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Exploring Prescriptive Process Mining and Visualisation

Master's Thesis (20 ECTS)

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Abstract:

Process mining is a modern field and fundamentally is involved with the analysis of event logs and the results subsequent to such an event log. Even newer is the inception of prescriptive process mining, whereby recommendations are derived via machine learning methods which originate from process mining logs. Visualising modern innovations in business and technology can be challenging to ensure that standards and users' needs are met. Thus this thesis analyses the visualisations drawn from prescriptive process mining and how it may be possible to build a guideline in the format of a dashboard to support case workers with ongoing work utilising the power of prescriptive recommendations. This can provide a base design which can be used across a variety of industries or organisational settings to support case workers completing their day to day tasks while utilising the power of prescriptive recommendations derived from process mining.

Keywords:

Process Mining, Prescriptive Process Mining, Recommendations, Prescriptive Analysis, Design Science, Dashboards, Prototyping

CERCS: P170 Computer science, numerical analysis, systems, control

Ettekirjutusprotsessi kaevandamise ja visualiseerimise uurimine

Abstract:

Protsessi kaevandamine on kaasaegne valdkond ja see on põhimõtteliselt seotud sündmuste logide ja sellisele sündmuste logile järgnevate tulemuste analüüsimisega. Veelgi uuem on protsesside kaevandamise algus, kus soovitused saadakse masinõppemeetodite abil, mis pärinevad protsesside kaevandamise logidest. Ettevõtte ja tehnoloogia kaasaegsete uuenduste visualiseerimine võib olla keeruline, et tagada standardite ja kasutajate vajaduste rahuldamine. Seega analüüsitakse selles lõputöös ettekirjutusprotsesside kaevandamisest saadud visualiseeringuid ja seda, kuidas juhtpaneeli vormis võib olla võimalik koostada juhtnöörid, et toetada käimasolevat tööd, kasutades ettekirjutuste soovitusi. See võib pakkuda baaskujundust, mida saab kasutada erinevates tööstusharudes või organisatsioonilistes tingimustes, et toetada juhtumeid, kes täidavad oma igapäevaseid ülesandeid, kasutades protsesside kaevandamisest tulenevaid ettekirjutavaid soovitusi.

Keywords:

Protsesside kaevandamine, ettekirjutusprotsesside kaevandamine, soovitused, ettekirjutusanalüüs, disainiteadus, juhtpaneelid, prototüüpimine

CERCS: P170 Computer science, numerical analysis, systems, control

Table of Contents

1 Introduction 5

1.1 Business Process Management 5

1.2 Process Mining, Visualisation and the Problem 5

1.3 Research Question/'s 6

1.4 Contribution and Structure of this paper 7

2 Background 8

2.1 Understanding Business Process Management & Process Mining 8

2.1.1 Business Process Management 8

2.1.2 Process Mining and BPM Lifecycle 8

2.1.3 Process Mining 9

2.1.4 Descriptive, Predictive and Prescriptive Analysis 10

2.2 Understanding Data Visualisation 11

3 Related Works 13

3.1 Recommendation Systems and Visualisations 13

3.2 Framework for Prescriptive analysis and Process Mining 14

4 Methodology 16

4.1 Prototyping Methodology 16

4.1.1 Step One – Analysis of Prescriptive Process Mining Literature 16

4.1.2 Step Two – Analysis of Visualisation Standards and Norms 17

4.1.3 Step Three – Design Prototype 18

4.2 Evaluation Methodology 18

4.2.1 Step Four – Preparing the Evaluation 19

4.2.2 Step Five – Conducting the Evaluation 20

4.2.3 Step Six – Final Iteration 22

5 Prototyping 24

5.1 Literature Pre-Processing 24

5.2 Content Rationale 25

5.3 Design Rationale 29

6 Discussion 33

6.1 User Outcomes and Findings 33

6.1.1 Usability 33

6.1.2 Workflow and Logic 35

6.1.3 Comprehension and Feasibility 35

6.1.4 Content Blocks 36

6.2 Proposed Updates 38
6.3 Study Limitations 39
7 Conclusion 41
8 References 43
Appendix 52
I. Supporting Documents 52
II. License 53

1 Introduction

1.1 Business Process Management

Business process management (BPM) within an organisation consists of holding an understanding of an enterprise's sequence of activities then from this how may process be altered, enhanced and streamlined [1]. Business Process Management is defined as: "*supporting business processes using methods, techniques and software to design, enact, control and analyze operational processes involving humans, organizations, applications, documents and other sources of information*. [4]" making BPM a collection of an enterprise which is used to streamline and eliminate waste to better company performances.

BPM is a cyclical action which begins in the phase of discovery often this is where the process is initially defined. Discovery is where there is a focus of the key processes and a process architecture are developed. This leads to enterprises specifically mapping out their process via a variety of methods. Commonly known as the subsequent step of analysis, here this step the as-is process model which was formed is taken a step further. This step being to offer insights on the weaknesses and impacts that the current process has to offer [2].

Now that the process is known BPM can take itself further offering proposals to improve the process (if required). This section of the lifecycle is referred to as redesign [2], there are many ways in which companies can change their current process to aim to enhance. First one must understand why redesign may be considered.

Transferring from BPM to look to the pivotal elements of a business's core competencies are to ensure they hold control over their expenditure, productivity and can in the modern era operate in an agile environment often with consideration to the customer first [5]. Redesign from a BPM standpoint is to phase out older items and ensure that new changes which are proposed will result in a benefit for the business. Following this the changes are implemented and executed often via process models which would show a to-be agenda [2]. Also known as process enactment, this is the modelling of business processes, something crucial as we progress through this paper [3]. Finally the last stage of BPM as taken from the lifecycle is to see monitoring and controlling where the process is run and segments of the track the tasks take are analysed to squeeze further improvement and make even further process recommendations in the future [1].

1.2 Process Mining, Visualisation and the Problem

A tool of the BPM process is process mining. This data driven tool uses data logs which supports discovery, analysis and monitoring of data via the inspection of event/service logs of enterprises [30]. Further to this one area is seen as challenging the user to consider the specific events which occur in a process [1]. After the implementation of a redesign, monitoring and control processes often require the need to take event logs to map into the premade process logs. Examples where process mining is used can be found; often disconnected from any actual real life data [6]. They are often taken to utilise the connection between the process and a recommendation system [7]. Process mining is especially important and useful when evaluating event logs, event logs are often the critical element of interconnecting BPM to the models which are developed [8].

Process mining looks to present the evaluator with a variety of information, this can be then be presented via a multitude of formats descriptive simply showing stats an example will be used as a SaaS operator. To describe their data they may show how many signups over a period of time they have had. Taking this one step further the company might predict how many signups using the historic records to propose this. Finally prescriptive is a recommendation where this information is historically reviewed and change is appropriately

advised [9]. This kind of data in the Netherlands was analysed and it saw in specific areas of the supply chain when utilisation of such data that business performance enhanced [12] identifying the importance of paying attention to such data in enterprise and how by discovery of norms and prescribed factors can enhance business in the real world.

Prescriptive recommendations often come via process mining and then extraction of different tasks into models. This then presents the consequences of following the recommendation systems which are proposed. From past literature the visualisation is shown often following a before and after prediction; an item used across a vast array of academia. Fields where further research shall be evaluated include, Hospital management, customer journey management and also in a general business context to enhance the reach of KPI's all of which will be advanced during the related work.

These recommendations are then often visualised to show how improvements come from each model. These visualisations often include a similar approach to explaining the recommendations. From my analysis I shall show how there are a few approaches to these visualisations, including the following two manors (a) Utilization of process maps and decision trees to show the event logs from outcomes of the recommendations systems. (b) Furthermore accuracy, model fit and the savings provided by the recommendation from the system are frequently shown within bar charts and line diagrams, this will be further explored within the methodology.

As mentioned above often the data utilised via process modelling is put into recommendation systems, to further understand this a few examples on how this work are displayed. This will be further expanded upon in the related works review.

Descriptive and predictive analysis, including how these items can be easily automated [13]. Many companies utilise such analysis via mainstream tools such as Tableau and PowerBi amongst many more to present management with statistics covering a variety of business elements [14]. Predictive and descriptive data is almost seen as commonplace across global homes subsequent to the Covid-19 pandemic and scientists using these visualisation techniques to explain the variety of complex issues the pandemic has brought to the world during 2020 [15].

Yet visualisation of outputs from prescriptive process mining have not been fully analysed as of yet, henceforth the expansion to review prescriptive process mining and as suggested within [105] design an artefact which will be a contribution to the research field of process mining.

1.3 Research Question/'s

The paper will strive to answer the following research questions which are focused on finding common ground and establishing guidelines for visualisations derived from prescriptive process mining outputs.

- RQ1: How visualisation of prescriptive analysis formed from process mining can be used to support ongoing work?
- RQ2: Is it possible to categorise and group common visualisations when displaying prescriptive analysis born from process mining?
- RQ3.1: What decisions and/or knowledge is needed by a caseworker during ongoing case work?
- RQ3.2: What data and metrics are important for decisions and daily work?

- RQ4.1: What schema's (visualisation norms) are used by those when creating a dashboard?
- RQ4.2: Is the product presented in a way that the end-user could see themselves using the product? (*Based on visualisation structure and standards*)

To further motivate the research questions they anticipate to drill further into the topic to understand exactly how firstly visualisations are utilised to support ongoing projects; what could even be construed as a visual element derived from process mining and how common visualisations and outcomes from prescriptive process mining can be grouped into a dashboard. The questions then look to focus on specific visualisations, is there a type of visualisation suitable to this kind of research and if so can visualisations be grouped into a category or selection, when identifying a specific item. The first two research questions are to focus on common visualisations presented from recommendations derived from prescriptive process mining and how such recommendations can support ongoing work. This will then facilitate the need to understand the decisions case workers make and how the recommendations can be useful; how they can be presented and what contributing elements support working with data derived from process mining in day to day business cases. Understanding these different decisions and knowledge needed by a caseworker will support development of a dashboard where prescriptive recommendations can be presented. Due to this it is also required to follow visualisation standards for users to actually use a working artefact. The final questions ask about a visualization standard, utilising the original knowledge gained from the questions above; it is to be researched if visualisations should be presented in a specific way utilising knowledge from design science. It will explore how it may be simple to present the user with a framework of guidelines to how it is possible to provide all audiences with an easy understanding ensuring norms and needs of the user are considered. It will be reviewed how the designed artefact can be used and how feasible such a product is within the workplace.

1.4 Contribution and Structure of this paper

The core contribution of this research paper is to fill the void for decision makers in business who are looking to use prescriptive visualisation in their own businesses. This will come with an ideal dashboard which can be used by process workers when dealing with recommendations derived from process mining in a workplace. As is seen above and further expanded later within Background and Related work sections of the paper, literature shows how prescriptive visualisation is used to explain how change was made and prove the benefits past time, or in the case of this study focusing on prescriptions for ongoing work and how such prescriptions can be analysed and displayed. This paper will look to focus on prescriptive process mining outputs and visualisations within the context of business processes. The paper will focus specifically on the needs of case workers who deal with recommendations brought out of prescriptive process mining. The results of prescriptive work are to be considered and analysed for how process changes in this industry can be enhanced by utilising prescriptive process mining. Alongside this contributing to the expert learning coming out of the University of Tartu.

The Thesis will be structured as follows: it will look into the background of the topic of both process mining and data visualisation, then touching on related work by scholars in this field. Before a methodology is brought out, subsequent to the methodology the results and discussion of the work will be considered before continuing to offer a guideline for visualisations in this sphere.

2 Background

2.1 Understanding Business Process Management & Process Mining

2.1.1 Business Process Management

Business Process Management (BPM) as a concept itself lies in a family of disciplines, it is all about the model of thinking [21]. BPM is a form of Business Intelligence (BI) which encompasses a broad range of options to utilise data analysis [24]. BPM in general is set up within companies to enhance said enterprise's performance. Dumas et al.[1], an acknowledged contributor in this field, discussed the field of BPM to exist within a lifecycle, one could say a loop. This lifecycle is shown below (figure 1) and explained in further detail throughout the background on BPM and Process Mining.

