Control Flow versus Communication: Comparing Two Approaches to Process Modelling

Abstract

Purpose: Business process modeling integrates and visualizes relevant information essential for managing day-to-day business operations. It plays a critical role in the design and execution of business transformations. Recognising the role of process modelling, a large number of modelling languages, methods and techniques have been developed. Each offering diverse advantages and having inherent limitations. Traditional and popular process modelling approaches focus on the exact specification of the control flow of business processes whereas more recent approaches like Subject-oriented Business Process Management (S-BPM) are focused on the communication between process participants. This study provides comparative insights about these two approaches through their experimental application. We do so by comparing BPMN (Business Process Model and Notation); a control flow approach, with S-BPM; a communication approach, with a specific focus on their suitability for novice modellers.
Design/methodology/approach: This paper reports on an exploratory experiment which compares BPMN to S-BPM. Applying cognitive load theory, we compare the experiences and outcomes of novice process modellers, assessing perceived ease of use, model quality (syntactic and semantic) and modelling efficiency (time to model) across the two approaches.
Findings: Study results show that S-BPM (a communication approach), led to significantly better user performances for process modelling than BPMN (a control flow approach). We point to how a different modelling approach such as S-BPM could be either considered as an alternative or to complement the more popular control flow approach BPMN. This observation was especially relevant for modelling contexts where domain experts are novice process modellers.
Originality/value: This study provides first empirical evidence that communication approaches like S-BPM could outperform modelling approaches which are control-flow based (i.e. BPMN), especially when being used by novice process modelers who hold the domain and process knowledge. We use this as a springboard to present important considerations for practice and guide future process modelling research.
Article Classification: Research paper

Keywords: S-BPM, BPMN, control flow, communication, model quality, modelling efficiency, modelling effectiveness.

1 Introduction

Business process modelling is used to graphically represent how an organization conducts its operations; systematically defining and depicting activities, events (and their states), entities, enablers and relationships between them [1]. It alleviates organizational complexity by documenting existing processes and plays a critical role in many business transformation efforts. Business process modelling is not a new area; it has existed since the emergence of industrial engineering and basic flowcharting [1]. Companies today use process modelling extensively with far reaching effects [2]. By deconstructing organizational operations and creating transparency, process modelling has become an essential prerequisite to digitization, corporate restructures, strategy operationalization and critical decision making of day-to-day business operations. Growing reliance on process modelling has resulted in many larger organizations heavily investing in and benefitting from it; with hundreds of staff (in various roles) trained and involved in designing and maintaining sometimes thousands of process models [2].

Despite its benefits, process modelling has inherent challenges. It can be a time-consuming and resource-intensive effort [2, 3] with a heavy reliance on 'trained process modellers' to collate and synthesize *"fragmented process knowledge"* and get these validated through domain experts "*with no familiarity with process modelling languages*" [1, p. 162]. This has the effect that the domain knowledge gets filtered by process modellers (who are usually 'outsiders to the process', i.e. they lack domain-specific knowledge), which may introduce inconsistencies between the model and the real work-practices. The dominant dependency on an expert modeller limits proactive contributions of stakeholders and process participants in the model development [1]. In addition, the efficiency of this way of process modelling is rather low because workshops facilitating a dialogue between modellers and domain experts represent a bottleneck [4]. As most of the total effort of process modelling consists of the personnel costs of the modellers and end users involved [5] modelling time is a major cost driver.

Accurately modelling business processes in a formal notation seems to be challenging even for trained experts. In an experimental study conducted by Haisjackl, Soffer, Lim and Weber [6] many errors in business process models remained unnoticed by modellers who claimed to have moderate experience in process modelling. This fits with the results of a study of industrially-used process models (N = 172) in which 81% of the models were found to contain errors related to the control flow or the syntax of the notation used [7]. Given the apparent difficulties in applying the conventions and rules of formal process modelling notations, it is not surprising that many organisations still rely on ad-hoc ways of process modelling without any formal notation or proper BPM tool [8, 9].

