

DOCTORAL CONSORTIUM

ENHANCING PROCESS MODEL VISUALISATION TO FACILITATE THE UNDERSTANDING OF STAKEHOLDERS

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Over the past forty years, the use of process models in practice has grown extensively. Until twenty years ago, remarkably little was known about the factors that contribute to the human understandability of process models in practice. Since then, research has, indeed, been conducted on this important topic, by e.g. creating guidelines. Unfortunately, the suggested modelling guidelines often fail to achieve the desired effects, because they are not tied to actual experimental findings. The need arises for knowledge on what kind of visualisation of process models is perceived as understandable, in order to improve the understanding of different stakeholders. Therefore the objective of this study is to answer the question: How can process models be visually enhanced so that they facilitate a common understanding by different stakeholders? Consequently, five sub-research questions (SRQ) will be discussed, covering three studies. By combining social psychology and process models we can work towards a more human-centred and empirical-based solution to enhance the understanding of process models by the different stakeholders with visualisation.

Keywords:
understanding,
process
model,
stakeholder,
designer,
visualisation
psychology

1 Introduction

Over the past forty years, the use of process models in practice has grown extensively. As the creation and use of process models involves a broad range of stakeholders, it is crucial that these models are intuitive and easy to understand (Dumas et al., 2018; Mendling et al., 2007; Reijers and Mendling, 2011). The notion of ‘process model’ is a broad one, also involving a wide range of notations and visualisations. We regard process models as simplified and abstract representations of systems, and their interactions, that are essential for a particular purpose (Geissdoerfer et al., 2018; Kerim, 2023; Smirnov et al., 2012). Until twenty years ago, remarkably little was known about the factors that contribute to the human understandability of process models in practice (Mendling et al., 2007; Petrusel and Mendling, 2013). Since then, research has, indeed, been conducted on this important topic, by e.g. creating guidelines (Slagter et al., 2017; Mendling et al., 2010). Most guidelines focus on the visualisation of process models and are intended for the designer to use when modelling processes. When choosing a guideline, designers consider multiple factors, including the audience and purpose of the model. Unfortunately, the suggested modelling guidelines often fail to achieve the desired effects, because they are not tied to actual experimental findings (Mendling, 2012).

The practical need for more transparent and understandable processes grows more important in light of the transition to a more circular economy. This increasing need is illustrated and underlined by the VMRG (the Dutch industry organisation for metal facades). The VMRG closes the leakage flows of materials from supply chains and moves towards zero carbon in the construction sector. This VMRG achieves with a process-based approach by using the Business Process Modelling Notation (BPMN). Fledderman (2023) from VMRG states, *“Formulating and modelling processes [...] is done from the user perspective. This, knowing that on the one hand, we have to support processes with digitalisation, [...], and on the other hand, that we have 1000+ companies as users, with a very diverse level of knowledge, to include in the communication. We are already experiencing user-(director)-designer communication issues in daily practice. How do we ensure that we do this better and more effectively?”* In the Dutch construction sector, in which VMRG operates, VISI software is the mandatory standard for the exchange of construction process information (Bakker & Spees, 2024). The basis of this mandatory standard is the process model notation Design and Engineering Methodology for Organisations (DEMO), stressing the importance of understandable process notation.

In practice, there are currently several drawbacks and challenges concerning process models when presented to the intended readers, to stakeholders. Based on Freeman (2020), we define a stakeholder as a group or an individual that affects or is affected by process models (e.g. executives, customers, employees, management, investors, media). Researchers are taking steps to map and improve said drawbacks and challenges. Mulder (2019) highlights this by showing five cases that lack communicability with different stakeholders using the same process model, based on DEMO. Simply because process models are not usually designed with different stakeholders in mind. Different stakeholders have different factors contributing to their understanding. Experiences from practice show that the human element is often overlooked (Jans, 2023), especially for the stakeholders who do not (want to) see process models regularly. As Van Gils (2023) stated when interviewed: “[designers] need to create one process model with multiple visualisations for multiple stakeholders at multiple levels of abstraction”. For example, a process model as shown in figure 1, used in the construction sector, might not be perceived as transparent and understandable to other stakeholders and could be interpreted differently. The need arises for knowledge on what kind of visualisation of process models is perceived as understandable, in order to improve the understanding of different stakeholders.