2.1.2 Process Mining and BPM Lifecycle

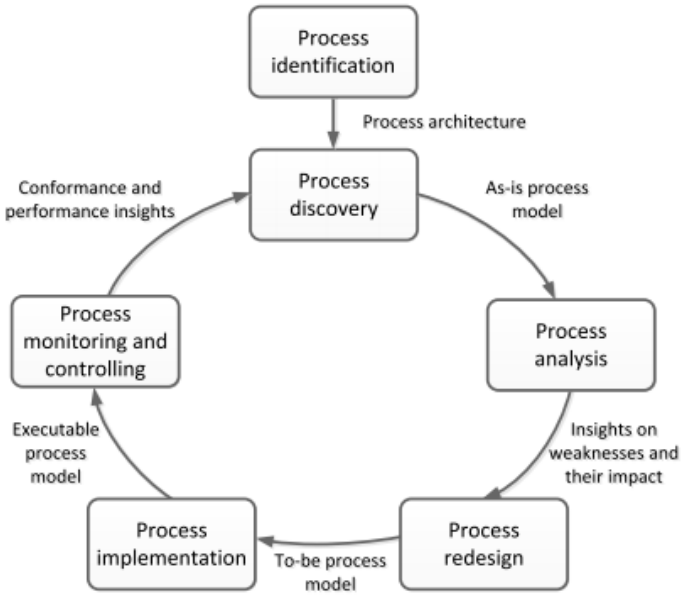

Figure 1 - BPM Lifecycle [1]

As a background on the BPM lifecycle is shown; process mining shall be introduced and how it is interconnected within such a model. This explanation could also cover workflow process mining, a detailed description of a workflow [23] similar to discussions above of the process log of an individual activity. This indicates that the workflow/process log can be structured [23]. A definition exactly to the goal of process mining is as follows: *"The goal of process mining is to extract an explicit process model from event logs, i.e., the challenge to create a process model given a log with events such that the model is consistent with the observed dynamic behavior* [24]".

The lifecycle commences with discovery essentially reflects what the exact process we are trying to analyse is. [24] This example shows how within a claims handling process discovery is all about understanding the exact actions which take place; specifically they have used an event log to display this. The event log specifically refers to the process instances in order for the process being discussed to take place. This event log shall later be considered in further discussions of Process Mining. Discovery is essentially where this is first located by the individual conducting BPM. It is noted that within this initial phase of discovery when items are added into process logs it may not be initially understandable [1].

The next stage of the process lifecycle is analysis, to understand analysis is to know here the business practitioner is attempting to locate the weaknesses within the model which has been discovered [1]. As discussed by [1] there are many ways in which you can take and analyse the information. In interconnecting this to process mining, the model would here show a “control-flow” and this is connected to the event log which was taken from discovery [25]. Now the phase of analysis is completed, it will either be monitored as it continues on its life until the requirement for re-design is met. Here the model is adjusted, redesigned and is sent back into the cycle to see if the new KPIs have been met [25]. The final state of the BPM lifecycle is to monitor, this is where the items are closely attended and the current data is added to see if support is needed [25]. During the process of process modelling it is imperative that the control flow is always met. There are various methods to ensure this happens, in essence ensuring the basic workflow has a pattern [25]. This explains how BPM lifecycle wraps itself around process mining; a key element as already mentioned for process mining is the development of a model from logs [22]. Data mining consists of two elements classifications (a category) and prediction (the data into a model); Data is classified then added into an algorithm which then was built to show a result, often surrounding the utilisation of testing a data set by forming a training data set [36].

It should be added that [29] have argued that it is nearly impossible for process mining to be utilised via all the stages in the aforementioned lifecycle. There are various notations for such parties which process mining belongs within, another is Business process intelligence [24]. In the academic era the idea of process mining is a combination of “computational intelligence and data mining” [25], to understand these two terms we look to first computational intelligence. This is a combination of a variety of algorithms from machines [26]. Then data mining, this is the understanding and analysis of observational data; Observational data is considered data which has been collected for another purpose rather than the data mining you exactly want to pursue [27]. This is not to say that the item of discussion process mining only looks at such types of data often it is run for experimental purposes [28].

As discussed already within the BPM lifecycle key to process mining is the Event log. Process mining begins from this log [30]. This event log (also classified as nodes), is then constructed into a model; said model is then via a specific algorithm of choice presents the knowledge to the user [22]. Process mining which shall be examined in further detail is often split into 1. Discovery, 2. Conformance, 3. Extension. These three items are seen as the three possible goals for a process mining journey (figure 2) [30].

2.1.3 Process Mining

Process mining is based upon the observed actions conducted by users or individuals depending on the process which is being evaluated [30]. Process mining is merely a part of BPM and is utilised within such fields to support the event chains.

Discovery is to take the event log and show “a-priori” this is the information how it should exactly occur without any deviations [25]. What is a result of discovery is the model showing the process.

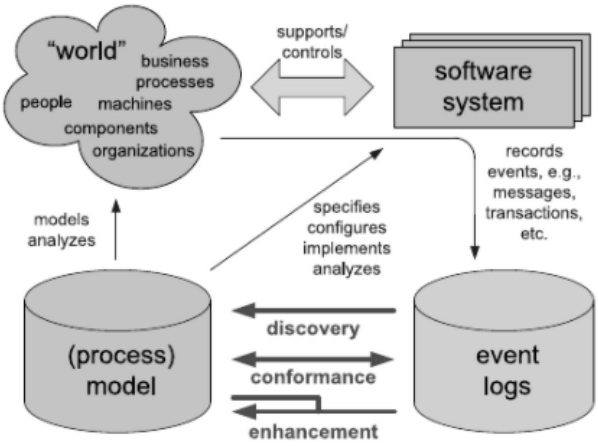

Figure 2 - Basic types of process mining [30].

The second item conformance is to check the reality. Does reality occur in comparison to what is supposed to be happening? This element of process mining requires an event log [25]. Finally Extension or also known as enhancement [25], supporting users to enhance the existing process.

2.1.4 Descriptive, Predictive and Prescriptive Analysis

So far all of process mining and BPM has explained how the extraction of data can show a result [21]. There are a variety of ways the results of such studies can be presented, descriptive, predictive and finally prescriptive mannerism [33]. In the present era the majority of finance within active business is spent within descriptive and predictive analysis [35]. Descriptive is in essence showing the exact result from the logs which are reported upon, in layman's terms the current status of whatever may be reviewed [33]. Predictive analytics can be very easily summarised as "*Predictive analytics is a set of business intelligence (BI) technologies that uncovers relationships and patterns within large volumes of data that can be used to predict behavior and events* [34]". This is suggested as predictions based upon monitoring what is presently happening [34]. Monitoring being the final stage of the BPM lifecycle [1] shows how all these different terms and segments are interconnected. Understanding one alone is not suitable for gaining a broad understanding of process mining and analysis. Prescriptive is the suggestions from the analysed data model and the subsequent results from this [33]. In essence when considering the BPM lifecycle if a user has entered the recommendations stage, prescriptive analysis would show exactly what the implication of the change is [35].

Prescriptive challenges are answering the question of what can be done and why; considered by many the most cultivated type of business analytics as if done correctly the best results can be found [35]. To arrive at the end result of a model to perform prescriptive analytics the evaluators must use a specific model. As done by Katerina Lepenioti [35] a depiction of methods most commonly used for both predictive and prescriptive analysis was drawn out. Here showed that there are many potential paths for models when utilising prescriptive analytics.

There are a variety of models which can be utilised to find prescriptive results. A. Probabilistic Models, B. Machine Learning / Data mining, C. Mathematical Programming, D. Simulation, E. Logic-Based models [35]. In essence all the models are enablers of the outcome for prescriptive analytics. In summary "*prescriptive analytics generate specific*

action recommendations to achieve a goal [37]". Prescriptive analytics can be used in sync with data mining techniques utilising recommendation systems, types of systems as elaborated above [17, 19].

2.2 Understanding Data Visualisation

The essence of visualisation is for users to understand/read what may be being presented to them; as suggested within [38] it is about guiding the reader to facilitate a comprehension on what is being presented. Representation is in the forefront of the concept of data visualisation, this discusses the mode that the data is being shown, be it chart, matrix, map etc… [38]. Also discussed by Kirk, data visualisation should follow three principles to be trustworthy, accessible and elegant for the user [38]. A lighthearted but very meaningful definition comes from [39] who discuss data visualisation to be similar to origami in essence the formation of patterns which are useful. As data science as a practice develops it should also be added there are multiple tools to support visualisations which support the user input large data sources into the norms - a variety of charts [48].

If data visualisation is in essence the simplicity of representing a dataset into a visual form then this leans its way to being biasly interpreted; the data visualisation should always be considered as being led by its creator, in many cases for a purpose [40]. Commonly such biases are most obvious within politics and one example of bias visualisation was the British Brexit Bus, which falsely claimed financial gains for the UK whilst touring the United Kingdom [41]. This being said the argument was brought forward by [42] how to enhance data visualisation to make it more valuable, especially in the era of big data where in many cases unimaginably large data sets are being used. To further understand the term 'big data', it is that with a major volume and variety inside the model [43]. The reason big data is being defined is due to its close connection to visualisations and how it fundamentally can support to drive business decisions [42][44].

How a user chooses to present data in a visualisation can greatly contrast the intended meaning, why choice of visualisation method is so important [45]. Visualisations of data can come in many shapes and sizes; [45] provides a simple example on one type of visualisation 3D and how they can be misinterpreted. This holds for all different types of chart and even in different human states [47].

Visualisation and process mining equally are tightly connected. The knowledge gained here will lead to key visualisations of how in a world where all norms are followed the path for how things are taken can be viewed [31]. This will put the data into a language which many will understand a common BPM recognised language is Unified Modelling Language ULM; a standardised approach to process modelling [32]. UML provides users with the visualisations within a language created for all to understand how to read and interpret. There are many languages which can be covered within process mining to support the visualisation of data; BPMN, EPC and Petri are all additions to this [25]. Process modelling approaches are often to conduct a variety of activities [48], in the example of process mining for a software product, this follows a similar trend to discover, check and enhance the experience [31] with this in all cases the user must analyse visuals for different purposes; different models will be used for such activities. It should be added when dealing with recommendation models (commonly interchanged alongside prescriptive analysis), here the model may not be dealing with human bias but the model's inaccuracies [46]. Visualisations in the field of prescriptive analysis cover a large variety of arenas including marketing and strategic management meaning often there will be different causes and purposes for the visualisation [51]. These visualisations moving to dynamic means within prescriptive analysis provide a wider opportunity for how information is shown [51]. This could be a reason no presently administered framework exists.

To summarize data visualisations cover a vast amount of what we see in the modern world, and there are problems as expressed via biases and model inaccuracies; creating the most optimal solution without error is yet found and there is no direct framework [46], but there are methods for alleviation.

3 Related Works

The related work looks to papers which have very close connections to visualisation drawn from recommendation systems. Seeing how past scholars have managed to gain patterns and discussed their discovery when performing research within this field. Additionally to this the thesis then discusses similar frameworks for prescriptive analysis derived from process mining; yet here the scholars may not have touched directly on visualisations.

3.1 Recommendation Systems and Visualisations

Creating a framework for information to be visualised or 'knowledge visualisations' is something produced by Eppler in 2004, as suggested by Eppler at this time there is no "validated prescriptive framework" [50]. This lack of classification between prescriptive analysis and visualisation is what this paper shall build upon. Work in building a framework and standardisation for descriptive data visualisations has been done by Heidi Lam et al [51] providing seven scenarios which can support descriptive analysis end goals; this outputs the environments, the reasoning behind such visualizations and what the end user would anticipate has been conducted; this work specifically elaborates on the lack of prescriptive framework underlying this would take an alternative type of analysis. Discussing the fundamental importance of conveying the correct message of the data visualisations original goal to the end user is important [40] [55]. Focusing on prescriptive analytics [40] shows utilising Pierce's framework (how to connect data and the intended message to the visualisation); that there is often a greater tendency to have a wider range of conclusions (and attributes) in the graphics when conducting prescriptive messaging; learning how there can be associated connections. Prescriptive analysis could also be referred to as the action based on recommendation systems; such visualisation has been reviewed [53][54]. This paper shall follow the logic from these scholars to ensure prescriptive visualisations can understand all the connotations from the intended cause.

Recommending a visualisation based upon a specific task is conducted within [54]; visual recommendations and trends are here analysed and visualisations are recommended against the specific complex analytical tasks. It can be said though here Vartak et al do specifically pay mention to visualisation tools such as RapidMiner, here they often provide recommendations based upon the data size and trends it has found. Despite offering some kind of framework and outline for understanding visualisations it does not constitute to just prescriptive analysis which this paper is to later focus on, but the paper more focuses on a wider understanding towards visualisations within recommendation systems [54]. The paper suggests that only experts with knowledge of algorithms are needed to understand this information better. Similarly to what this paper aims to target, the visual ease of understanding is considered [54]. Recommendation based upon patterns from a HARVEST recommendation system is created by Gotz and Wen [53]. The aforementioned paper works to provide recommendations based upon user patterns and dynamically advise task specific visualisations [53]. This paper shows recommendations based on specific users not in a general case to prescriptive process mining visuals as this paper shall evaluate. Furthermore the paper lacks on providing any reason why said visualisation is good for specific tasks in building a framework this paper shall fill this gap. Furthermore there have been some attempts to specifically show prescriptive analysis via visualisation. These visualisations are often very focused to a specific industry within a paper. Specifically where CAS (Computer Aided Styling) models have been utilised alongside trend lines to evaluate a Pilot retention, this advanced prescriptive model referenced visualises the trends shown and contemplates human feelings within the algorithm to make its recommendations [61]. This paper shall bring out support for these specific papers that offer visualisations to provide a guideline for any institution when creating such visualisations.

