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An empirical investigation of intuitive understandability of process diagrams

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ABSTRACT

Context: Business process modeling is an activity that includes several different roles, e.g. business analysts, technical analysts and software developers. The resulting process diagrams can be either simple or complex. Nonetheless, they must be understandable to everyone, even those without the necessary knowledge of process modeling notations.
Objective: The goal of our research was to evaluate intuitive understandability of diagrams, modeled in different process modeling notations, with regard to diagram complexity.
Method: An empirical research was conducted, including 103 students with the goal to empirically validate the intuitiveness of the diagrams, modeled in most commonly used process modeling notations, i.e. Unified Modeling Language 2.0 Activity Diagram (UML AD), Business Process Model and Notation (BPMN) and Event Driven Process Chain (EPC). Results were analyzed using the Kruskal–Wallis test, together with the Mann–Whitney post hoc tests with Bonferroni correction.
Results: In the case of processes with lesser complexity, participants using BPMN diagrams were significantly outperformed by those using either EPC or UML AD ones. However, when complexity of processes was higher, participants using EPC diagrams performed significantly worse than those using the UML AD and BPMN counterparts. Moreover, participants that used UML AD diagrams were not significantly outperformed by users of diagrams in other process modeling notations, regardless of their complexity. Thus, UML AD was recognized as being the most versatile notation.
Conclusion: Since the existing studies do not offer a holistic overview of the intuitive understandability of process diagrams with different complexity, modeled in different process modeling notations, our research can help decide which notation to use when representing processes that have to be understandable by all stakeholders.

1. Introduction

Business processes represent a core asset of corporations, since they have a direct impact on their products and services [1]. They are defined as a set of one or more activities that are executed in a predefined order, with the aim to achieve a business objective [2]. Business processes can be analyzed and improved with business process models, since they define the essential elements that drive the business. Business process models can be represented in the form of a graphical process diagram, which visually describes the sequences of activities [3]. Such process diagrams are the result of business process modeling (hereinafter referred to as BPMo) [2], which enables companies to document and redesign their processes. Documenting business processes helps stakeholders to understand how they work, whereas a redesign represents improving already established ones [4]. Each of these aspects demands a different role, e.g. business analyst, technical analyst and software developer [5]. Consequentially, there is a need and a challenge for notations that would be understandable by all BPMo related stakeholders. In order to achieve this goal, the notations have to be represented with graphical symbols that reference real-world concepts and have to be intuitive for their readers [6].

Currently, there are many process modeling notations. They offer different sets of graphical symbols in order to represent a process diagram, while the basic set of vocabulary remains similar (e.g. activities and flows) [7]. However, since the intuitiveness of such graphic symbols differs between the notations, it can be challenging to represent precise, intuitive business processes [8,9]. The differences in understandability among various notations have already been confirmed by several studies [10–12]. Moreover, studies suggest that some of these notations are too complex to comprehend even for business analysts [13]. Additionally, the complexity of process diagrams can negatively influence their understandability [14].

To this end, we conducted an experiment, where we assessed to which extent the process diagrams, modeled in predominant process

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modeling notations, are intuitive for participants without prior knowledge in respect to their complexity.

The article is organized in the following manner: the second section reviews the state-of-the-art issues from all parts of the investigation, which includes BPMo, intuitive understandability, process diagram complexity and the related work. The third section presents the details of the experimental research, while the fourth section provides the analysis of the results. Finally, the results are interpreted in the last section, where we also address the limitations and implications of the research in theory and practice.

2. Research background

In the following subsections we will introduce the process modeling notations, define intuitive understandability and address the diagram complexity. Also, we will overview the comparative studies in light of the aforementioned fields.

2.1. Process modeling notations

Existing process modeling languages come from different scientific traditions, e.g. IDEF family of languages, formal languages and business process management languages [15]. Each serves different purposes, e.g. describing or analyzing a process [16], and has been developed to support communication among project stakeholders. Process modeling languages include a precise syntax, semantics and a visual process modeling notation. The latter focuses only on visual aspects of process modeling language [17], which is also the focus of this paper.

As part of the process modeling languages, there are many different process modeling notations, such as Petri Nets, Workflow Process Description Language (WPDL), Unified Modeling Language 2.0 Activity Diagram (UML AD), Business Process Model and Notation (BPMN), Event Driven Process Chain (EPC) and Integrated DEFinition Method 3 (IDEF3) [16,18]. Among the aforementioned, business process analysts usually prefer modeling diagrams in notations, such as UML AD, EPC and BPMN [18], which are presented below.

