resources with the required skills to work on AI projects (Ichishi and Elliot 2019; Lee and Shin 2020). It appears that the traditional IT skills alone are insufficient for AI. The challenge of security indicates that the controls to ensure data security need to be reviewed to ensure they are sufficient for AI (Adadi and Berrada 2018; Wirtz et al. 2019). Use case development challenge refers to identifying practical uses cases that can provide value (Baker et al. 2020; Desouza et al. 2020). It appears organisations are finding it difficult to prioritise and select valuable use cases.

The main part of the framework has been developed using circular arrow shapes to show that the 2PDT is a framework that is applied as a continuous process. The people, process, data, and technology components, which are taken from the IS theory in AI (Jessup and Valacich 2008; Lyytinen and Newman 2008; Rezazade Mehrizi et al. 2019), are continuously applied, monitored, reviewed, and

enhanced as required. The 2PDT framework is versatile to apply in diverse approaches to the management of AI (i.e. Agile, DevOps, hybrid adaptations).

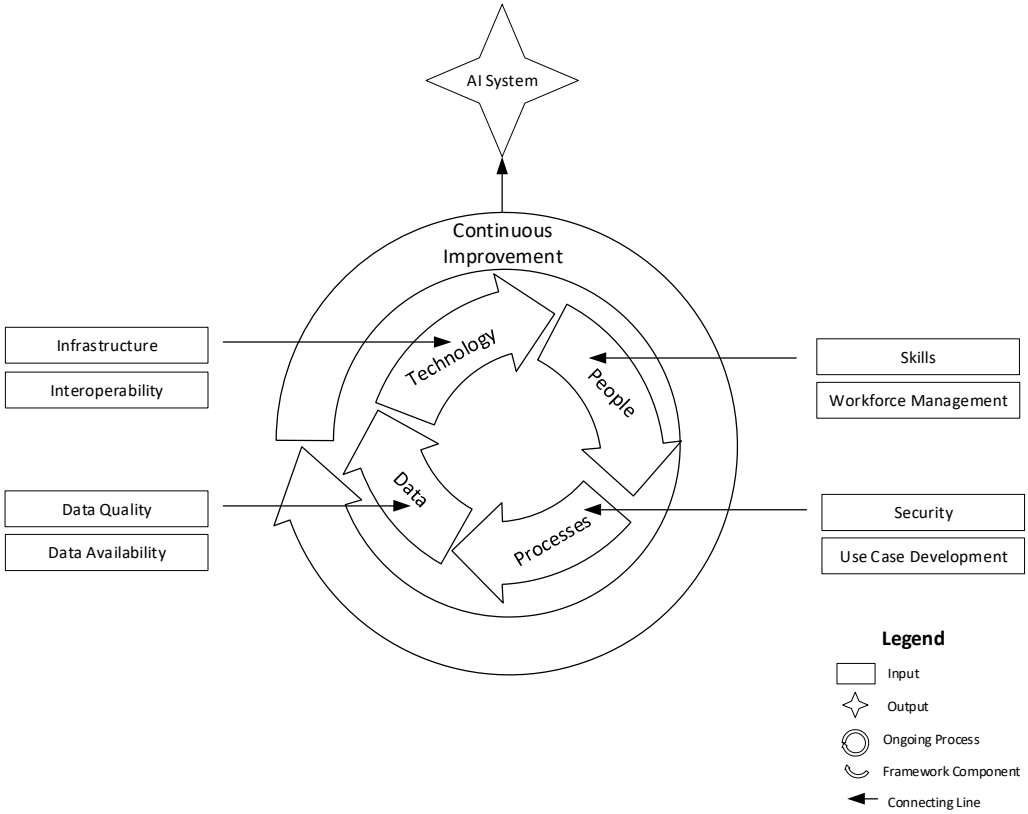

Figure 2: 2PDT Framework

People

Human beings in general are the people who build and/or use a system (Benyon 2013; Jessup and Valacich 2008) for example an end-user, programmer, or a business analyst. People are key to the management of AI as they provide use cases for AI development and are involved in verifying AI output. AI is expected to always support human thinking and hence people will always be at the centre of AI task performance and decision making (Deloitte 2017; Xu et al. 2020; Zhang et al. 2019).

Process

The activities which are performed to reach the required goal with the available system (Jessup and Valacich 2008). For example, this can include the process of manufacturing goods, selling products, human resource management, procurement. Examples of processes applicable to AI include processes such as use case development, system security certification, and algorithm selection.

Data

Raw substance that is recorded and can be in a formatted or unformatted composition (Jessup and Valacich 2008), for example an individual's date of birth or mobile number. Quality data is a key input for AI which means it must be structured and modelled effectively. Managing data quality (Desouza et al. 2020) in AI projects is an area which requires investigation to assess whether additional quality requirements exist for managing data quality in AI projects.

Technology

Is a mechanical and/or electrical medium which consists of hardware and software that transform some input data into some output (Benyon 2013; Jessup and Valacich 2008). For example, a programming language or a computer system. Research indicates that AI technologies are well developed to support organisations based on a small number of technology challenges identified in the domain literature.

Continuous Improvement

The continuous improvement procedure, which is illustrated with a circular arrow, is not covered by the frameworks presented above, it is being proposed to encourage refinement of these areas and will be a contribution from the research.

The research will investigate the identified challenges and any new potential challenges which are uncovered during data collection to identify how they can be practically overcome in order to be applied in management of AI projects. For example, from the technology category determining the optimal manner in which algorithm selection can be made.

We assert that the 2PDT should be an effective mechanism because of its agility, rigour, and completeness.