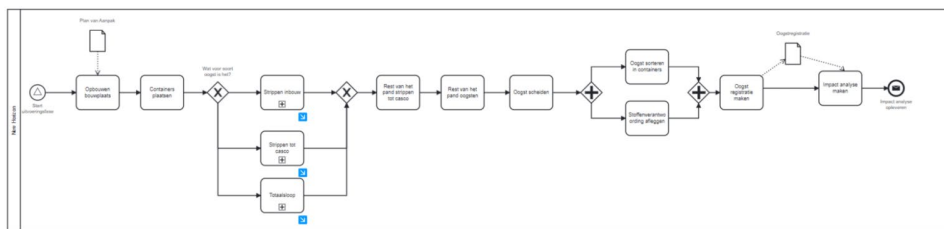


Figure 1: Example of a BPMN process model

Source: Own

Stakeholders might need to make decisions based on the process model from the previous example, shown in Figure 1. If these stakeholders base their decisions on the (wrong) assumption of understanding, this could lead to negative effects, e.g. planning risks or negative financial impact. Thus, the designers must not make the reading, understanding and visualisation of the process model harder than it needs to be. Based on Mandelburger (2021), we define a designer as the person who makes a process model, e.g. architects, process analysts, and others.

The general population familiar with complex visualisations is growing, although the number of people able to deduce the relevant information from these visualisations is difficult to estimate (Boy et al., 2014), this is called visual literacy. In the proposed study we define visual literacy as the ability to effectively, efficiently, and confidently understand, use, create, and extract information from well-established data visualisations, inferred from Aisami (2015) and Lee (2016). In today's society, with more individuals using and encountering visualisation, the need grows for individuals to become more visually literate regarding complex visualisations (Börner et al., 2019; Kiper et al., 2012).

Current research into the understanding of process models mainly comes from the enterprise engineering and process modelling communities. Interdisciplinary research has much potential to address some of the larger problems facing organisations (Waldman, 2013). So far, the number of interdisciplinary studies is limited, an overview of several relevant studies can be found in Table 1. For example, Rosenthal et al. (2022) combine process modelling and cognitive psychology to look into the understanding of process models. Cognitive psychology focuses on the inner workings of the brain. However, because we focus on the stakeholder's understanding of visual process models the domain of social psychology may be more relevant. The study of social psychology scientifically investigates how individuals think, feel, and behave in a social context (Kassin, 2023). Social psychology has a diverse set of topics, everything the stakeholder thinks and therefore acts on falls within this scope. It examines both the 'social' and the 'non-social' factors that affect people. Accordingly, how designers visually influence the stakeholders through process models falls wholly within social psychology. By combining social psychology and process models we can work towards a more human-centred and empirical-based solution to enhance the understanding of process models by the different stakeholders with visualisation.

What are process models? Every notation allows for an "informational payload" needed for the various kinds of decisions stakeholders need to make. Therefore, with its (informational) payload, each notation serves a specific purpose and might not be suitable for use in every situation. There are many process modelling notations available (e.g. BPMN, DEMO, VISI, Flowchart, ArchiMate, EPC, DFD, IDEF0, Petrinet) (B). Within this PhD research, we will focus on two notations that have significance for practice: BPMN and DEMO.

Table 1: Overview of interdisciplinary studies

Study	Area of interest							
	PM			CP	SP	ET	V	U
	Other	BPMN	DEMO					
Abbad et al. (2023)		X				X		
Bera et al. (2019)		X		X		X		
Figl (2017)		X		X				
Hipp et al. (2014)		X					X	
Malinova Mandelburger and Mendling (2021)		X		X				
Mendling et al. (2007)	X							X
Petrusel and Mendling (2013)		X				X		
Reijers and Mendling (2011)		X						X
Rosenthal et al. (2022)	X			X				X
Zimoch et al. (2017)		X				X		

Note. PM: Process modelling. CP: Cognitive Psychology. SP: Social Psychology. ET: Eye-tracking. V: Visualisation. U: Understanding.

