Assessing the effectiveness of five process elicitation methods: A case study of chemotherapy treatment plan review

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A B S T R A C T
To reduce the probability of failures and to improve outcomes of safety-critical human-intensive processes, it is important to be able to rigorously analyze such processes. The quality of that analysis often depends on having an accurate, detailed, and sufficiently complete understanding of the process being analyzed, where this understanding is typically represented as a formal process model that could then drive various rigorous analysis approaches. Developing this understanding and the corresponding formal process model may be difficult and, thus, a variety of process elicitation methods are often used. The work presented in this paper evaluates the effectiveness of five common elicitation methods in terms of their ability to elicit detailed process information necessary to support rigorous process analysis. These methods are employed to elicit typical steps and steps for responding to exceptional situations in a safety-critical health care process, the chemotherapy treatment plan review process. The results indicate strengths and weaknesses of each of the elicitation methods and suggest that it is preferable to apply multiple elicitation methods.

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1. Introduction

Human-intensive processes (HIPs) play a critical role in society. We say that a process is human-intensive if the contributions of human process performers have a significant impact on the process outcomes and require substantial domain expertise and insight. Important HIPs, such as many health care processes, often involve complex coordination and interaction among human experts and complex software and/or hardware systems. Such HIPs are also often safety-critical in that defects in their design or errors during their execution can lead to loss of life or to other negative consequences. To reduce the probability of such problems and to improve process outcomes, it is important to analyze HIPs for the presence of a wide range of problems or vulnerabilities, to carefully evaluate the impact of process modifications, and even to provide real-time guidance to process performers (Avrunin et al., 2010; Christov et al., 2016).

A number of types of rigorous analysis, such as fault-tree analysis (Vesely et al., 1981), failure mode and effects analysis (Stamatis, 1995), model checking (Clarke et al., 2000), and discrete-event simulation (Robinson, 2004), have been applied to HIPs and shown to be useful for process improvement (Avrunin et al., 2010; Chen et al., 2008; Damas et al., 2009; Connelly and Bair, 2004; Raunak et al., 2009). But the quality of such analyses often depends on having an accurate, detailed, and sufficiently complete understanding of the safety-critical HIPs that are being analyzed. This understanding is typically represented as a formal process model that could then be used as input to various rigorous analysis approaches. The level of detail and the precision of process information that needs to be captured in such a model are typically higher than the level of detail and the precision of process information that are needed for informal and less rigorous analysis approaches. For example, model checking and automated fault-tree analysis might require knowledge of which steps could be performed in a process, the possible orders in which these steps can be performed (including concurrently), the problems, or exceptional situations, that might arise in a process, and how these problems are handled.

Eliciting such detailed and precise process information is difficult. In HIPs, the complex coordination of human and automated agents often results in process knowledge being distributed among...
several stakeholders. These stakeholders may have different and sometimes conflicting views of the process and may use different terminologies to describe it. Another difficulty stems from the fact that exceptional, or abnormal, situations often arise during the execution, or performance, of a process (Koopman and Hoffman, 2003). Moreover, errors that can compromise the safety of HIPs may be especially likely to occur on process executions during which exceptions arise (Leveson, 1995; Spear and Schmidhofer, 2005). This implies that such executions need to be considered in addition to the typical, or normal, process executions. A further indication that such executions require special scrutiny is the fact that responses to exceptional situations are sometimes referred to as workarounds (Koopman and Hoffman, 2003; Kobayashi et al., 2005), an indication that these responses may be poorly specified. Spear and Schmidhofer (Spear and Schmidhofer, 2005) observe that organizations that fail to clearly specify how process performers should respond in different situations suffer from more errors than organizations that specify these aspects of their processes. Thus, it is especially important to elicit and understand the exceptional situations that may arise during executions of a HIP and how process performers should respond to them.

To tackle the difficulties associated with eliciting detailed and precise process information, a variety of process elicitation methods are often used. While the strengths and weaknesses of process elicitation methods have been studied (e.g., (Preece et al., 2015; Westat et al., 2010)), more information is needed about the ability of these methods to elicit the kinds of detailed and precise process information necessary to support rigorous analysis. A recent comprehensive survey of the literature (Unertl et al., 2010) suggests that despite the use of a wide variety of process elicitation methods, little is known about the relative strengths and weaknesses of these methods in terms of their ability to elicit different kinds of process information, particularly information about exceptional situations. There has been work on understanding and specifying the handling of exceptional situations (e.g., (Kobayashi et al., 2005; Lerner et al., 2010)), but the focus of this work was on the mechanisms for handling exceptions and how to precisely describe these mechanisms, not on the methods used to elicit the handling of exceptional situations in processes.