These issues persist despite the advancements in current notations, such as BPMN 2.0 that aims to provide a set of domain concepts that can easily be understood and applied by business people [10]. Could it be that we are dealing with a more fundamental problem related to the paradigm that underpins our way of thinking about processes? At a Dagstuhl seminar held in 2016 on "Fresh Approaches to Business Process Modelling", gathering about 40 BPM researchers from around the globe, this was the central question being discussed – in particular, "whether the BPM community should create an entirely new paradigm for process modelling. One can think of more intuitive drawing conventions that laymen would use, and of models of an entirely different kind (i.e., not process-centric and not data- or case-centric) that still bear the possibility to support modern and future business processes" [9]. Among the approaches discussed during the seminar was Subject-oriented Business Process Management (S-BPM) [11]. Unlike most other approaches to process modelling, S-BPM focuses not on the control flow but on the communication between process participants that are represented as encapsulated behaviour specifications called "subjects". Proponents of S-BPM argue that based on the modularised process model structure and a significantly reduced set of modelling elements, domain experts are enabled to directly model their own work-practices without requiring extensive training in process modelling. Loosely coupled message connections between the modules allow concurrent modelling, potentially speeding up the overall modelling time. The value of this idea is beginning to be recognised in process modelling research [12].

A number of comparisons between process modelling notations have been published [13, 14], most of which dating back to the 2000s before BPMN became the dominant notation. They did not consider S-BPM or other communication-based approaches, which at the time were not well established and only poorly known in the wider BPM community. While a few experience-based reports highlight the benefits of using S-BPM for process modelling [15, 16], to date there are no comparative empirical studies of S-BPM. More generally, comparisons between control flow-based and communication based modelling approaches are rare. A notable exception is the study by Kock, Verville, Danesh-Pajou and DeLuca [17] who investigated the influence of communication flow orientation in process modelling (using data flow diagrams) on redesign success. It was found that this modelling approach was "significantly and positively related to the perceived ease of generation, ease of understanding, and accuracy of the model" [17, p. 573]. The lack of empirical studies makes it difficult to understand the comparative values of these two types of modelling approaches.Taking S-BPM as a representative communication based modelling approach and BPMN as the most popular control flow based modelling approach, we aim to address this gap by answering the following two research questions:

RQ1: *How does end users' modelling performance (modelling effectiveness and efficiency) differ between S-BPM and BPMN?*

RQ2: *How does the perceived ease of modelling for end users differ between S-BPM and BPMN?*

We apply cognitive load theory to formulate our hypotheses and implement a controlled experiment. This study aims to provide empirically supported deeper insights into the selection and deployment of process modelling approaches; in particular, to explore if emerging communication approaches could be more effective and efficient than control flow approaches that form the basis of current modelling standards. The results could open up a whole new spectrum of process modelling research opportunities.

The remainder of the paper commences with background literature, which provides a brief introduction to the two modelling approaches being compared: BPMN (2.1) and S-BPM (2.2). This is followed by the study design (3.0), study findings (4.0) and detailed discussions (5.0) which outline study implications, limitations, and an outlook for future work. The paper concludes (6.0) with a summary overview of the paper. Additional information is provided as Supplementary-Material and made available at https://tinyurl.com/383tzf97.

2 Background and Literature Review

Whilst there are many specific purposes of business process modelling, the overall goal is to describe the way in which work is done in organisations (Dumas book, ref. [1]). Different perspectives can be applied to reach this goal, including the control flow and the communication perspective.

Most commonly, business processes are viewed from a control flow perspective, i.e. a view of processes as sequences of activities. For example, Hammer and Champy [18] define processes as “a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer”. The control flow view has directly influenced the kinds of models that are most frequently used for describing business processes. Despite various differences between common process modelling notations such as flowcharts, UML Activity Diagrams, Event-driven Process Chains (EPC) and BPMN, they ultimately represent processes as flows of activities. BPMN does include constructs for representing the exchange of messages between process participants; however, its primary focus remains on the control flow [19].