A contributor to the visualisation community Munzner, has discussed visualisation models in a wider domain specifically for visualization systems, yet they have lacked prescriptive advice. Munzner does add to the field contributing three recommendations of which one is shown: *"Third, we argue that the visualization community would benefit from more papers that focus on problem characterization, and thus that they should be encouraged at visualization venues."* [62]. A perfect example in past literature to the gap which is currently existing within literature, which my paper will address and add to this field.

3.2 Framework for Prescriptive analysis and Process Mining

Applying frameworks to prescriptive types of analytics systems has been done by Nalchigar and Yu [52], in this case academia has been brought forward to review the insights from within machine learning algorithms and that influence which is perceived from the prescriptive goals. The questions which are being asked by the users directly from the outset. This identifies where a gap is being formed, between prescriptive literature and that regarding visualisation. The paper under discussion has a prescriptive framework, yet not for visualization of such analytics. Refined goals can support understanding of what the end user and creator of such analytics is anticipating the end user will want to view [52]. Additionally to prescriptive analytics there are also other types of data analysis, descriptive and predictive. Bringing the three together into one framework for analysis, when utilising all three types. The prescriptive model has a recommendation provided for how it should be utilised, bringing a summary of feedback and text suggestions when such results are provided [56]. This paper does not discuss visualisation in great detail but does give a framework for utilising such data types. This presents a guide for academic framework with prescriptive data handling which can be considered when forming visualisations.

Process mining frameworks for visualisations are discussed within [57][58][59[60], these papers all discuss a desirable framework or method to view data extracted from process mining. Yet in these cases it may not drill down specifically to prescriptive process mining. Gschwandter introduces common practices in how process mining can be visualised from stage to stage, specifically within the discovery stage of BPM within the utilisation of event log visualisation [57]. This paper explores in Gschwandter's case the six present approaches to visualisation, yet does not present a recommendation, the paper does however acknowledge the formation of any such framework can have a comprehensive impact on the field [57]. As the key areas of visualisation within process mining is brought out within [57], Sirgmets et al [58] aims to build a framework for process mining and visualizations which shows how many present visualisations are formed without much logical argument. This framework follows four cornerstones, which in essence can be broken down into what is the user chasing and then is the result of this output understandable. When a visualisation meets the requirements of its user and is understandable this is beneficial for all parties involved; an example of a framework yet not specific towards visualisations to what my paper will expand upon. This framework as explored within [57] asks the data formulator to ask a hierarchy of questions before providing the analysis to ensure the best results are met. Derived from process mining are often many pieces of information about specific events; [58] looks to show how the visualization of specific events can be visualised. This paper acknowledges the key role visualisation has in process mining, especially surrounding event logs, yet it does not focus specifically on this and more looks to the construction of an instance graph, an "abstraction of an instance"[58]. This could be considered a narrow approach to process logs and therefore despite looking at how an instance graph is visualised it does not consider prescriptive analysis in a broader sense of process mining, further no ideal framework is proposed. This paper merely recognises the importance of what is to be achieved rather than creating a framework of visualisation itself; the paper

looks toward a specific visualisation derived from process mining where this paper will look to collate a variety of visualisations.

Finally a standard for event logs a key element of process mining was studied within [60], this paper does show how process logs can be stored within a specific language and then from such a language the process log is visualised to the end user. Yet this is showing from the specific paper a more descriptive basis for analytics. The above shows how frameworks and guidelines have been created within process mining and including that of visualisation but not in specific regard of prescriptive analytics. Understanding the different languages which are used to display visualisation is important as this shall support creating guidelines.

4 Methodology

The paper will utilise ideas from design science and as well as more traditional qualitative analysis to analyse how prescriptive results derived from process mining can support ongoing work and specifically how to formulate a dashboard for operational use for case workers. The method shall be broken down into six steps as shown in figure 3, step one and two analyse the prescriptive process mining literature alongside visualisation norms and design science theory. Collating this information, step three shall be where a prototype design is formulated from the initial information ascertained in steps one and two. Then based on the first three stages, the evaluation is created, where an interview and post interview survey are prepared. Then conducting the evaluation based upon the preparation derived from research questions and also themes found throughout steps one to three. Finally there will be a last iteration to the favoured design (as multiple prototypes will originally be created in step three) and this will be elaborated on why these changes were made based on user feedback.

Figure 3 – Methodology

This methodology was formulated in conduction with design science approaches and is appropriately discussed throughout the following text whereby the ‘what’ is being conducted is further explained presenting how this relates to the research questions and why. The model and method above was generated in coordination with design science examples from the following papers [99], [100], [101]. Specifically the elements of process iteration expanded on in both 4.1 and 4.2 which was inspired from [100] “figure 1” and [99] “figure 4”.

4.1 Prototyping Methodology

To conduct step one and two this was first and foremost derived from developing ideas which are derived from the existing theories and literature [100]. The data to complete steps one and two for building the prototype will be gathered from Google Scholar and other online academic databases to name a few, IEEE, ScienceDirect and Jstor.

4.1.1 Step One – Analysis of Prescriptive Process Mining Literature

Firstly step one, qualitative analysis of papers which cover the topic of process mining and proceed to provide recommendations will be utilised. These papers have been found searching the following phrases such as, ‘prescriptive process mining’, ‘recommended actions via process mining’ were used to capture papers directly written on this subject and then related work of such papers shall be analysed to provide a broad understanding of the

topic. These questions will be addressed with their results expanded on in section 5.1 and 5.2. Where analysis is to be conducted; initially the papers will be grouped into similar themes; discussed as literature preprocessing before more solid foundations and findings can be made. The questions asked in this section are designed from the research questions, especially research question one (*How visualisation of prescriptive analysis formed from process mining can be used to support ongoing work?*) where the questions are focused on understanding what ongoing process workers need, use and how information is presented to them. This ties into the second research question ensuring that a standard or consistent style of visualisations are observed from the literature. The second research question aims to further understand the visual aspects which are common themes in process mining and also understand visual components which process workers utilise in day to day life when using systems. This question enables analysis on each element as a group as where the MosCoW method is to be conducted. This method facilitates splitting the components later added onto the prototype into categories which are Must's, Should's, Could's and Won'ts [102], this enables each prototype element to have a clear focus. As discussed the questions asked and elaborated in section 5.2 facilitate for a greater content orientated understanding. The questions which are being asked during qualitative analysis of the papers not only ascertain what ongoing work could be defined as but they are aimed to see what each paper suggests a case worker will need to support their ongoing work. This will also look into understanding the important decisions that case workers would make on a daily basis to support their role when acting upon prescriptive recommendations.

4.1.2 Step Two – Analysis of Visualisation Standards and Norms

Step two is then to build alongside step one where details gathered focus on the expectations of the case worker, common visual patterns displayed in dashboards (and recommendations) as well as the important modules a case worker will need to work with. As this information is collected it is also important to answer the fourth research question to see what visualisation norms can be utilised to encompass all of the data which is required by a caseworker. Then the information on visualisation standards obtained during this step will be collated with that from step one to conduct step 3, building the prototype shall be conducted. Understanding the visual norms within not only process mining but in building of the dashboards and IT visualisations to bring multiple elements of design science into the final product. This will contemplate academic knowledge away from the direct discussion of process mining and recommendations looking at visual norms specifically to do with dashboards which is the chosen method of presentation for the visualisation. The academic theories on designs and standards in the IT industry will come from analysis of google scholar as well as searching on perceived expert dashboard building tools to understand industry experts' best opinions and theories on presentation of materials. The idea of building a dashboard to display the information was founded from prior knowledge working with a SaaS company into how enterprises in the modern era work not only with data but how process workers access information. With the knowledge of a dashboard being the end goal, the second research question was strongly considered during the analysis of standards to ensure that the components for current work were considered and implemented in a visually appealing way. Also step two saw to answer the fourth research question; here the visualisation standards on dashboards were considered and how and why specific components are designed in a specific way and placed in the location that they are. Ensuring the information is presented in a logical order following a visual schema leads to a more synchronised viewing experience for the end user. Due to this such standards are to be evaluated based upon academic theory in screen and software design, therefore user principles for the given audience as reviewed within the academic research of the papers will be taken into account and analysed in section 5.3.
Both the first two steps will use a process of qualitative analysis into a collection of documents whereby notes from all the research papers used will be collated for further analysis. This analysis will consist of mapping trends in the papers and seeing how different

artefacts may be useful for the case worker in day to day life in an organisation. The first two steps also are following guidelines from [105] which ensures that any research within design science meets specific criterion, as indicated there are seven guidelines in table one which are fundamental for design science approaches. In discussing the research questions especially one through to three we are ensuring guideline five that “Research Rigor” is conducted to make informed decisions for IT artefacts.

4.1.3 Step Three – Design Prototype

The next step (step 3) is to mould the information ascertained by literature review on process mining and visual standards in the first two items of this study by building multiple prototypes and designs. As discussed the data to be analysed is that which was captured in the first two steps of the research process; information on both prescriptive process mining and design science norms. This prototype will collate the results and information which are drawn out of answering all four research questions as done by data analysis in the initial process.

The wireframes as shown in 5.3 are the final wireframes, to obtain these the process which was conducted is as follows; initial concepts were drawn up then there were iterative changes made in consultation with fellow masters level students from the University of Tartu computer science department. A short discussion on the iterative changes and what happened during this method is shown below, the iterative changes based out of ideas from the paper [63].Two fellow members of the University of Tartu Computer Science institute will be shown each drawn wireframe, they shall provide suggestions how this could be visually improved as seen in 5.3. These members were chosen as they both had knowledge on PowerBi dashboard creation from prior work experience. PowerBi being a widely used visualisation tool, this was seen as a good experience bridging professional dashboard building into the prototype design. The iterative process developed from [101] will take three attempts to iterate. This actually led from originally having three wireframe examples to only two as the suggestions from this design was removed and added to the other two ideas.

4.2 Evaluation Methodology

The final part of the study is to analyse the product from the development of a workable solution; test data will be explained as an aid to the visual example of wireframes where an evaluation will be conducted looking into how process workers work with the dashboard. Utilizing the wireframes shown in figure 6 and figure 7 (section 5) this was explained using a case from a SaaS ticketing agency utilising references from a dummy user story (below). As discussed in [105] this will be conducted as an observational method, to study the created dashboard in a working environment. This will support the verification of the third research question understanding a case workers day. This solution will then be posed in step 4 (preparation of the analysis) and step 5 (conduct the interviews explained throughout this section and analyse the data to make final iterations as in step 6) of the analysis across four interviews whereby analysis of the core competencies of the dashboard will be analysed.

The interviews will have the following conditions, a consent form is to be signed by the interviewee prior to their uptake, when this has been done the following steps that will be taken are as follows: The interview which is held will take place over Zoom with screen sharing enabled, for the wireframes and story to work in synchronization in creating the results and work visualisation for the interviewee. Each meeting will be recorded and uploaded to Zoom plugin Grain.io which will transcribe the discussion automatically. During the interviews notes will be taken as each question and comment is made; assisting this the transcribed meeting with timestamps. This interview and then follow-up survey will be designed to understand as much information regarding the product as possible away from an interview setting. Here it is hoped that possible flaws from the interview process will be picked up on here as respondents see it as an easier environment to be more candid with their responses [103]. One of the methods used during the separate zoom calls will be

affinity diagramming, to pinpoint each unique test user's opinion on the platform especially regarding challenges. Then once the evaluation has been completed, following advised research methodology within [103] a final further iteration (step 6) is desirable to enhance the effectiveness of what is being designed as well as use this evaluation to present the final solution of this paper as in section 6.2, this comes after another set of reiterative changes. Initially changes were made in the prototyping stage now subsequent to the evaluation to present the best product from user feedback as [101] discussed for iterative change.

4.2.1 Step Four – Preparing the Evaluation

Further explaining the evaluation; obtaining knowledge on user interaction and feeling from the prototype is very important to do so a case study was formulated and tested across a few interview cases. 'Respondent validation' [93] here is being used to derive findings from potential case workers in order to better understand the logic behind the study and how it can be operationalised in the real world environment [94]; using this idea behind this study on qualitative research case studies. Initial considerations on the purpose of the study, how the study will be actioned alongside the collation of results evaluated in section 6 are to be under consideration.

