# Towards User-Centered Prescriptive Process Monitoring Systems (Extended Abstract)

Kateryna Kubrak[1]

[1]Institute of Computer Science, University of Tartu, Narva mnt 18, 51009 Tartu, Estonia

**Abstract**

Prescriptive process monitoring (PrPM) systems recommend actions during the execution of business processes to improve performance. Existing techniques for developing PrPM systems differ in the performance objectives they optimize for, the output they provide, and the algorithms they use. Most existing research on PrPM systems focuses on the efficiency and accuracy of the algorithms used to generate the output. In contrast, less attention has been given to the usability of these systems. While some works that have proposed a technique also designed an interface for it, their focus is primarily on showcasing the technological capabilities, not on addressing end-user needs. This gap limits the applicability of PrPM systems in practice. This thesis addresses this gap by studying how users interact with the recommendations produced by PrPM systems. Specifically, this thesis advances user-centered PrPM by first, synthesizing PrPM into a conceptual framework. This framework is structured along the categories of objectives, types of recommendations, required data inputs, the policies they follow, and user evaluation. These categories help to understand the range of PrPM outputs that can be presented to end users. Second, the thesis tackles the question of how an interface for PrPM outputs can be designed. Based on an analysis of the outputs of PrPM techniques and a series of interviews with potential users of PrPM systems, we map the information needs of three distinct user groups (process analysts, operational workers, and operational managers). Based on this mapping, we design and evaluate a PrPM tool, namely Kairos which provides recommendations to perform actions during the execution of ongoing cases of a process. We evaluate the interface of the tool with the end users and as a result, we derive suggestions for designing user interfaces for PrPM systems. Finally, to assist users in understanding the outputs of PrPM techniques, the thesis proposes a prompting method for a Large Language Model (LLM) to enhance the explainability of PrPM outputs. The prompting method is implemented in Kairos and evaluated with end users, leading to insights into the potential benefits and challenges of designing LLM-based user interfaces for PrPM systems. In summary, this thesis contributes to the design of user-centered PrPM systems by ensuring recommendations are not only technically robust but also usable and actionable for end users. Its findings advance both the theoretical understanding and practical implementation of PrPM systems.

**Keywords**

Prescriptive process monitoring, end-user information needs, user interface, usability, explanations, Large Language Models



## 1. Introduction

Prescriptive process monitoring (PrPM) is a family of techniques that recommend runtime actions to optimize quality, efficiency, or other performance dimensions of a business process. These techniques usually rely on Artificial Intelligence (AI) approaches to predict undesirable outcomes of a running case within a process and to evaluate the potential impact of different recommendations [1]. In recent years, research has focused on improving PrPM techniques to become more accurate and efficient. However, comparatively little attention has been given to the presentation of the outputs of PrPM techniques and end-user interaction with them. While a few examples of user interfaces for PrPM exist, their design is centered around showcasing the technique itself and not the needs of the users interacting with it.

In AI-driven systems such as PrPM, acceptance of outputs remains challenging due to, for instance, unsatisfactory user experiences with user-AI interfaces [2]. Human-Centered AI (HCAI) addresses this challenge by putting end users' needs at the center of AI design [3]. HCAI is operationalized through three main approaches: explainable AI, which focuses on making black-box AI models understandable;

*Proceedings of the BPM 2026 Best Dissertation Award, Doctoral Consortium, and Demonstration & Resources Forum (BPM 2026) , Toronto, Canada, September 27th to October 2nd, 2026*

kateryna.kubrak@gmail.com (K. Kubrak)

0000-0002-4607-4000 (K. Kubrak)

user-friendly AI, which emphasizes usability and usefulness; and responsible AI, which addresses trustworthiness and fairness [2]. In this view, usability, i.e., enabling users to achieve their goals effectively, efficiently, and satisfactorily, is the starting point for making outputs understandable and actionable [2]. The current gap in research regarding user interaction with PrPM outputs presents a limitation for the practical implementation of these techniques.