The perspective investigated in this article is communication-based, in that processes are viewed as the interaction between individual actors by means of messages. Such an approach had not explicitly been formulated and formalized until the 1990s, when several approaches were published originating from research in distributed, multi-agent systems and philosophical theories of communication [20-22]. One of these approaches is Subject-oriented Business Process Management (S-BPM), which was proposed by Albert Fleischmann [21] who amalgamated theories of distributed systems [23-25] and social systems [26]. There has been an annual S-BPM conference (https://s-bpm-one.org/) since 2009, and several books on S-BPM have been published. The approach has already been deployed by organizations across a wide variety of industries [27-29]. Its grammar is consistent with the formal semantics of abstract state machines [30]. S-BPM has evolved over the years to include additional concepts such as exception handling that are needed for modern business process management. Specifications of S-BPM include the concepts described in the foundational book [11] and a semantic meta-model [31]. Thus, the subject-oriented approach can be best characterised as a conceptualization of process models – rather than only a modelling notation.

The remainder of this section describes the fundamental concepts of BPMN and S-BPM as examples of the control flow and the communication approach to process modelling. A particular focus is on S-BPM (as most readers are not familiar with it) and its distinguishing features with respect to control flow. Section 2 of the Supplemantary Material provides a comprehensive overview of key differences between S-BPM and BPMN.

2.1 BPMN

The Business Process Management Initiative introduced the Business Process Modelling Notation (BPMN) in 2004 in response to an increasing need for standardization in business process modelling [32]. Its primary goal is to deliver a standard language which is understandable by the business users and at the same time is robust enough to be automatically executed by IT systems [33]. BPMN is based on the revision of other languages, especially UML Activity Diagrams, RosettaNet, Activity-Decision Flow and EPC [34], with later revisions introducing more modelling elements and execution semantics.

BPMN is recognized by its high expressiveness, richness in semantics and ease of understanding [10]. Moreover, BPMN is supported by numerous academic and commercial process modelling products which is the reason why BPMN was quickly adopted by practitioners and established as the industry standard for process modelling [35]. Today, BPMN is used around the globe as the de-facto business process modelling standard. It is considered to be used for various applications beyond classical BPM to represent processes in building information modelling (BIM) [36], smart manufacturing [e.g. 37] and others. BPMN adopts a control flow approach to process modelling and is presented via different diagrams. Among the various diagram types (e.g. Collaboration Diagrams, Choreography Diagrams and Conversation Diagrams), Collaboration Diagrams representing the control flow of activities are dominant and are being used in this study. BPMN has two element sets: basic and extended. The extended set contains 50 elements and is mostly used for modelling complex processes. The basic set consists of 10 elements, grouped into four categories: Flow objects, connecting objects, swim lanes and artefacts. Flow objects and connecting objects are composed to create control flows. Swim lanes partition the control flow according to different organizational roles and departments. Artefacts display further information about a process such as data or comments [33]. Section 1 of the Supplementary-Material introduces the core elements of BPMN which have been used in this study. Figure 1 presents an example process model of a university application process (which is described in Appendix A) modelled using BPMN.