The evaluation following guideline three "The utility, quality and efficiency of a design artifact" [105], will be focused on ensuring that the prior research and prototype design has been done effectively according to the research questions. The interview will understand if the dashboard design meets the daily needs of process workers while also reviewing how experts in support teams the primary focus of this case study believe such a dashboard can support ongoing work. The interview will aim to see if the dashboards lend themselves for understanding and if users believe they would be useful. It should be said not all four of the research questions are to be answered from this evaluation; the second research question will not be answered during this evaluation as it will be focused on during step one analysis of literature. Questions one and three the interview will discuss the dashboard and the ongoing tasks and work, while the fourth question will discuss how the visualisation looks and feels from the users perspective and if they believe any components are out of place visually.

The aim of the case study is to follow research question one and understand how visualisations formed of prescriptive analysis from process mining could be used to support ongoing work. In formulating the visualisation the following discussion points will be considered and reviewed.

Interview Questions include:

- As a caseworker / someone who understands a caseworker's daily tasks, what do you believe is the most important information required in day to day work?
- Does the dashboard present enough information as required by a process worker to make informed decisions?
- Based on the dashboard presented and the user story I have just presented can you please support me to answer the following questions:
    - Do you believe the design and flow of work is organised? Please elaborate on this opinion?
    - Based on the scenario explained, do you believe a similar dashboard can be implemented into your workplace? Please elaborate on this opinion?
    - What are your comments on the sections displayed within the screen, are they clear?
        - What would you imagine to be shown in the specific sections within your enterprise?
    - Is the dashboard understandable, would you simplify it if possible?

- Which dashboard design do you prefer and why?
- What changes would you make to each dashboard and why?
- Specifically speaking from a design perspective is the dashboard easily identifiable in terms of the different objects and it is easy to read?

All of the above questions would be used in each interview, based on the responses additional changes would be made to pivot the interview along in the fashion to gain more insights from each participant.

Subsequently to the questions asked in the interview, each wireframe was shared with the interviewees along with a post interview survey. This survey conducted by Google forms, focused on three core elements: original domain and systems understanding, the system usability and expectations on the system. Firstly ascertaining the knowledge and previous experience with IT systems was crucial to denote how comments taken in the interview can be validated. The previous experience [96] looked into wider domain expertise before drilling down asking about dashboard design and experience as well as any knowledge on process mining. The system usability scale [97] and more questions derived on usability were then asked utilising design heuristics for usability [95]. The usability questions were asked to understand how the explained user story could support the interviewee's knowledge on using the system as intended. The final questions were based on the users intentions and if they believe there is potential to continue using such a dashboard [98]. The survey will have a variety of question types to ascertain both design based knowledge focused on the fourth research question to see how the design science approach leads to a product which presents a sound research as discussed by guideline four [105], the contribution. The survey will use open ended questions as well as discuss the System Usability scale where questions are asked to rank specific items between very good and very poor on a scale of one to five. There are also other questions scored out of five to see the interviewees general opinion of the product in terms of use in a working environment. The survey will aim to ask dashboard specific questions in order to provide information for step six and the final iteration of the product. The survey which was sent using Google forms is accessible in the Appendix.

This post survey was intended to further understand the interviewees thoughts away from the pressure of an interview scenario with the ability to grade specific elements usability, further grasp their knowledge regarding the content to be displayed while considering feasibility of the dashboard in different organisations.

4.2.2 Step Five – Conducting the Evaluation

Conducting the interview and analysing the results; providing the survey and reviewing the results is key to not only see how the dashboard answers the research questions but understanding how this approach can present a product for users to support ongoing work derived from prescriptive process mining.

Looking at the actual interviews; the participants who will participate have a variety of experiences, as explained in figure 4; the focus for the interviews will be to discuss with both active users of such systems alongside more technically grounded individuals to attempt to draw a wide array of opinions. These opinions will support answering the research question regarding case workers decisions during ongoing cases. Additionally interviewing a managerial expert and a change specialist will support understanding regarding the higher level perspective within an organisation; the change specialist also should provide further

insights into the visualisation norms and how ongoing work is impacted. As part of the post interview questions information on the individuals work history will be attained (discussed in 6.1). *For privacy purposes those who were interviewed will be referred to as I1, I2 etc…, it should also be noted where two participants work in SaaS companies these are different enterprises. This was done to attempt to get a wider analysis field.* These individuals were chosen to participate in this study as they were known from my history of academia and employment and based on my working experience I believed their variety of knowledge would be valuable within this study.

ID	Experience & Work	Experience /knowledge on process mining?
I1	Innovation and Change specialist for manufacturing company	Yes
I2	Support manager with SaaS company	No
I3	Case worker using ticketing system for SaaS company.	No
I4	Case worker using ticketing system for SaaS company.	Yes

Figure 4 – Interview Participants

The interview method whereby information shall be presented is as follows, in two interviews (I1 and I3) the first dashboard will be displayed first and the story as set out in figure 5 (*It should be noted this story was made in step 4 so subsequent to prototype production*) was first elaborated and explained using the dashboard wireframe as a visual support. To ensure that first impressions and the fact that the story doesn't sway the interviewee's opinion in the other interviews I2 and I4, the second dashboard will be presented first along with the user story. Once completed and comments have been attained, the interview shall be flipped to show the other dashboard utilising the same story as originally shared. Here comments on workflow and design reigned the primary focus following questions more based on the concept, usefulness and necessity.

During the interviews which will mostly consist of semi-structured questioning depending on where the conversations lead us from the original questions. A further concept is to be used during the interview which will gain consistency across the board was to introduce the concept of affinity mapping, this concept will be used asking users to note down in the chat items on the following concepts; improvements, initial understanding and general thoughts which could be absolutely anything. After the questions were asked for this section only the user was asked to type a short thought into the chat. Which will later be taken out and added to my own whiteboard, separated by colour depending on the interviewee. This is to be predominantly done to gain further insights and brainstorm more for potential addon's in the future. The interview method predominantly followed [95] where notes based on the respondents answers and questions were taken.

Story shared in interview

The dashboard currently being observed is for a SaaS ticketing service whereby the user would be handling active client inquiries and issues.

This user would be working to ensure the customers are satisfied and when unique tickets are created for them this would lead to a variety of actions being potentially taken. The information within the initial box where the case ID is presented would include the specific information of the client this case is affiliated with. The Name, contact information, account details such as length of subscription, and payment plan. Also if relevant for this contact a further link to historic tickets would be included within the initial case information box. Moving along the case progress would show the specific information relating to the start and anticipated close date for this ticket as well as the cost incurred from this ticket in terms of additional hours worked by the development team for the unique item. The third box is showing recommendations, these would be what the support worker must complete. Recommendations that are relevant to what needs to be completed would have a brief explanation of the options presented by the recommender system; a few examples could be conduct a specific action, escalate, make a client call and so on. The fourth and fifth items shown are the overall progress of the entire support branch, this would be the cases open, closed cases in a given time period dependant on the KPI's the team works within as well as a tracked bar to how close the team is to obtaining its objectives with case closed to open ratio. Finally there would be a process map, this would be of the entire journey of the case (and all other open cases) so far which would indicate in a different colour the specific case being worked on. An image of both a decision tree and process map (with highlighted journey) would then be displayed to the interviewee to further the visual understanding of this segment as mentioned some members do not have experience in process mining specifically.

Figure 5 – Story from Interview

As discussed subsequent to the interview the two surveys one for the first and one for the second dashboard are to be sent to the interviewees alongside the dashboards.

4.2.3 Step Six – Final Iteration

To provide a final iteration of the dashboard and select one of the prototypes to present within the conclusion analysis needs to be conducted based on the interviews and surveys. As discussed the interviews will be broken down into the following competencies. The usability,

The core competencies which will be focused on based on the interviews and survey are as follows:

- The perceived ease of use for the system, how do case workers believe this can support their daily tasks - Usability.
- Following the design logic discussion, it is important to know more insight into the flow a user is going to take - Workflow.
- How products are used is not always as anticipated, there will be further discussion to understand how users found and understood each element - Comprehension.
- The feasibility of building a dashboard wireframe which is then implemented and used across a variety of industries - Feasibility.
- How is the information displayed relevant for the worker, alongside how is the information displayed being relevant and understanding to what more/less could be shown in supporting users - Content.

In reviewing the above core competencies it is possible to review this paper's main research questions in relation to the product which has been presented; specifically how the interviewees believe the different elements of the dashboard can support ongoing work. The knowledge ascertained will answer how workers believe such a dashboard can support their

ongoing daily tasks, meanwhile there are many visual considerations in how this guide can work in practice, and the materials (content blocks) considered within it.

The above competencies will be how section 6.1 is set out whereby the analysis of the interviews will be conducted. The analysis will occur by reading through the transcripts for comments in relation to the competencies mentioned above, and pinpointing unique comments which are suitable. Additionally the results from affinity mapping will be reviewed particularly in relation to the changes made in section 6.2. The survey offers more space for detailed analysis following the standard practice [104] the scores are to be added up with odd and even scores treated differently. Odd scores will be deducted one point and five will be removed from the even scores before being multiplied by 2.5 to find the final score out of 100, the final analysis derived from the system usability score can be found within the appendix. The other questions from the survey not related to the SUS will also be reviewed depending on the question's purpose, if they are alphanumeric they will be averaged across the spectrum to understand the opinion of the audience. The evaluation will confirm that the designs can support case worker ongoing work while ensuring outputs from process mining are grouped appropriately and all the knowledge needed is shown. Both survey and interview will be also focused to ensure changes can be made to the prototypes and a preferred design style is found; while ensuring that the final project provides an artefact that has undergone a detailed search and exploration for the best product [105].

5 Prototyping

Analysing the literature and grouping literature for later decisions on content for the design will be considered before utilising the MoSCoW method to decide the content fundamentals for the prototypes displayed in this section. These must and shoulds will be groups of content which shall then be added to designs utilising design literature. Once initial prototypes are created there will be iterative changes until the final versions for evaluation are presented.

5.1 Literature Pre-Processing

When analysing a variety of papers, it was integral to ask questions whereby informative and actionable information could be derived from the study. These questions and the purpose behind them within the method will be analysed further in this section. Ensuring the first research question is validated was the first action; '*How visualisation of prescriptive analysis formed from process mining can be used to support ongoing work?*' This took to evaluate the tactical and strategic nature of each paper. Tactical being those problems which are addressed in the near future and change the immediate action of a process worker; strategic papers where process mining was used to change an entire process or in one instance influence the adoption of a specific project [64]. As in one instance where to plant charging points across the city of Amsterdam [81]. In analysing what the main project ambitions were it was possible to categorise the papers into tactical and strategic groups. Here focus upon the tactical papers would be further considered, this considered it is not to suggest visualisation styles of strategic papers was then not considered in analysis later.

Results - Table 1.

Tactical	Strategic
Reference numbers: [74], [20], [37], [70], [71], [11], [83], [10], [73], [7], [79], [69], [72], [76]	Reference numbers: [75], [80], [78], [81], [15]

Further questions of relevance which were asked when analysing the papers were to look at whom the process workers were when recommendations were aimed at them to enhance processes. This supports enhancing visualisation dashboards later to ensure the goals can be met meeting visualisation requirements to match the target audience. Questions were then asked on the exact prescriptions and then it is possible to understand the consistent nature of the recommendations showing the most frequent patterns on the outcomes from recommender systems. This alongside understanding the visual format or wide range of formats which was considered supported enhanced knowledge of what is being presented subsequent to the algorithm running; be it textual, graphical, tabular or with a variety of attributes on a dashboard. Upon reading the papers it was clear to see a variety of academic papers utilising ProM and alongside bespoke systems ProM was a process mining tool regularly used to display process mining outcomes. Therefore additional analysis not specified in the methodology was carried out based on this finding - Analysis where ProM was downloaded and reviewed to see how this plugin works for the end user (*ProM is found [65]*). Then utilizing the specific add-ons [73],[83] to this platform to further analyse what this standardised approach presented when displaying results. Not necessarily using ProM but with an idea to use in the future [75] and other papers showing they used a system which could utilise ProM [70], [37]. This led to the question what systems were used by each research paper to display and present the recommendations if any at all. Other questions

which were touched upon however do not have as much baring as those discussed above were to review if the paper was looking in a real environment or developing a prototype suggestion, the machine learning and recommendation system algorithm which is used when recommending based upon process mining, and finally the specific data and logs which were the original starting point of any analysis here it was to review what is the point of origin in the cases which derived an understanding of the process workers tasks to further the knowledge on the end user to enhance visualisations with additional items than just those which should be considered a must required. These further items to what is crucial and are simply complimentary are discussed in section 5.2.

As referred to above is imperative that prior to deciding on the content for the prototype the papers are filtered into more relevant categories. Considering only tactical based papers it could be suggested that in those analysed there are three core use cases in the end goal for tactical prescription.

Results - Table 2.