BPMN is a functional notation used to model the activities and decisions of an organisation (OMG, 2013). This notation focuses on the “how” of the organisation. BPMN is used frequently because people focus more on the “how” of the organisation. BPMN allows for a payload of e.g. functions, activities, decisions, and sequences (OMG, 2013). DEMO is an abstract method, containing a notation to model the construction of an organisation (Dietz and Mulder, 2020). This method abstracts the organisation from implementation and realisation. It gives a view of the “what” of the organisation. DEMO is also often used but less frequently than BPMN because people focus less on the “what” of their organisation. DEMO allows for a payload of e.g. responsibilities, products, roles, functions, data, rules, and dependencies (Dietz and Mulder, 2020). DEMO and BPMN are important to study due to their significance for practice and are complementary to each other as they allow for different payloads serving different stakeholders.

Why is visualisation so important to understand? So far, there is no standardised terminology, typology, or classification system for core visualisation concepts anywhere (Börner et al., 2019); visualisation can mean various things to different people (Csinger, 1992). Visual literacy is becoming as important as the ability to read

and comprehend text (Lee et al., 2016). Despite the importance of visual literacy and visualisation, researchers have paid little attention to the application and development of visual literacy (Kiper, 2012).

As visualisation plays a crucial and essential role in communicating models (Hoppenbrouwers et al., 2012), being able to measure visual literacy is increasingly important. To our knowledge, only a few visual literacy scales exist (e.g. Aisami, 2015; Boy et al. 2014; Kiper et al., 2012), and they are not widely accessible. When using process models for communication, it is essential to be aware of the different views people involved have (Hoppenbrouwers et al., 2012); all meaning is relative to culture (Ware, 2004). Thus, stakeholders from different cultures and with different knowledge could have a different understanding of one specific process model visualisation (A, B).

2 Problem Definition

As mentioned, different stakeholders have different visual needs that need to be met to communicate process models effectively (Börner et al., 2019; Hoppenbrouwers et al., 2012). The designer does not always keep the different stakeholders and their level of understanding in mind. This requires a balance between human-oriented communication and rational engineering, which can be described as “a challenge and often a bit of a struggle” as you cannot assume that all people are familiar with process models (Hoppenbrouwers et al., 2012). Additionally, designers often make the mistake of too easily considering a process model to be effectively communicated without thorough validation. Similarly, stakeholders tend to assume they possess a sufficient understanding of process models and their visualisations. This proposed PhD study aims to enhance the understanding of process models of the different stakeholders in practice.

2.1 Research question

As discussed above, the biggest challenge to increasing the added value of process modelling in practice, is to enhance the understanding of process models by stakeholders. This research aims to develop an artefact that helps to improve the visualisation of process models to enhance common understanding and thereby increase the value of using process models in practice. We work towards solving this

challenge by combining the enterprise engineering and process modelling domains with the social psychology research domain.

Based on the previous sections, the following main research question is formulated:

How can process models be visually enhanced so that they facilitate a common understanding by different stakeholders?

To answer the main research question the following sub-research questions (SRQ) are formulated:

SRQ 1: What is known about the occurrence of misunderstanding when reading process models?

SRQ 2: What are the visually oriented factors that facilitate the understanding of process models?

With SRQ one and two, we establish the current state-of-the-art regarding this topic. This allows us to more accurately define research gaps and future research that we may have missed before.

SRQ 3: What is the difference between different types of stakeholders when reading and interpreting process models?

SRQ 4: What aspects related to visualisation will improve the understanding of process models by different types of stakeholders?

With SRQ three and four, we will measure understanding of process models among different types of stakeholders (e.g. experts and non-experts) to develop a baseline of understanding without interventions. With this baseline, we have a foundation to experimentally compare potential improvements.

SRQ 5: What artefact can be designed to be useful in facilitating the understanding of process models in relation to their visualisation?