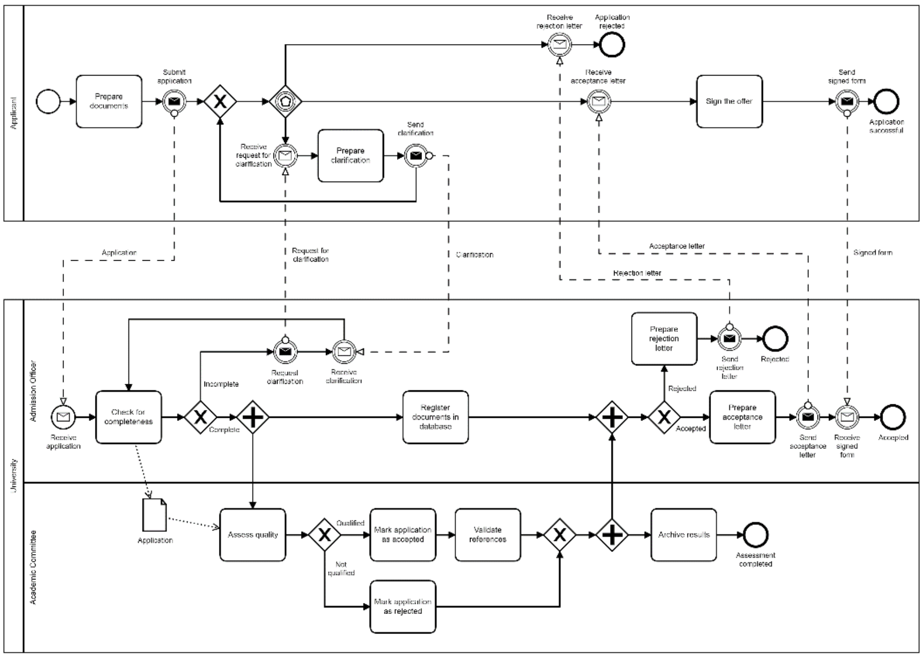

Figure 1: A university application process modelled in BPMN

BPMN Collaboration Diagrams are usually modelled using the typical workshop approach described in the Introduction, during which a group of stakeholders simultaneously work on a common process model. Individual parts of the diagram are difficult to be modelled without affecting other parts, because they are tightly interconnected by the global control flow [12]. Take the lane “Academic Committee” in Figure 1. There is no way for members of the “Academic Committee” to individually model their part in the end-to-end process, without having to involve other stakeholders of the overall process. For example, the AND Split in the “Academic Committee” lane makes sense only when viewed from a global perspective that also involves the “Admission Officer”. In addition, the “Applicant” needs to be involved to coordinate with the “Admission Officer” to which location in their own control flow the acceptance and rejection letters (and other messages) need to be sent. Therefore, the typical way of modelling afforded by a monolithic Collaboration Diagram is through a close coupled workshop [38], bringing together all stakeholders at the same time.

2.2 Subject-Oriented Process Modelling

The key concept in S-BPM is the notion of a ‘subject’. Subjects denote process-centred functionalities that are executed by human or computational actors (for example a ‘bot’ or a digital agent). They roughly correspond to the role concept used in other modelling approaches but are independent of particular organizational structures and therefore represent a higher abstraction layer [39]. The term “subject” is inspired by the subject-predicate-object structure of most natural languages: The subject represents the active entity, the predicate represents the action, and the (direct) object represents the passive entity on which the action is executed. S-BPM is called "subject-oriented" because it emphasizes the active entities rather than the actions that are the focus of control-flow based modelling approaches.

A process in S-BPM is conceptualized as the communication between two or more subjects. This is modelled using a *Subject Interaction Diagram* (SID), capturing only *subjects* and *messages* exchanged between them. An example is shown in Part A of Figure 2, showing the S-BPM version of the university application process (mentioned above and outlined in Appendix A). SIDs do not show any sequential or logical relationship between messages. They are conceptually similar to BPMN Choreography Diagrams.

For every subject in the SID, a separate Subject Behaviour Diagram (SBD) defines its internal behaviour by means of a state machine interlinking three types of states (see Part B of Figure 2). *Send* states represent the dispatch of messages to other subjects, *Receive* states represent the reception of messages from other subjects, and *Function* states represent tasks that do not involve other subjects. States are connected using transitions representing their sequencing. The behaviour of a subject may include multiple alternative paths. Branching in S-BPM is represented using multiple outgoing transitions of a state, each of which is labelled with a separate condition. Merging of alternative paths is represented using multiple incoming transitions of a state. Parallel paths are not allowed within an SBD. Parallelism in S-BPM is modelled by using a separate subject for every behaviour that is to be executed concurrently. Triggering and synchronizing concurrent behaviours is handled by the exchange of messages between the respective subjects.