A. Alarm / Risk Based	**B. Next steps in a process**	**C. Resource allocation** ***(the next step for a given resource)***
[74], [20], [37], [70]	[83], [71], [11], [10], [7], [79], [69]	[72], [76]

The designs shown below will be focused on specific cases which follow the ideas shown in cases B and C. This was decided as despite the alarm / risk based systems do implicitly impact the next task, for the most part in a successful operation one would hope no prescriptive recommendation is even made. This said alarm based recommendations could also be considered given the initial research question; a discussion of ongoing work. This has been considered as an emergency situation not one where prescriptive process mining results are being used to direct the process workers tasks on a day-to-day/task-by-task basis, in some cases this was using process mining for contingency planning [20]. For this reason as a prior acknowledgement to ensure consideration of ongoing work is paramount then in consideration to the content and design rationales presented throughout this section. Additionally in terms of a dashboard to present to case workers a couple of papers [11],[75] cover the enhancement of a customer's next action and not a caseworker. This can be considered informative to see what these academics class as interesting for next actions but in terms of ongoing case work this shall also be contemplated as potentially less relevant information. In the case of [10] this is considered not only to present more purchasable products to the end user but enhance the stock processing procedure.

5.2 Content Rationale

Deciding the content blocks and sections to display on the dashboard which has been created came fundamentally from analysing papers, seeing what reappears and segmenting different needs into actionable blocks. Specifically known in the SaaS world as ‘Content Blocks’ [66] this is a block of which contains specific tools or a summarised category of information. By formulating each section as a block it can be easily positioned within the viewer’s discretion for use on a screen. Going one step further within those blocks you can decide specific information to always be shown due to the needs of the end user eradicating the customisation per individual use case. As it must be added this design is for utilisation across multiple possible work cases so the content blocks (and more specific data inside them) can change case to case. Yet this dashboard has been created to ensure that the blocks are useful in the majority of cases to be considered for use.

In deciding on what is required for the dashboard the required content will first be analysed before discussing complementary niceties which have been possibly added just to provide more information to make the screen more aesthetically pleasing. Given the analysis there are three core sections any dashboard would fundamentally need to show; A. The case selection or specifically detailed information (unique case identifier), B. progress of the specific case at hand as well as of course the final requirement the C. recommendations provided.

Considering the case selection or provided case in a system (A.); when a process worker is assigned a task or a batch of tasks at the first instance it is imperative for the process worker to know the unique identifier, often in the form of a case number. This is shown in all papers studied albeit with different terms as [79] presents just basic Case_ labels or [10] as Customer ID. In some cases [20],[79] the option of case was provided to the worker, this provides the case worker an option for which case to go next. Therefore a block which will display the case number (or in some cases, supply a choice) is imperative to beginning or continuing any work. Without the knowledge of the case the worker can't proceed with the task. In each task a worker conducts, there is often a start and end point of the process [10],[69] , this shown as either a node diagram or textual explanation in the papers; in papers where end user dashboards are shown this is seen in the form of a process bar [79], [7]. This would not be the only element which would be displayed in this content block, further more specific information on the case being dealt with would be displayed in this content block. To support the workers knowledge the progress (B.) of the case given the manageable criterion are to be shown, this could be the time open [37], the journey in the case so far [79], or a number of other progress components. Knowledge of the progress so far/journey [67] of the case is a must to formulate decision making for the user more aware. The final core segment required for process workers when working on their tasks when considering prescriptive recommendations (C.) is of course to show the recommendation in an easy to understand format. Due to the nature of the paper this is of course the most imperative block to be shown, in section 5.3 rational of the design chosen for how this block is being displayed will be shown. In providing users with the three aforementioned content blocks this would present users with enough information to make a key decision on whether to follow the recommendation or to reject and proceed in another manner. These blocks combined formulate a core competency for the user which is know-how on the exact case being considered, complementary knowledge and the potential ability to change their next action based upon provided recommendation/'s.

Alongside holding 'must' required content blocks, the proposition shows more than the three items above. These additional blocks can't be held with the same imperative need, yet they are needed in their own right to add visual cues, provide more choice to users as well as enhance a process workers knowledge. The first one of these elements can be considered a nicety in that it provides immediate understanding to the knowledge worker; D. visual mapping, often displayed in two formats either that of a decision tree showing how the recommender system came to this valid approach [73],[37]. One example of such a map can be seen in [75] utilizing Google Analytics user flow map. Alternatively and more common theme in process mining as a whole is that of a direct process map (also known as node-link diagrams), showing the path cases can take from origin to endpoint, meanwhile highlighting lags - more useful here to introduce change in a strategic way to eradicate the holdup [70]. Additionally showing the individual case and the path it has taken to ensure completion of the journey. Elaborating on the importance of node-link diagrams within process mining has been work seen in [58] where their study to generate a framework for process mining visualisation discussed this. As discussed above knowledge for the process worker is very important displaying such maps albeit not necessary for getting the job done; this does add to the idea of a process worker being the human element of a process whom understands

the entire strategy and therefore can use their intuition when following the systems suggested recommendations. Another additional element which was seen across a couple of papers, is the use of different end goals to manipulate the machine learning algorithm. As discussed within [73],[79], they suggest time and cost to be different dependencies and therefore run different recommenders to enhance this, meaning when coming into a system with a process worker. This would present a choice of which recommendation type to follow depending on the focus of the system. Therefore a E. Improvement filters are proposed for those instances where there may be multiple recommender systems working [73],[70],[79][83] and a user could choose the ideal enhancement direction. Lastly for key additional blocks yet not required for a process worker to complete their tasks is that of an F. Overall Information block. This block would present more high level information and unlike all previous examples would be the only block which has no reference to the current ongoing case work. The fundamental idea behind this design block as well as to simply add additional knowledge and information was to support these papers core aim was to enhance the key performance indicators of said workers [71],[11],[10]. Here providing holistic information across the entire workflow can enable caseworkers to make more informed decisions given their specific targets and how many ‘live’ cases potentially going through the workflow.

A smaller possibility and actually not considered in the final designs due to the perceived lack of need by the process workers, is a space whereby the user can gain more information on the algorithm being used. In [7] you see specifically this is shown, possibly as this visualisation dashboard could be aimed at a higher level worker than daily process workers who make ongoing decisions. This medical dashboard asked questions on the cluster type, regression method and showed images on the statistical results driven from the analysis. Due to fact that most process workers are not necessarily required to understand the in depth working or knowledge on the type of machine learning system which has been implemented. This is truly a feature which just adds to the understanding for those involved. Final broad content consideration is how the dashboard could possibly be layered on top of an existing system or used as a plugin for a currently utilised system. In multiple cases the papers used plugins on ProM process mining systems [73],[83], yet this is for sure not definitive and to work across multiple industries and solutions used by enterprises. The following dashboard would ideally be embedded into the current system whereby recommendations can be carried out directly from within the dashboard. This means the design friendly prototypes can be successfully implemented despite the working norms of each user.

Given the above blocks, which sections can be considered to have a consistency of granular information which can hold throughout multiple use cases and therefore can be shown in addition to a placeholder. Considering each block; the specific ones where you can find granular information to be considered are A. The Case Selection / Case Information, C. Recommendation and F. Overall Information. The other sections as mentioned above will not have such granular detail which can be provided as they are likely to change as each different use case operates. Starting with A., the specific data which can be held across all cases as a prerequisite is that of the case’s unique identifier. In paper [7], the unique identifier is analysed as “unique case ID” and displayed as a collection of numbers; in the specific case of this dashboard multiple IDs are shown. Considering the recommendation block, the must information to be shown to the process worker is the recommendation in textual output alongside a short description [79]. This elaborates to the worker what is specifically required; the reason behind making this standardised is short textual information provides the most clear information to the worker. Specifically taking the IT example of functional and non-functional requirements, this “defined classification” [68] is seen as the best way for the people who are providing a specification to be elaborated upon within the IT field therefore textual messaging has been chosen for this purpose. As discussed in 6.2 it

was not always possible to ascertain the true formulation of recommendation to the end user, so for the aforementioned reasons this choice has been made. The final data source which will be shown across all the different examples with more detailed information is within section F. the overall information which also has consistent ideas across multiple papers; the total number of cases which is currently open and passing through the process will be displayed [79] also not specifically mentioned as displayed to the end user but very useful in the context [20] as the users KPI of how many jobs are allocated is tracked, further understanding of the totals is key. This total number provides a good overview to each worker knowing the kind of ideal number of cases which should be closed per day. Additional papers which display KPI's for workers where similar assumptions can be made are [71], [10]. Additionally overall progress averages can be shown, however depending on the ideal decision metric this may change, the following examples suggest where averages more specifically - "process instance duration" [20] could be a useful drawing point for the case worker, albeit this is potentially a more useful metric in strategic cases; case to enhance school curriculum options [80]. Even within alarm and risk based analysis to see an average time condition [74]. Despite this average/'s shown changing depending on the actual case it is a metric which will remain on the page. The use of overall averages when dealing with a specific case can build case workers familiarity against their colleagues and support bringing a wider company standard.

In summary the six content blocks which will then be implemented in each design are as follows:

A. The Case Selection / Case Information
B. Current Case Progress
C. Recommendation
D. Mapping
E. Improvement Filter
F. Overall Information

When these items are placed into the MoSCoW method as discussed above the table is displayed as shown below, there are a few items which can be seen as listed as bullet points in the 'Won't' section. This was chosen as seen out of scope when dealing with the choice of a process worker. Potentially if the dashboard has a different audience than those who deal with ongoing work this could be included. It should be noted all elements within the table and discussed above were seen across the papers as discussed in table 1.

Results - MoSCoW - Table 3.

Must	Should	Could	Won't
A. Case Information &/ Case Selection C. Recommendation	B. Current Case Progress E. Improvement Filters	D. Mapping (different types of maps) F. Overall Case Information	Algorithm Selection Algorithm details

5.3 Design Rationale

Encompassing the six content blocks into a user friendly design is crucial. As previously discussed ensuring the design rationale meets the following initial criterion is fundamental "understand/read what may be being presented". Given the variety of design principles provided in academia and utilised in day-to-day work with SaaS providers, the prototype dashboard will have two variations which are focused on meeting each specific principle,

these designs were created over a series of iterations before reaching the final prototype for evaluation. The above content block decisions were used to complement the design, ensuring the following visual criteria shall be met "*visual analytics aims to reduce the effect of information overload, and achieve higher utilization of large data set*s" [84].

There is a framework discussing process mining visualisation do exist as discussed, these focus on different items to this paper. It should be noted unlike another paper where a framework on visualisation for process mining was discussed [58]. This paper focused on the specific way to visualise process mining therefore made recommendations specifically for the actual visuals process mining will present. This paper discusses multiple design rationale, not just limited to process mining. Recommendations despite originating from process mining are often not displaying the node graphs or decision trees specifically but the information more for an end user to complete an action. As discussed in the dashboard section D. mapping - inside these elements one would anticipate the framework discussed here to support how this would be visualised, but only within this section as process mining is specifically visualised and not the recommendation procedure.

Despite showing two possible dashboard designs they were initially generated focusing on Gestalts Principles [85] considered for both designs. These principles have core elements which will be highlighted in the designs shown. Primarily the law of common regions which ensures that all items are held within a given section when they are similar. The idea of multi-stability which shows how users dislike items which show uncertainty; in essence for the designs provided we will show that texture around elements ensures clarity for the viewer. The final principle of Gestalt which is to analyse proximity, this is the grouping in the case of the blocks grouping the most relevant items together and splitting those which maybe are more important than less important.

The first dashboard as shown in figure 6, follows firstly logic from SaaS and dashboard experts Sisense. This logic is termed the 'inverted pyramid' [86] showing the most significant elements at the top then going down to show more generic information. Given the blocks system utilised generated to segment the different information which is going to be shown the first dashboard you can see shows the primary information at the top flowing down with the least significant information displayed at the bottom of the page. A visual taxonomy developed by Shneiderman [87], has also been the founding roots for the initial design where his idea of an overview, zoom and filter to present details upon the user's demand is suggested. This in essence is the fundamental core to the dashboard in section one whereby the user is to filter to instantly draw details on demand.

Iterative changes were considered on dashboard one as shown in figure 6; were mainly to do with the space awarded to two sections, these sections being the overall information and map shown. Originally the idea was to show equal space built from top to bottom, however as the case is proven to be the most important aspect with the most information it was awarded more space. Additionally the information on the case was slightly expanded to take over 50% of the element it is in, as from the discussions during changing the dashboard it was seen that this probably needed more space if the information which was to be placed there is to fit. Otherwise this design did not change from the initial concept of a top to bottom model based on the users' actions and importance of sections. Furthermore one item which was included in iteration one then was totally removed, this being a question mark box which when interacted with would load a screen overlaying the dashboard with information on the specific algorithm in use.