To address this research gap, we formulate the research objective (RO) as *to provide end users with usable outputs of prescriptive process monitoring techniques.* This RO is divided into four research questions (RQs).

- **RQ1:** *What are the outputs of PrPM techniques?*
  There is a variety and fragmentation of PrPM techniques. Existing PrPM techniques require different input data, target different objectives, and offer a variety of outputs. It is not clear which outputs are valuable to end users. Therefore, we review existing PrPM techniques and categorize the types of objectives they target, the data they require, and outputs they produce. With such a mapping, we can align the outputs of PrPM techniques with end-users needs.
- **RQ2:** *What user groups could benefit from working with the outputs of PrPM techniques? What are the users' information needs?*
  In this thesis, we aim to make the outputs of PrPM techniques usable. For that, we need to understand the potential users. While analysts are the primary users of process mining techniques when it comes to process analysis, research has shown that the end-users of PrPM techniques extend beyond process analysts. For instance, the outputs of PrPM have been used by claim processors [4] and physicians [5], showing their usefulness for other stakeholders such as managers and process workers. Therefore, with this research question we aim at understanding what the end-user types are and what PrPM outputs benefit them.
- **RQ3:** *How to translate these information needs into a user interface design for PrPM systems?*
  The mapping of end-users' information needs enables the design and development of a user interface. Designing an interface involves analyzing the differences between the identified end-user groups and investigating how their needs can be addressed in a UI. Specifically, the design of the interface needs to be aligned with the needs of each user-group to ensure that the PrPM outputs are usable.
- **RQ4:** *How to enhance the understandability of PrPM outputs?*
  The effectiveness of PrPM interfaces depends on the extent that recommendations are followed, which itself depends on the users' ability to understand what the recommendation means. Previous work has highlighted the challenges of providing understandable explanations of outputs to business users [6]. To tackle this challenge, we explore the possibilities of explaining the PrPM outputs in a natural language.

By addressing these research questions, we seek to make the outputs of PrPM techniques usable for end users and thus bring the research efforts closer to developing user-centered PrPM systems.

## 2. Research Method and Contributions

To achieve the research objective, this thesis follows the Design Science Research Methodology [7]. DSRM consists of six phases: *(1) Problem identification and motivation, (2) Definition of the objectives for the solution, (3) Design and development, (4) Demonstration, (5) Evaluation,* and *(6) Communication* [7]. Figure 1 provides an overview of the activities and outputs of each of the phases, as well as mapping to the research questions.

*Phase 1.* DSRM begins with identifying a specific problem and justifying the value of its solution. In this thesis, this phase corresponds to **RQ1**. To answer the research question, we conduct a Systematic Literature Review of existing PrPM techniques.