For a subject-oriented process model to be complete and syntactically correct, all messages specified in the SID must be handled in the SBDs of the two subjects involved. The SBD of the sending subject needs to include a *Send* state specifying the message and recipient name (see Figure 2). Correspondingly, the SBD of the receiving subject needs to include a *Receive* state specifying the message and sender name. There is no explicit diagrammatic association of the messages shown in the SID with the corresponding *Send* and *Receive* states in the SBDs. At runtime, any incoming message is placed in the so-called input pool of the receiving subject, which can be thought of as a mailbox. When the execution of the subject has reached a *Receive* state that matches the name and sender of a message in the input pool, that message can be taken out of the input pool and behaviour execution can proceed as defined in the SBD.

The most apparent difference between S-BPM and other process modelling approaches is the reduced number of conceptual elements in S-BPM: only two elements in SIDs (Subject, Message) and three in SBDs (Function, Send and Receive states). This allows creating visual representations based on very few conventions that can be quickly agreed upon by process modellers, and, as a result, S-BPM's notation is less comprehensive than BPMN.

Another feature of S-BPM is that it separates and loosely couples different process perspectives. For example, the distinction between subjects and organizational roles separates behavioural and resource perspectives. The input pool concept separates behavioural and information perspectives, encapsulating internal behaviour from external communication. This is different from BPMN, where processes are contained in organizational pools and lanes, and message flow is tightly interconnected with the control flow. In addition, S-BPM does not include parallel routing within an SBD, as it represents concurrent behaviour by using separate subjects. In fact, the most common structural difficulties encountered by BPMN modellers are linked to constructs that do not exist in S-BPM: subprocesses, interlinkage of message and control flows, multi-merger, and split-join gateway combinations [40].

The decomposition of a process in separate subjects has the additional consequence that process modelling can be done in decentralized (or role-distributed) ways. This means that different parts of the process (i.e. subjects) can be assigned to different domain experts (or "subject owners") that can model their subjects' behaviours largely independently of other subject owners. This is because of the encapsulation of the internal behaviour, captured in SBDs, from the external behaviour (i.e. the messages sent and received) captured in the SID. While the external behaviour provides constraints for the internal behaviour, subject owners can freely model their SBDs that reflect their own, partial views of the process. Ideally, the subject owners are identical with the respective participants in the process. Process modelling in S-BPM typically involves alternating between phases of individual modelling (of SBDs) and cooperative alignment (of SIDs) during which subject owners agree on messages to be exchanged [41]. Based on the decoupled SBDs, individual modelling can occur asynchronously leading to concurrent subject behaviour modelling and thus accelerated creation of process models.