The work presented here is a step toward understanding the strengths and weaknesses of some of the most frequently used process elicitation methods in terms of their ability to elicit detailed process information needed for rigorous process analyses, and in particular information about exceptional situations in HIPs. As part of a larger project (Avrunin et al., 2010; Mertens et al., 2012) investigating the use of automated analysis techniques to improve the safety and efficiency of medical processes, we conducted a case study evaluating common elicitation methods applied to one safety-critical health care process, chemotherapy treatment plan review. We selected five elicitation methods: direct observations; unstructured interviews; and three semi-structured interview methods based on partial scenario descriptions, complete scenario descriptions, and full process descriptions, respectively. These are some of the most commonly used elicitation methods (e.g., (Dykes et al., 2005; Unertl et al., 2010; Woods and Hollnagel, 2006; Badker and Christiansen, 2006; Patterson and Miller, 2010; Graesser and Murray, 1990; Hallock et al., 2006)) and were all readily applicable to our selected case study. Specifically, we chose observations and interviews, because a recent comprehensive study of the workflow/process literature found that observations and interviews were the most frequently used methods (Unertl et al., 2010). We chose the semi-structured interview methods, because we were interested in eliciting process steps and the supporting materials are suitable for eliciting this kind of process information.

Our work specifically focuses on how well these methods elicit two kinds of process steps: 1) typical steps in the process (i.e., normal process steps), which include steps for recognizing exceptional situations and other process steps necessary to carry out the process when no exceptional situations arise, and 2) steps for responding to exceptional situations. We also evaluated the selected elicitation methods in terms of their abilities to discover disagreements among process performers about how the process is to be executed. The results indicate strengths and weaknesses of each elicitation method and show that each method contributed to the understanding of the process, suggesting that it is preferable to apply multiple elicitation methods when trying to develop a robust understanding of a complex process.

The rest of this paper is organized as follows. Section 2 presents the research method for evaluating the five process elicitation methods, Section 3 presents the evaluation results, and Section 4 discusses these results including threats to their validity. Section 5 summarizes the contributions of this work and describes future work.

2. Methods

To evaluate the selected five elicitation methods, we used them to elicit information about a chemotherapy treatment plan review process. We chose this safety-critical HIP because it had considerable complexity, especially with respect to exceptional situations. This process elicitation was part of a larger project on medical safety focusing on creating detailed formal process models and on evaluating formal analysis approaches, such as model checking and fault-tree analysis, in terms of their ability to support improvement of medical processes (Avrunin et al., 2010; Mertens et al., 2012). During this project, a nearly 70% reduction in errors reaching the patient was observed (Mertens et al., 2012).

We applied the selected elicitation methods in a specific order to minimize the influence that an elicitation method might have on process performers during the application of subsequent elicitation methods. We first conducted unstructured interviews to gain an initial understanding of the process and to avoid introducing any of our preconceived notions about the process. We used this initial understanding to construct a formal process model that we then used to support the semi-structured interviews. The process performers involved in the observations were not involved in the unstructured interviews, so they were not influenced by those discussions. We undertook the observations before conducting the semi-structured interviews, which involved questioning the process performers, to avoid having the semi-structured interviews influence the observed behavior. The semi-structured interview methods were applied in an order such that each semi-structured interview method provided more process information to the interviewees than the semi-structured interview method applied before it. The selected order of method application and its potential influence on the results are further discussed in section 4.4.

Our primary goal was to evaluate the selected elicitation methods in terms of their ability to elicit normal process steps and steps for responding to exceptional situations and, thus, effectiveness was determined in terms of the number of elicited steps and whether critical process steps were missed by a method. Method efficiency, a secondary focus in our study, was determined in terms of the time spent with domain experts for each elicitation method and the number of process steps elicited per unit of time. Other evaluation dimensions, such as susceptibility to researchers' bias, the ability of a method to gain information about the context of process performance, and the effect of a method on the psychological state of process performers, are outside the scope of this work and have been extensively studied and reported elsewhere (e.g., (Preece et al., 2015; Westat et al., 2010)).
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