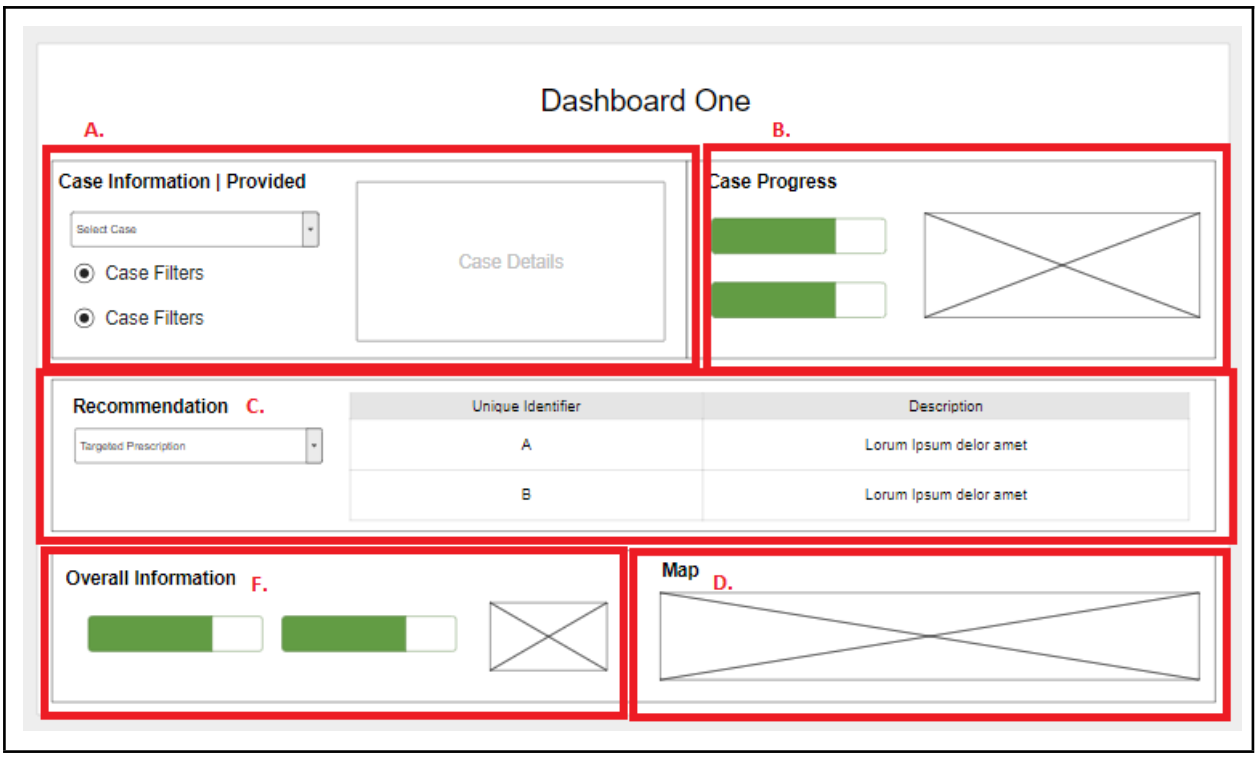

Figure 6 – Dashboard One

The second dashboard followed one of the four design principles as developed by Pousman and Stasko [88], the principle being 'Multiple Information Consolidators'. The predominant structure used is "*screen-based in order to convey much information and make users aware of changes to that information*" [88]. This dashboard was built with the fundamental idea to ensure that a logical order for the process worker to click through; in this case from left to right across the screen. Ensuring the most important information remained at the top so readers can read left to right but also prioritizing key information, when analysing accessibility for disabled users this is often discussed [89], furthermore studies and web agencies have discussed the use of what is known as the F-shape pattern for reading online. This is commonly used for UX investigating how users often browse consumer websites, albeit the proposed prescriptive dashboard is not a simple user browsing a web page, this pattern is based upon how the eye evaluates screens [90],[91],[92] . This pattern therefore should be considered knowing the pattern users take to read the screen. Not only being in a logical order but displaying information as the eye is familiar with on other systems.

The iterative changes brought to the second dashboard (figure 7) actually created an entire swap from a three column layout which was originally utilised as this dashboard focused on a logical flow. The three column layout was removed for a few reasons first being we have more components than three; albeit this layout did combine D. Mapping with F. Overall work to show column one selection, column two recommendation and column three a more holistic process overview. This however was changed as it did not make logical sense in a logical layout to display all items equally. Some of the prior logic which has been discussed looking at the inverted pyramid was still considered, wishing the user to begin their journey with the most important information at the top. Further academic research away from just screen reading came to web and UX norms which then presented the F shaped design which is being shown on the second dashboard.

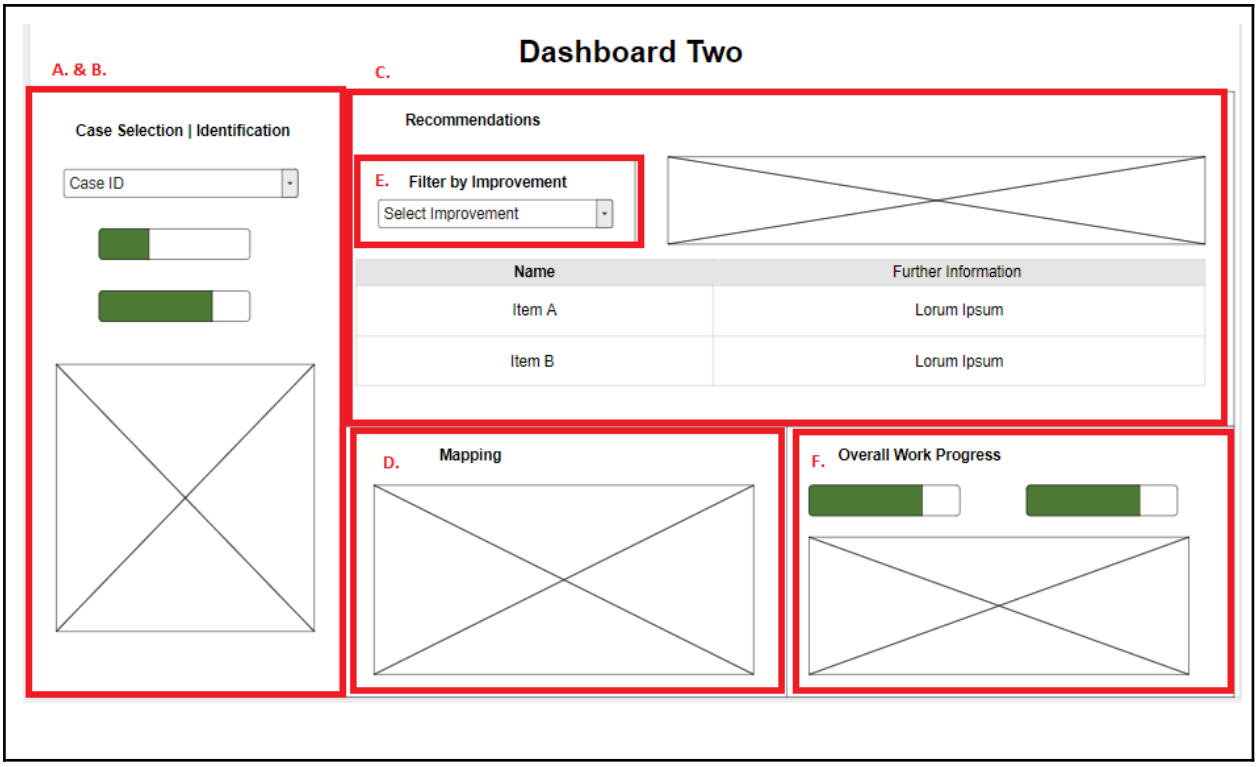

Figure 7 – Dashboard Two

On both designs each element despite being maybe shown from a different visualisation style is displayed in a similar way to portray to the user the core information as chosen by organisations who may choose to implement this visualisation structure on top of their platforms for case workers. This section will be a brief discussion of what is inside each visual block, slightly elaborating upon section 5.2 using examples from the user story used in section 6. Segments A. and B. Case selection | Implementation and case details both show what option of cases (if any) are being presented to the case worker and then the specifics on the case which the case worker will be working from. The overview will provide details on the case and the related client while the case progress would show this cases progress as per the usual flow alongside how this case is doing when reaching deadlines and open time. This is obviously not an exclusive summary but it is to provide a more specific idea on what could be shown in each content block of course depending on context. Section C. (recommendation) and also in dashboard 2 Section E. the filter, will be specific also to the case however it will show the most actionable information to the case worker based on the prescribed information. This information is to be displayed as a short textual sentence explaining the next action based upon an assortment of potential next actions, alongside a reference so it can be understood by the system which action is taken for improvement to the ML algorithm and enhanced training. Finally both near the bottom and as mentioned in section 5.2 offering less importance to the viewer is section D. (mapping) and E. (overall), respectively the mapping element will display a chosen method of visualisation of the process to the user, be this a fuzzy visualisation [11],[10], DNR Graph [71], decision tree [73],[37] or node diagram [70], this is considered for all dashboards as a nice visual qwerk. Finally the overall work progress box shall provide detailed information on all cases and not just the one on the caseworkers screen. This will be able to show a total number of cases and provide the user with information on team targets and expectations to gain a wider understanding on one information panel than the requirement to jump across multiple areas. A consideration which was not added to the design as companies use a vast array of different internal systems but should be noted in any implementation is the ability to connect section C. Recommendations to the actual software used by each user. This proposition differs from the business case as how do process workers company to company often

complete their tasks. If as indicated in [79] then there could be an additional activation button to enact the best recommendation for this time.

6 Discussion

As discussed in section 4.2 as prototypes have been presented and iterated, completing steps one through to three of the proposed methodology step four and five were to design as also focused upon in section 4.2 and then conduct an evaluation of the product. The results to this evaluation will be brought out in section 6.1 before a final iteration on the design will be brought out and discussed in 6.2. Based on the interviews and subsequent surveys the following section will look to discuss the interpretation of usability, workflow, comprehension, feasibility and the content included. Once completed this feedback will be collated to present a final dashboard which utilises those thoughts from the evaluation period; this proposal (6.2) will be the foundation for discussions for potential future work and analysis as provided in the conclusion. Additionally section 6.3 will discuss limitations to the study.

6.1 User Outcomes and Findings

As discussed in 4.2 some questions will bring out more questions between the two dashboards to identify the better style and better flow for the user meanwhile other questions on the challenges and information are more likely to encompass both dashboards with similar features but different design principles added. The subsequent paragraphs will be laid out in order focussing on the five key discussion points in order from usability, workflow, comprehension and feasibility combined before looking into the actual content which is shown and what a user would need to see, before analysing any additional challenges which shall assist with the formation of 6.2 and the final product. Firstly one element which is to be slightly elaborated on is the experience of each interviewee, within the survey there were questions focused on understanding the users' knowledge and experience. This included questions on the current time in employment, experience with dashboards and finally a technological self-estimation. All the members being interviewed had over three years in professional employment with Interviewee three having the most at five years. All the users have used or use various dashboards in their day to day employment. Interviewee one discussed making dashboards in a previous workspace and also in university projects, while interviewee four explained holding experience with Bi tool PowerBi. Finally all of the interviewees claimed to be good (three people) and one (very good) on a one to five based scale regarding their self-estimation of technical competence. These questions were gathered to ascertain a more detailed outlook into the experience and knowledge of how these individuals were suited to support this study. These questions supported ascertaining knowledge on how the specific individuals were understanding what a case worker would do on a day to day environment and how each interviewees different approaches could be qualitatively analysed.

6.1.1 Usability

Predominantly focusing on the perceived usability of the product the surveys were the best as each dashboards were questioned based upon their system usability score. As discussed the system usability score was provided during the post interview survey for each dashboard. According to [104] the average system usability score is 68. The score as provided by each user is shown in figure 9, also trends will be highlighted into questions which received predominantly lower scores will be reviewed. Where the normal System usability score would ask questions such as 'I felt very confident using the system", this was slightly amended during the survey to change language from felt to feel due to the nature of the platform. Averaging the final scores from the users you can see dashboard one has 73.12 and dashboard two 68.12 following the trends from interview discussions which preferred the first version, for both dashboards the median score was 70. A common theme across the questions was a clear agreement surrounding a variety of questions, the system was not seen as massively complex with strongly disagree and disagree being used only for this question. Alongside this a question which received good feedback was if the system is cumbersome here this system scored very lowly suggesting the interviewees felt the system

is good to use. All users additionally agreed that the system was well integrated at least from the perspective of the different sections complimenting themselves within the description and visual provided. The couple of questions which can be analysed from a more negative standpoint are those discussing the frequency of use for the system which could provide an insight onto the need of this dashboard by this audience, however this said the case worker who has had previous process mining experience (interviewee four) did go against the trend for marking this score. Both interviewee two and four agreed on one negative element on the dashboard presented in that it was inconsistent, from further discussion this is mainly due to the different size allocated to the components. Finally summing up the system usability scores provided by the surveys there was agreement although not strong that the system would take a short time to learn and that they believed the majority of people who would be using this dashboard would be able to pick up what is presented quickly; albeit this question interviewee one and four did take a neutral standpoint, this said no one believed it would be challenging to learn or for newcomers.