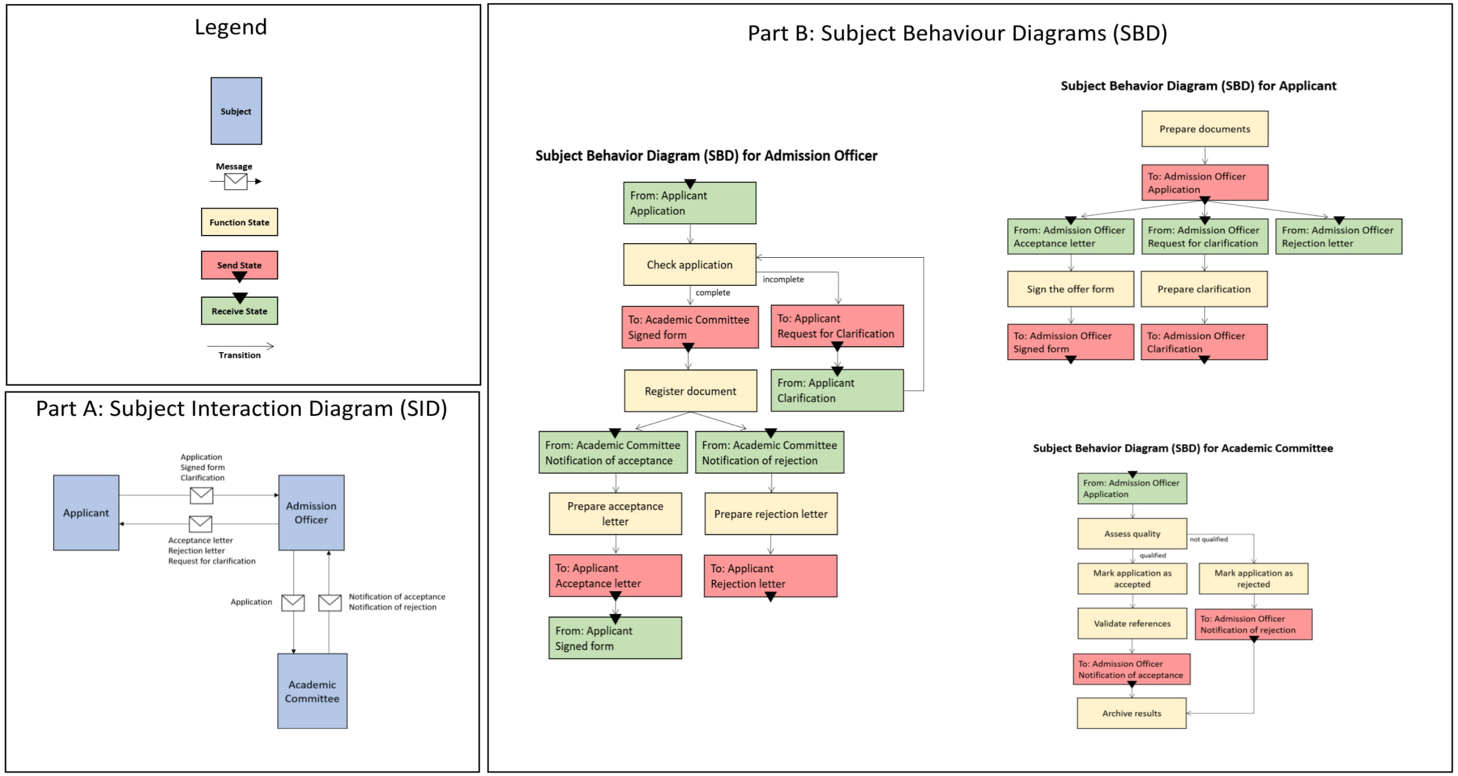

Figure 2: A university application process modelled in S-BPM

3 Research Design

We apply an experimental design to explore the differences between using S-BPM and BPMN for developing process models. Experiments is a commonly used methodology to compare and evaluate modelling approaches (e.g. Batra and Davis [42], Singer and Zinser [43]). Several studies have offered guidelines or frameworks to help researchers who wish to empirically compare modelling languages [e.g. 44, 45, 46]. After reviewing these frameworks, Gemino and Wand [44] framework is selected as the guiding analysis framework for the design, operationalisation and reporting of the study findingsThis framework offers a practical decomposition for designing empirical comparisons of the modelling languages and has been adapted by other conceptual model evaluation studies.

Next, the research model is presented (3.1), introducing the main constructs and their relationships. Then the research hypotheses are presented together with theoretical justification (3.2), followed by the details of the experiment design (3.3).

3.1 Research Model

Based on our review of relevant work and guided by Gemino and Wand [44] framework for comparing modelling approaches, we derive a conceptual research model (as presented in Figure 3) to address the set research questions.

The two modelling approaches; S-BPM and BPMN are treated as the ***independent variables*** in our study. The ***dependent variables*** consist of both performance-based and perception-based measurements. The performance-based measures relate to RQ1 and are twofold. The modelling techniques' effect on the outcome – the model (*modelling effectiveness*) is operationalized by the syntactical and semantical quality of the created model. The modelling language's effect on the process of modelling (*modelling efficiency*) is operationalized by the time it takes to create the model. RQ2 is based on a perception-based measurement, where we capture the modeller's *perceived ease of use* of these two modelling techniques.