UML has emerged as de facto standard for software industry's modeling language [19] and is also an ISO/IEC 19501:2005 standard [20]. UML is formally defined by the Object Management Group (hereinafter referred to as OMG) in 1997 and the first major revision UML 2.0 was approved by the OMG in June 2003. UML 2.0 introduces thirteen types of diagrams, which are divided into three categories [19]: (1) Structure Diagrams, (2) Behavior Diagrams and (3) Interaction Diagrams. More specifically, for the purpose of business process modeling, UML offers Activity Diagrams [10,21], which are part of Behavior Diagrams.

EPC was developed in 1992 at the Saarbrucken University in a joint research project with SAP AG. Due to its integration into the Architecture for Integrated Information Systems (ARIS) Toolset, EPC became widespread in practical use [11] and is supported by major vendors of enterprise resource planning solutions and business process reengineering tools [16]. As such, the notation has been established as the industry standard for modeling business processes [22]. The basic idea of EPC is that events trigger functions and executed functions trigger events, producing a chain of functions and events, hence the name "event driven process chain" [23].

BPMN was initially published in 2004 by the Business Process Modeling Initiative (BPMI). The primary goal of BPMN is to provide a notation, understandable by business users, from business analysts to the technical developers and business staff [5]. BPMN was partially inspired by the already mentioned UML AD [2]. A vast interest in the standard resulted in adoption by the OMG in 2006. The newest major version of BPMN is 2.0 and it extends the scope of BPMN 1.x in form of execution semantics, new graphical elements and defines new types of diagrams. As such, BPMN 2.0 enables users to model a different set of processes, i.e. conversations, choreographies and collaborations [5]. BPMN is also the de facto standard for business process modeling [2,24] and an ISO/IEC 19510:2013 standard [25].

2.2. Intuitive understandability

Intuition is defined as "the immediate apprehension of an object by the mind without the intervention of any reasoning process" [26]. Moreover, if something is intuitive, we can understand it immediately without prior knowledge or training [27], which is similarly defined in other domains as well [28,29]. This is also in accordance with BPMo, since it has been confirmed by existing studies that process diagrams are required to be intuitive and easy to understand [6,8]. Indeed, one of the main challenges of business process modeling languages is to model the business processes in a precise and user-friendly way, where each graphical symbol that describes the business process should be intuitive for users [8]. The intuitive graphical representations make the communication between participants in the business process easier and more effective, consequentially making the acceptance of the modeling technique wider in a non-academic environment [30].

On the other hand, understandability in the context of process diagrams is defined as the ease with which the diagram can be understood by users. It is measured by (1) the time, required by the subject to solve the tasks, (2) number of correct answers, related to understandability and (3) the ratio between the number of correct answers and the time [31].

Based on the aforementioned definitions, for the purpose of our research we defined "intuitive understandability" as the ease with which the diagram can be understood by users immediately without any prior knowledge or training.

2.3. Business process control-flow complexity

As already discussed, process modeling notations are used to depict a process in the form of a process diagram. Such diagrams serve as a base for communication between the stakeholders and other relevant participants of the process and should therefore be easy to understand [32]. Additionally, the complexity of process diagrams has a negative impact on their understandability [14,33].

In order to reduce the complexity of process diagrams, it is useful to measure it by using metrics, which tell us whether a process diagram is easy or difficult to understand [32]. To this end, many metrics have been proposed, which are mainly derived from software engineering (e.g. the number of Lines of Code was adapted in business process metrics as number of activities) [34]. On the other hand, existing studies have shown that gateway complexity highly influences the overall complexity of the diagram. Hence, Control-Flow Complexity (hereinafter referred to as CFC) has been proposed, which is independent of the language used to model business processes and has been validated [14,35]. This is important, since the majority (59%) of business process metrics are not validated [36].

The aim of CFC metric is to enable the complexity analysis of process diagrams with the focus on gateways (i.e. splits and joins). Therefore, the formula is calculated by counting the fan-outs of XOR-split, OR-split and AND-split gateways.

XOR-split CFC is determined by the number of n possible states that arise from splitting behavior of XOR. Therefore, XOR-split CFC adds n to the CFC metric of the diagram.

$$CFC_{XOR-split}(a) = fan{-}out(a)$$

OR-split CFC is calculated by considering that there are 2^{n-1} possibilities to execute at least one and the most n of outgoing flows. 2^{n-1} is therefore added to the CFC metric of the diagram.

$$CFC_{OR-split}(a) = 2^{fan-out(a)-1}$$