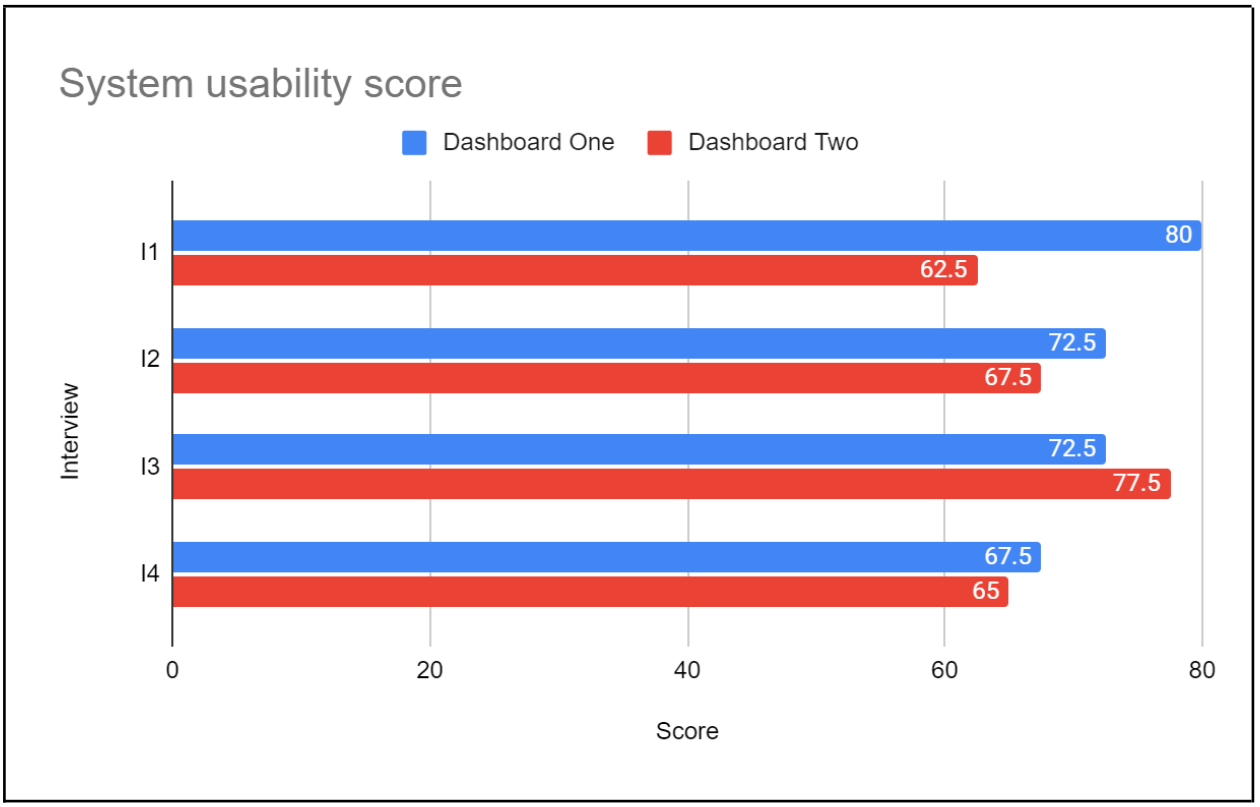

Figure 8 – System Usability Score

Then considering comments ascertained during the interview, interviewee three claimed that the second dashboard was “a bit less understandable than the first one” this was based on their feelings towards usability. Finally the second interviewee suggested that this was positive with a simple structure across both designs, despite preferring the first one. These questions not only supporting the individual in terms of answering the fourth research question on visualisation standard and ease of use, but the answers complement how the users believe the dashboard can be used within ongoing work if it is user friendly then this indicates the platform would receive more use.

6.1.2 Workflow and Logic

The workflow and logic of the dashboards was something that was brought out more within the interviews, especially with question D as mentioned in section 4.2 which focused on the

ease of flow for the user. The research question regarding the daily tasks and knowledge needed by the users would be supported in knowing the workflow and logic; here if the workflow and logic is positively responded to, then the adjustments in 6.2 can be made to the dashboard to change the flow or ensure the flow is suitable for day to day use. In general all four interviews had more negative comments attributed to the second dashboard when it came to the flow of information across the screen. A theme which was consistent across all four discussions and survey responses was that the first dashboard made more sense as you could totally understand the case with the information at the top before looking down to the recommendations. Interviewee one claimed the first dashboard has a simple and "familiar flow which could be followed by any prospective user". As something which was focused on in so much detail this showed in overall positive comments from the discussions. There were comments raised on flow by all four users though specific to items within the second dashboard; Interviewee two suggested that dashboard one provided him with more "clarity with the order of information" to what is trying to be shown and in which order each task was conducted. The two interviews which involved case workers interviewed three and four mentioned that in the second dashboard needing to understand the information is very key to make any decisions and if the second design potentially would need to involve scrolling on a smaller screen this could pose challenges. This issue obviously means that the flow of information would be disturbed; leading to items of improvement being made, Interviewee three proposed "could the case information be displayed in a modal which overlays the dashboard so in a single action all core information pops out", this would be so in the fewest clicks for the user the most important information is readable. The fourth interview discussed that possibly inside dashboard two the recommendations feature could be "recommendation block is very large in comparison to the other elements, could it be made smaller?" Effectively being squashed for more information to be shown on the case. An outcome which was discussed regarding both dashboards though and especially discussed by interviewee number one the sections which showed the case information and the overall information are "split at opposite ends of the screen" this was not understood in reading and obtaining the information by a user to conduct decisions which then were seen at the top of the screen. This user discussed that in his experience when providing a specific case and more overall information this could be closer to making a direct comparison to the current case and overall process. The workflow seemingly despite some questions or causes for concern was widely liked and simple to follow what a user would have to do within the narrated use case. Additionally the fact the workflow is understandable despite a few updates being requested this shows that the interviewees could see themselves using the product. Not only if the product would be used but this validates the initial research question in terms of how prescriptive visualisation can support ongoing work; as the users will know their current workflows and this will indicate that this analysis is suited to being simultaneously completed.

6.1.3 Comprehension and Feasibility

Comprehension and the feasibility in practice were the next points to be further discussed as both are more to do with how these dashboards could work in a real life case or even the information which is being displayed is understood, there will not be a comparison between the dashboards but more discussion to the overall comprehension and feasibility. These are the most important points for the final research question; understanding if the users would use the product. If this is accomplished then the other research questions are in essence answered too as the decisions and important metrics are recognised. Firstly discussing the comprehension; the users understanding what the purpose of each element is and what they believed it could bring them if using this system. Interviewee four claimed that due to "there is a clear and labelled layout in a nice parallel with a one, two three kind of setup in the terms of the actions which are needed to be taken in order making a legible screen" here this comment obtained when discussing the user flow also showed that this individual found due to a clear flow how the dashboard would be used is comprehensible. All interviews

essentially agreed that the dashboard was comprehensible despite possible content changes being suggested as discussed in the next discussion point. Based on the user story and further explanation on each section which was given the second interviewee discussed that “there is clarity how I would elaborate to a team member on what needs to be done”. One area of comprehension which was mentioned by interview number one was actually to do with both designs as on both the map is allocated a similar segment of screen size, this interviewee discussed for a process map to be legible and fully understood this space could possibly squash the visual making it challenging to comprehend what the map was sharing, this discussion went on to mention how the map in large process flows would inevitably have many branches and this would be not clear where the current item is even with colour changes. Specifically focusing on discussions within interview one and two as both individuals with experience in either managing a team or implementing change the feasibility was discussed in how such a dashboard could be enacted. The first interviewee suggested the only method this dashboard would be useful is with “integration” and “clickable elements which performed tasks” here this user was suggesting the recommendations should be actionable directly from the dashboard and if not the recommendations next steps can be immediately loaded from this screen. Both discussed how if all the information as explained could be shown on one screen this could be a workers hub and central point for the case workers roles. Discussing feasibility for the case workers was different as they do not have experience in enacting change or managing team members in a live business environment; here both just said if it is simple to use with expectations laid out prior to use they would see no reason why a dashboard with this information would not be useful. Interviewee four who has a knowledge on data ascertained via process mining did however suggest that the dashboard is very rigid and focused on unique use cases.

6.1.4 Content Blocks

The final point of validation was that of the content, especially the blocks derived from the literature and so important to how the end users' understanding of the system is generated. This would validate each section fits what the case workers are working on daily and would ensure that only appropriate visualisations are shown for ongoing work. This section will go through A-F in terms of the content blocks discussed in 5.2, adding any challenges which were found, question B in section 4.2 focused on content and this was a valuable discussion at the end of each interview whereby a more granular open ended discussion happened over each element and the specific sub items within the more general content block. Starting with A. Case information &/ Case selection, interviewee three immediately said that this section is “most important to be clear and contain explicit information”. Other comments on this section were generally positive across the interviews with little more to add as each discussion acknowledged why this section was shown and why importance was provided that the element was towards the top or left side of the screen when someone would often look first. The interview with a support manager interview two actually discussed this element with specific to figure 5 and the user story suggesting if all case information and historical cases could be provided on one screen with a simple ability to open the historic tickets that this would be useful in any field process mining or not when handling support enquiries; “not something used in the system with my team, simply a great ability for the user”. To discuss section B. the current case progress, all interviews had a similar approach here, this is valuable working with tasks in a orderly way; yet even though Interview one and four did have prior understanding of process mining (without using it in a workplace) this did mean that this section generally didn’t undergo much discussion as a lack of experience with this area was mentioned. Moving onto section C. Recommendation , interview three and interview one both did discuss how it is possible to enact what is being presented. What would the user have to actually do. “Is the purpose of the dashboard to present the next step I would take or can I proceed to do this here from this screen?” was a question asked in interview three. A valuable question which is considered in the final design which is presented. The interaction between a company's systems and this dashboard which has

been presented clearly a question that the participants were not clear on in regard to this component. The first four sections though in general all had positive feelings and not many negative comments, the last three items were open to more discussion. D. Mapping, this was something that neither case worker really said they would need to help with their work as in their role they would understand how and why cases would begin or end. Discussed by interview number one there were a lot of questions about the process map or decision tree being shown. This participant indicated that this would “not be vital” at any stage for a decision to be made. Additionally the second interviewee also added that the map is “pointless” for a case worker unless they are very inexperienced in the role. The first interviewee also added on the second dashboard specifically the position of the map is irregular as it is in the middle of the screen yet most probably the least “important” piece of information. Section E. the improvement filters also was seen to have some criticism with the specific use case for the end process workers. Interviewee two suggested that his team would not always be aware of the best item to focus on, so presenting team members with an option to change the recommendations source is not necessary. He suggested this section would be his role to “change for my subordinates”. The section also drew issue from interview number one who suggested allowing process workers to just change the basis on the recommendations would be like “rolling a dice for the worker, they would not know the end goals for the company even within their targets”. Neither process worker had comments on this section probably suggesting the more experienced interviewees were discussing something that is very relevant. The final item F. Overall case information also drew some negatives but was also enjoyed, generally providing a mixed opinion across the discussions. Within the fourth interview it was discussed that from their perspective it may be challenging as there is an added pressure of constant comparison all day with other team members, also sometimes when completing tasks the KPI’s should not be the sole focus to getting the job done; “my manager doesn’t always set targets it is more regarding the quality of tickets completed”, this showing that again this element of the dashboard could be very niche. This idea was furthered within interview one where this participant suggested that there have been examples of showing or not showing overall progress information company to company, quoted saying this is down to “user and professional choice”, indicating something which is ideally made for a variety of uses this module could have a variety of uses. The business support manager interviewee two however enjoyed this section suggesting that in their current work environment this overall progress is only presented to the management team, furthering the knowledge down the business is useful for making employees feel more worthy. Similarly interviewee three indicated that this would be a nice function being able to ensure that progress is being made and see how this progress reflects the business expectations and norms. These expectations and norms complement how this product if put into action from the prototype presented can show how the users may actually use the product for their ongoing work.