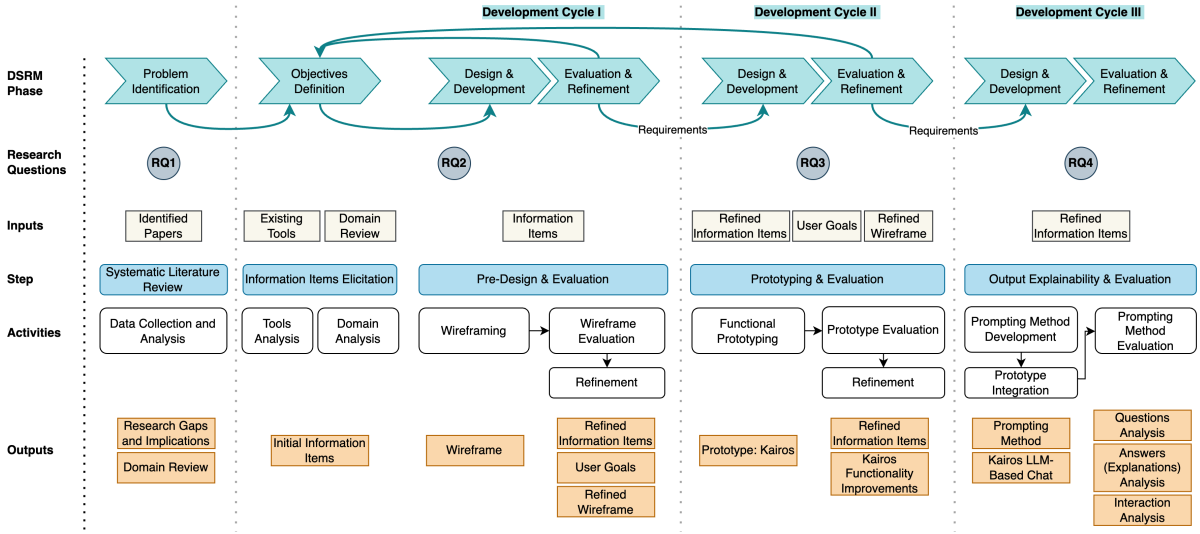


**Figure 1:** Mapping of the research method to RQs, research activities and outputs. The phases are based on DSRM [7].

- **Contribution 1:** A framework that classifies PrPM techniques along the following dimensions: objective, recommendation types, data input, policy, user evaluation aspect. In the context of the thesis, this contribution helps in understanding the range of PrPM outputs. This, in turn, is the first step to gaining insights into how they can be made usable to end users. Broader, researchers benefit from this contribution as they can gain insight into the current state of the art of the field and identify potential directions for future research.

*Phase 2.* Next, the solution objectives are inferred from the problem definition and knowledge of what is possible and feasible. First, to consolidate the knowledge of the state of the problem, we build on the domain review from Phase 1. Then, for the knowledge on current solutions, we conduct an analysis of existing tools. As a result, we elicit information items to be included in the UI for PrPM outputs. Information items in this context correspond to the pieces of information to be included in a PrPM interface.

The phases *(3) Design and development*, *(4) Demonstration*, and *(5) Evaluation* are conducted three times in separate development cycles.

*Development Cycle I.* This cycle corresponds to **RQ2**.

In this cycle, we develop an artifact, a wireframe of a PrPM system that consists of the previously identified information items. To evaluate how well the artifact supports a solution to the problem, we conduct an evaluation of the wireframe with end users. We find that three distinct user groups could benefit from working with a PrPM system: operational workers, operational managers, and process analysts. They share some information needs, while others appear distinct. To further support the understanding of why different information items are needed by each user group, we connect them to the goals that users aim to achieve with the help of PrPM systems. Each user group's business goals are decomposed into decision goals and question goals, which in turn guide their information needs. This serves as input for the next development cycle.

*Development Cycle II.* This cycle corresponds to **RQ3**.

This cycle builds upon the previous cycle and incorporates the findings from the PrPM framework. Specifically, we develop a PrPM system called Kairos. The features available in its interface are based on the respective information items. The PrPM techniques included in the backend of Kairos stem from the review done in Phase 1. Afterwards, we conduct an evaluation with representatives of the identified end-user groups. The evaluation focuses on the usability and usefulness of the interface. The findings of the evaluation are summarized into a set of refinements for the interface. Based on the evaluation, we also formulate a set of suggestions for designing PrPM interfaces.

- **Contribution 2:** An overview of end-user groups for PrPM with their information needs and a set of suggestions for designing PrPM interfaces. The suggestions are summarized as: 1) personalized interfaces, 2) explanations for PrPM outputs, 3) possibility for interactive data exploration, 4) decision-making support and automatic case prioritization. These contributions have implications for developers wherein they have a set of the suggestions to take into account when developing PrPM interfaces. Researchers can build upon the findings to further advance research on information needs of end users within the process mining field.

*Development Cycle III.* This cycle corresponds to **RQ4**.