- The agility refers to the ability of easily and quickly integrating the framework into the existing organisational process of managing AI projects.
- The rigour comes from a study which follows an accepted research methodology which includes the views of AI experts.
- The completeness comes from a mix of existing theory which is brought together into a conceptual framework.

5 Research Design

The research is shaped by IS design theory (Gregor and Jones 2007; Hevner et al. 2004) which has been applied to define the research problem and existing literature has been used to develop the scope for a research project. The next step is to implement this project the output of which should provide useful contribution to the existing IS knowledge base.

5.1 Research Methodology

The research will employ a case study approach (Yin 2018) , which is commonly used in IS research and in research which adopts the same paradigmatic position (Myers and Newman 2007; Silverman 1998; Trauth 2000). The research will adopt a multiple case study approach as it offers a compelling and robust approach (Yin 2018). It is more compelling and robust as it includes participation from different teams and across different organisations. Including multiple case studies allows strong inferences to be made given this would be based on information gathered from more than one team or organisation. This research will include multiple cases which will be randomly selected from organisations who have or are working with AI projects.

Data collection methods will consist of semi-structured interviews and document reviews of cases (i.e. IT strategy, corporate plan, project plans, searching on participating organisations websites), which should assist with deep investigation of cases. Semi-structured interviewing method has been selected as it allows enhanced interaction between the interviewer and interviewee, and it will also offer opportunities for follow-up questions (Kallio et al. 2016; Rabionet 2011). Cases from both public and private sector organisations will be invited to participate in the research with AI experience being mandatory. Participants can be from different roles including senior management, middle management, project managers, and both technical and non-technical specialists.

The interview questions and data collection instrument have been designed based on the components of the 2PDT framework. This has helped us to develop key questions that cover each component and should give us useful results that can be related to the 2PDT components. Questions have been developed first allowing participants to explain their experience and circumstances and then discuss any challenges or issues they sense. Some of the questions that will be asked during interviews are; Please outline your role? Please outline the scope of your AI project(s)? Please outline the essential skills, experiences and/or qualifications required in your role and how can people acquire these? Please provide examples of data management challenges that you are seeing, and what are the approaches being used to work through them?

Data analysis will include a preliminary analysis step to review collected data and clean any inconsistencies, incompleteness, errors, and gaps. This may require going back to the participants to seek clarification where possible. This will be followed by the coding and analysis steps which will involve organising data into categories that are exclusive and non-overlapping. The thematic analysis method will be applied to the data collected from the case studies to evaluate the data and NVivo

software will be used as it has proven a useful tool to use for data analysis in qualitative research (Hilal and Alabri 2013; Wong 2008).

A pilot study has been conducted to test the research design and formulation of research questions.

6 Pilot Study

The pilot study demonstrated that the case study approach is well suited for this study. The interview questions were well received by participants and answers were provided without the need to provide additional information or detailed explanations. We are reasonably confident that the prepared questions are effective to answer the overall research question. The questions proved flexible by allowing follow-up questions to be asked based on responses received. The data collected shows we are on the right track, and some insights of our findings are discussed below. However, further data and exploration is needed in order to provide a meaningful discussion which will follow the main data collection phase for the study. At the time of this paper submission the main study is in progress.

Two AI technical specialists were part of the pilot study. One interview was conducted in person while the other virtually via Microsoft Teams. The pilot study was conducted applying Yin's quality tests (Yin 2018) to ensure validity and reliability and following a case study protocol. We have found that there is a strong correlation between the issues and challenges that are discussed in the AI domain literature and the preliminary data collection. The data (see Figure 3) highlights that the technology to support AI implementation is available, and that the main challenges that need to be overcome are in the non-technological elements involved. People challenges include finding human resources with skills in analytics, in-house experience in using the tools required to implement AI solutions, and the skills to make security assessment decisions. Data challenges include poor quality data, data spread disparately across systems, and in some cases required data is not captured by source systems. There is a mix of existing and new processes being invoked in AI projects. This includes waterfall project management methodology and using academic research methods to test hypotheses. Participants advised that they have not faced any process or technology related challenges or issues at the present time.

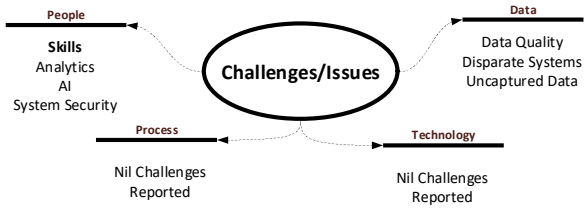

Figure 3: Preliminary Data

7 Conclusion

In this paper, we have argued that the AI domain is an area which requires a conceptual framework to bring structure to the domain. We have adapted the approach to AI analysis, calling 2PDT. Our tentative conclusion is that 2PDT is an effective framework for the research question formulation, research design, data collection and analysis.

The 2PDT framework should provide an approach to the management of AI that has a solution to contemporary challenges. The 2PDT is expected to be versatile in that it can be reviewed and enhanced overtime as lessons are learnt, and new challenges are identified to meet the evolving requirements within the AI domain by following the method used for its inception.

Reflection of the 2PDT framework and the approach; produced insights, questions, and ideas about the domain and the 2PDT framework. The recommendations are expected to be from a non-technical aspect to better manage matters such as privacy, ethics, social factors, and security, among others. In this paper, we recognise AI as a phenomenon that requires further investigation. The examination of 2PDT explores new challenges impacting the effective management of AI projects, and possible areas for further investigation. It is too early to claim practical contributions, but we assert that the 2PDT framework could provide a pragmatic approach in this domain. Better visibility is expected to be achieved once collected data is analysed, at which point it can be discussed further.

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