Other mentions which do not fit into the five ideals of the paper include discussion from the first interviewee who added that the removal of a few sections as suggested could make the screen bland so in this instance it may be important to not just remove items for the sake of removals. There should be other ways of adding more significance to the most important elements which have been discussed. The above section drew answers and discussions from the interview and surveys to find a variety of individuals' opinions from different working conditions.

6.2 Proposed Updates

As shown in figure 9 the final dashboard which was iterated on following the design science logic from dashboard one which when asked in the four interviews which was preferred overall the first gained three quarters of the picks. Affinity mapping was used to list the new features or challenges found by each user. This led to the following fundamental changes:

- Total removal of E. Improvement filters
- Changing the section D. Mapping to only exist as a modal when clicking a button at the bottom right of the screen.
- Adding another column to the recommendations, ideally how the dashboard would interact with other systems allowing for more changes.
- Making case information larger and more significant
- Moving overall information to the right to show all progress related items on one side
- Removing the three levels from figure 6 so there are only two levels stacked on one another.

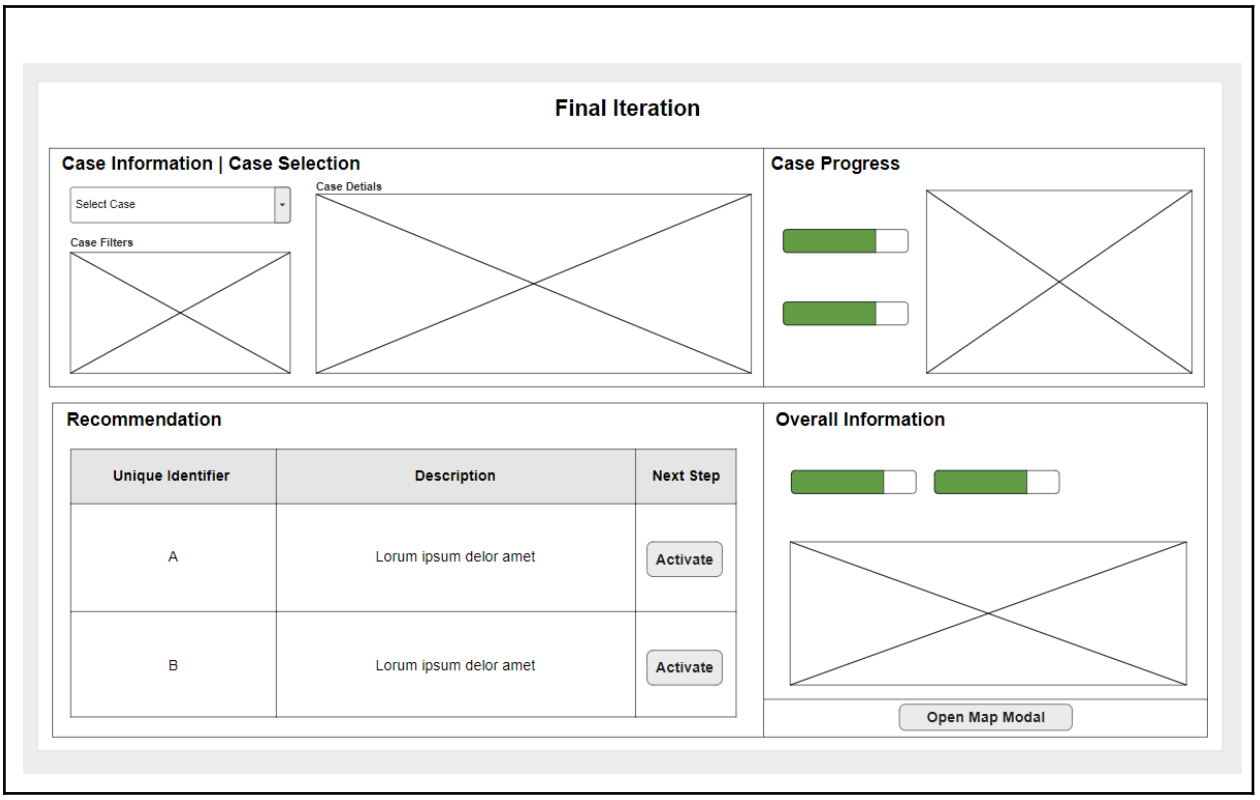

Figure 9 – Final Iteration

These changes were made so that as discussed the case worker would have a more clear and concise dashboard where less decisions are required so the focus can be on what is happening with their specific role, encouraging this design to be utilised by organisations for their case workers. This commences in making the day of a process worker easier by removing the E. Improvement filters based on feedback from managers. Additionally removing the process map or decision tree from the immediate view enables the availability in the bottom right corner to click and load the process map as a modal. Added more room in case progress where an estimated time could be added, this was one proposal from the first interview when discussing changes. The amendments made above altered the content based on the metrics and knowledge needed for daily decisions and recommendations when handling tickets (cases). This also was across all of the interviews one of the more needed sections. Furthermore, relocating the overall information to complement the case information so all information and content related items are shown on the same side of the screen and going from top to bottom in level of importance matching the design logic as applied within figure 6 and discussed in [86],[87]. All these changes were derived from information as shown in 6.2 and the fundamental basics discussed in section 5.3.

6.3 Study Limitations

Despite the paper being able to identify a framework which is fundamentally based on a variety of design principles and tag these principles alongside content blocks which were derived from detailed analysis on prescriptive process mining academia and subsequent user evaluation, it can be added this paper does have some limitations of which are to be further discussed.

The first limitation which is to be discussed regards the papers which were evaluated and the research information contained within such papers. First of all process mining and especially deriving prescriptive results from such is a very modern school of thought, this is indicated by multiple papers containing authors A. Terragni and M. Hassani [11],[75] and Aalst [21],[24],[25],[29],[30],[59],[60],[70],[83] who are seen as thought leaders on this subject, with the first paper for my analysis being written in 2008 [83], but most papers shown from between 2015 and the present day. This said that there are a few authors who are commonly found in the literature not to state that their accomplishments are lessened just there is less choice and general deviation as in other common academic thought. Highlighting not only the limited time this topic has been under the academic microscope but also showing this is not broad ranging and implemented across a wide variety of business practice; highlighted ever more by the actual studies which have been evaluated were often using fake cases or real life data but the prescriptions were not being actively used by the companies where this was happening, this is shown in the following papers [20],[70],[71],[72],[74]. Acknowledging the studies are merely tests and also multiple papers in the study have come from the same authors' shows the focus which this tool for business expansion is in its early adoption. Further to this looking at the analysis conducted to formulate the original dashboard designs specifically the generation of content here only reviewing under 30 papers have been used, in part due to the lack of studies conducted in this field, following through to formulate a framework/guideline for those proceeding challenges of course are met due to the diversity of papers presently written and potential scope this could cover in the future. Simplification of this is to suggest making a framework from a small sample of diversified information will not provide the outcome for all but merely for those that follow the similar path to derive recommendations via process mining. Discussing my specific analysis of the papers in more detail I found as shown in table 2 it was possible to segment the different practices and purposes of the papers. Given the research questions focus to discuss ongoing work which is a substantial element of this paper. As indicated in table 2 you can see a category of papers I found were 'alarm 'or risk based, here these papers looked to use prescriptive process mining with conjunction of ongoing work to present the recommendation when a perceived disaster or risk is triggered. Yet for the purpose of the models generated they would not necessarily work in this instance, as for such papers prescriptive process mining was utilised to facilitate a smooth ongoing work cycle but not actively used in the ongoing work cycle and utilised in each task by task basis. Due to this lack, it is therefore possible to present my work as only useful for specific ongoing works, not all ongoing works a limitation one could argue - yet this is discussed throughout as per the specific focus of the dashboards is to be embedded in day by day work. Initially the research question for ongoing work did not contemplate the varieties of purpose that prescriptive process mining could be given, henceforth the specialization later. Additionally when deriving what prescriptive process mining standard could look like was also ultimately presented with some limitations first predominantly down to the actual literature which was being dealt with. When analysing the papers in an idealistic world seeing what each end-user would have been working with when conducting the recommendations from process mining based decisions would have been critical in understanding real life cases and requirements on dashboards for case workers; this said only papers [7],[79] showed such analysis. The papers did have much more focus on the machine learning algorithm used, why this was used, how this being used benefited the process of prescriptive process mining. Then subsequent to running a case study (as

mentioned often with testing data) the results in comparison to the normalised actions would be displayed with papers showing [83],[76], yes this is a very useful visualisation of how process mining has benefited those who are implementing such systems but the information on what a case worker would specifically need to see is vague; this caused many assumptions throughout the paper to be used and specified.

As explained there were some limitations in knowledge generation given the lack of understanding in each case of what is suited to a case worker or even a management team; further expanded in section 6.1. The completion of my study with participants also had some limitations; no senior management who held process mining experience could be utilised during the interview stage, nor an end user who had experience with process mining at least in a business perspective (only in academia). The difference from academia to business responses when one has experience is vast. The primary limitation though of the interview procedure was the lack of any real working data and then ability to create a fully working system to explain to users in a user case with a potential system test, as it ensured the test participants had to formulate with their imagination how the case story would fit into the dashboard. This of course could present misinterpretation to some users; intentionally alleviated by the same interview structure and story that was shared yet it still can be considered something which if done in an alternative way may have presented differing outcomes.

7 Conclusion

In the future it is clear process mining is not something which is going to depart; throughout this paper there has been a discussion on the recommendations derived from prescriptive process mining, how they may be displayed, used and fundamentally can support ongoing work. This paper has reviewed the current space in academic literature whereby there is a gap in terms of visualisation from prescriptive process mining. Discussion has reviewed the concepts of process mining, prescriptive process mining and visualisation theory prior to following a design science based method collated from a mixture of work in this field [105], [99], [100], [101]. Based on this method research was taken analysing prescriptive process mining in ongoing work, the needs of case workers as it was seen the most common use case in current academic literature was in this sphere before producing dashboards and evaluating them to ensure they provide a guideline fit for work. The final design recommended for users to browse a one screen solution when handling tickets is found in section 6.2.

The prototype dashboards were based on a qualitative literature review to understand the current in practice use of prescriptive process mining as well as analysing what information a case worker would need to conduct their daily tasks. Derived from this analysis following the MoSCoW method, content blocks were formed which showed the most useful sections of information and that could be used in a variety of industries. Then utilising respected design science approaches and dashboard creation tips from industry experts the “inverted pyramid” [86] specifically, information was displayed in not only a readable but user focused method. These methods and respective dashboards were iteratively updated and this is discussed in detail alongside the changes made at each step. Each change with a user focus first, ensuring the research questions regarding case workers and ongoing work would be contemplated. These designs were then put to the test following an operational case study; information from over four years’ experience working with a SaaS solution was made to identify how this dashboard could be populated in a real case. This story was presented across a selection of interviews and looked to understand what the participants felt regarding the visualisation, if they would use the product themselves which scored an average of 3.75 out of 5 in the post interview survey.

This paper is tailored to provide a visualisation guideline for those wishing to build a dashboard subsequent to performing prescriptive process mining; the analysis is very strongly built to discuss how prescriptive process mining supports ongoing support based cases. Be this for use cases where a patient in hospital and the nurses are evaluating the next options for the relevant patient [7] or in the case of insurance and claims handling [70], and expanded upon within the case study which was built for use in a SaaS software support team dealing with customer problems. This shows the broad range of workplace environments this paper has attempted to satisfy. Which is why dashboard shown in 6.2 holds many fields blank with some key exceptions as these would be prevalent in any industry, the idea is this dashboard can be built upon by thought leaders who are actively using prescriptive process mining in their ongoing work. That said the paper does focus on specific use cases and not all ongoing work was considered for the final product; especially using prescriptive process mining to prompt alarms [20], [74] and alleviate risk. This was avoided as it was seen that using prescriptive process mining here is much more specific and the risk should be alerted and then appropriate measures taken, however it is not every day a company would encounter such risk so this mitigation strategy was not considered when drawing up visualisations.

As discussed within [106] process mining is a growing field and especially within the specific topic of deriving prescriptive results [71],[107]. That said in future it is advised that in future this research could be taken a step further and my dashboard guideline is utilised in a real life case where enhancements could be made, this could be made possible by building a

ProM dashboard template for experts to analyse. The evaluation saw the potential fruits of this project and drew positive conclusions from all attendants, despite the fact that the dashboard was founded from a young nature, prescriptive process mining literature.

8 References

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Appendix

I. Supporting Documents

Description	***Artefact***
Post Interview survey for additional information	Dashboard 1 https://forms.gle/GLKDPTUEK2ksJFoW9 Dashboard 2 https://forms.gle/1EuhycGVMB1Jf2oL9
Collation of SUS scores and calculations	https://docs.google.com/spreadsheets/d/1pfUw370HdgizOmF6IPsdWG7O-T04uu1NyIhoFY3zpG8/edit?usp=sharing

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