Following the results of the evaluation in Cycle II, we observed that one refinement that could be made in the interface is to improve the understandability of recommendations presented to the end users in the interface. Therefore, in this phase of Cycle III, we design an artifact: a prompting method that enables an LLM to elaborate on PrPM recommendations. The prompting method is implemented in a chatbot that is added as part of Kairos to enable its further evaluation. Specifically, we conduct an evaluation of the developed artifact with the end users, where they can interact with the chat that utilizes the prompting method. We analyze the questions the users asked, the answers the chat gave, and the interaction between the user and the chat. The users found that such conversations help them better understand how to use Kairos, and conducting such conversations is useful to their goals.

- **Contribution 3:** First, a prompting method that enables the end users to get explanations of recommendations in PrPM and understand them further by asking asking follow up questions in natural language. Second, insights into the potential benefits and challenges of designing LLM-based systems for enhancing explainability in PrPM interfaces. Additionally, the questions that end users have to a PrPM system can serve as input for designing explanations in the future. They could, however, also be used to analyze which questions truly stem from analyzing the outputs and which from the interface itself, which provides an avenue for future work.

## 3. Conclusions and Future Work

This thesis aimed at advancing user-centered PrPM by providing more attention to how PrPM outputs are communicated, explained, and consumed by end users. Overall, the results indicate that making PrPM usable requires (i) structuring outputs around concrete user needs, (ii) tailoring information and level of detail to distinct end-user groups, and (iii) providing explanations that help understand the output as well as the potential impact of it. At the same time, the studies highlight that usability gains can be undermined when recommendations are difficult to justify (“why this?”), hard to operationalize under organizational constraints (e.g., compliance), or face difficulties with integrating into common day-to-day interfaces. These findings suggest that the practical impact of PrPM depends as much on interface and interaction design and explanation quality as on the techniques performance.

The research results presented in this thesis offer several implications for research and practice. In the context of tailoring the design to the end-user groups, for operational managers, for instance, PrPM should prioritize resource-related information, performance, and allocation constraints, while for process analysts, the interface should make recommendations interpretable in the context of the process itself. This ensures that the outputs correspond to their goals rather than to what the system can generally output. Further, for LLM-enhanced explanations, the thesis also emphasizes the need for further advancement of causal recommendations and causal explanations in PrPM to better answer the questions of why a recommendation is given and how it affects a case. These necessary advancements in PrPM are not a question of interfaces, but rather of the underlying techniques. These techniques should be accurate and computationally efficient, but they also need to be developed with end-user needs in mind. Put simply, user needs should guide both the interface and the underlying methods. User evaluations showed that PrPM systems, once more mature, might also face challenges in adoption and integration from the organizational perspective. Some more highly regulated environments can be hesitant to using systems that have a recommendation or decision-making component in them.

Another relevant question will be in how to incorporate such systems into the usual workflows without completely disrupting the work. These are some interesting directions for future work.

Several limitations need to be acknowledged as well. Reviewing PrPM outputs involved an SLR on a dynamic research field, which only increases subjectivity in screening and data extraction, however necessary criteria and mitigation strategies were involved. Several empirical studies were conducted in this thesis. Some of them used limited examples (e.g., a single or few event logs) and within a restricted domain context, which constrains the generalizability of the findings. Further, in the first evaluation we relied on experts rather than representative end users, introducing potential selection and recruitment bias. However, the following studies involved direct representatives of end-user groups to mitigate that. Finally, the prototype implementations were intentionally limited in functionality, and the LLM-based component was evaluated with a single model whose generative nature reduces reproducibility. Therefore, the need for further evaluations and expanding the scope towards other domains is only underscored as part of future work.

## Declaration on Generative AI

The author has used generative AI tools to paraphrase and reword, as well as do grammar and spelling checks.

## Acknowledgments

This research was supported by the Estonian Research Council (PRG1226) and the European Research Council (PIX Project).

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