With SRQ five, we want to improve the visualisation of process models and research what kind of artefact would be best for that. With this question, we can see what direction can work to help the practice

3 Methodology

To answer the main research question and the sub-research questions discussed in the previous section, the proposed research project consists of three studies. The first study will be a systematic literature review to establish the current state-of-the-art regarding this topic. The second study will be an eye-tracking study combined with in-depth interviews to develop a baseline of understanding without interventions. The third study will be the designing and testing of an artefact following Design Science Research (DSR) to develop the artefact while using eye-tracking as a key instrument in evaluating the artefact.

3.1 Study 1: Literature Review

To answer SRQs 1 and 2, study 1 will be a systematic literature review. The study will use the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach (Page et al., 2021). This will help provide the knowledge foundation regarding process model understanding and visual factors that facilitate understanding. Furthermore, the aim is to identify knowledge gaps in the literature from the stakeholder perspective. This review will be the foundation for the entire PhD project. However, as it is important to be up to date with recent literature, updating this foundation is something that will be done during the entire PhD period.

3.2 Study 2: Eye-tracking

To answer SRQs 3 and 4, study 2 will consist of two parts. The first part will be an eye-tracking experiment. When reading and interpreting process models specific links between attention distribution and task performance have not yet been established (Bera et al., 2019). The advantage of eye-tracking is its ability to measure physiological responses to visual stimuli and record these responses in real-time (Hassan and Bialowas, 2017). Employing eye-tracking to compare various process modelling notations provides valuable insights into how stakeholders understand

process models. (Zimoch et al., 2017). With eye-tracking, we aim to find differences in how types of stakeholders (e.g. experts and non-experts) read and interpret process models. By mapping these differences, a baseline of understanding can be made for these groups. The experiment will consist of a questionnaire about the two process model notations, Design and Engineering Methodology for Organisations (DEMO) and Business Process Modelling Notation (BPMN). The participant will answer multiple-choice questions, minimising additional work requirements and the risk of data entry errors (Hassan and Bialowas, 2017).

The second part will be an in-depth interview. The participants of the eye-tracking experiment will be invited for an interview to further enrich and detail their answers to the eye-tracking questionnaire. With these interviews, we aim to get a deeper understanding of what the participants' thoughts were during the questionnaire. Through this retrospective thinking, we can hear from the various groups about their thoughts and opinions. With this information, we want to learn about what might be a cause of misunderstanding and what the various stakeholders think might facilitate their understanding.

3.3 Study 3: Artefact

To answer SRQ 5, study 3 will be based on Design Science Research (DSR). With the DSR approach an artefact (e.g. a guideline) can be created based on experimental findings. The results from study two will form the basis from which we develop an intervention targeting practice. The aim is to create an artefact or guideline that facilitates understanding significantly compared to the baseline established in study two. Through the same method used to create the baseline of understanding in study two, eye-tracking, we will evaluate whether there are significant improvements in understanding.

4 Expected Results

By combining the domains of process management (modelling) and social psychology, this PhD has the potential to address some of the problems facing organisations concerning process models. Because there is limited interdisciplinary work in combining these fields, this study is one of the building blocks for more studies like these in the future and creates more direction for future research. By

focusing on the stakeholders, we can get more focus on the human element, social psychology and visualisation. We aim to explore what visual adaptations can help facilitate the understanding of process models by stakeholders.

The practice has shown that there are currently several drawbacks and challenges concerning process models when presenting these to stakeholders. It is essential to be aware of the different kinds of stakeholders because the interpretation of models is contextual (e.g. relative to international/organisational culture as all meaning is relative to culture). The results of the three studies will help facilitate the understanding of the stakeholders and thus help practice make well-informed decisions based on process models.

5 Future Development

This research explores the visualisation and subsequent understanding of process models. This is not only an essential topic for practice but also for education. Using visuals in various learning environments is a vital learning enhancer (Aisami, 2015), making it a valuable tool for educational applications. Visualisation will improve how education is taught and help the students prepare for practice.

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