Modelling effectiveness is defined as '*the degree to which the modelling technique supports achieving the modelling tasks and is reflected in the correctness (quality) of the resulted model'* [adapted from 45, 47]. This means the quality of the outputs correspond to specified criteria resulting in high accuracy and low error rates. Modelling effectiveness is evaluated on Lindland, Sindre and Sølvberg [48] syntactic and semantic quality dimensions. Lindland, Sindre and Sølvberg [48] framework has been empirically examined and used for evaluating the comparative effectiveness of different modelling languages [e.g. 49, 50].

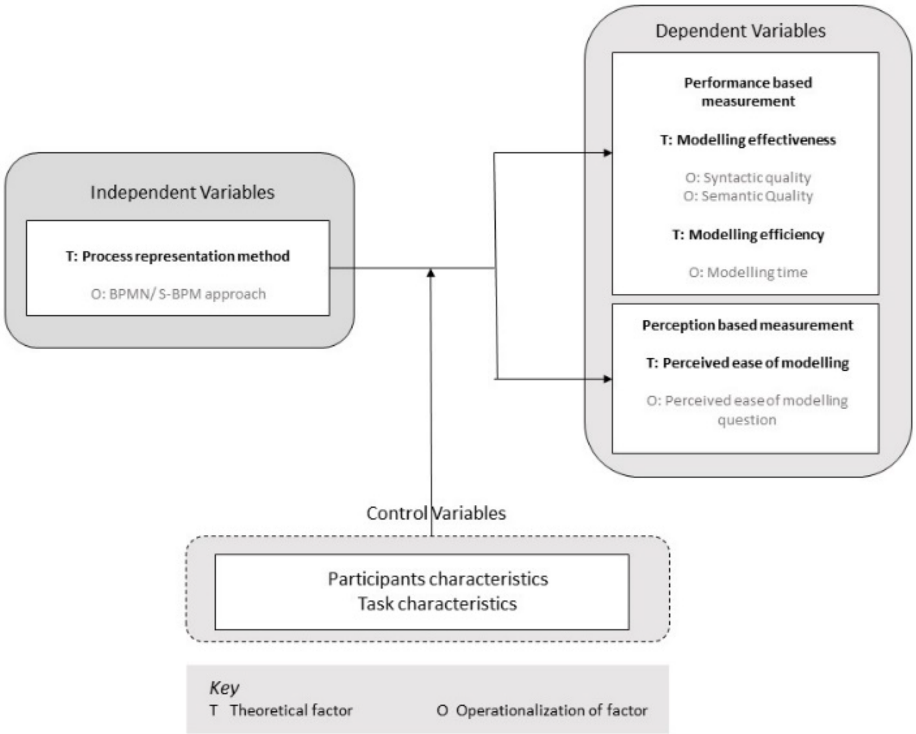

Figure 3. Research model

Syntactic quality (correctness) indicates the extent to which a model complies with the syntax rules of the modelling language. For the non-textual part of the model it refers to the correct use of modelling techniques and rules of how to combine and use the notations. For the textual part of the model it refers to checking whether the model is in accordance to the naming conventions and structure that has been defined in the language rules.

Semantic quality (correctness) defines the degree to which the model delivers a complete and valid depiction of the domain [48]. Completeness means that the model includes all relevant statements on a process that are correct. Validity means that all statements included in the model are correct and relevant to the problem.

Modelling efficiency defines the amount of effort expended for the design of the model. Quantifying the modelling efficiency is based on the time taken to complete the modelling tasks [51]. The modelling time is measured objectively in minutes, where we recorded the starting and finishing times of every team.

Perceived-ease-of-modelling is another dependent variable that is used in this study to compare the ease of modelling of S-BPM and BPMN. Adopting Davis [52] definition of perceived ease of use, we define perceived-ease-of-modelling as *"the degree to which an individual believes that modelling with a certain modelling language would be easy and free of mental effort"*.

Following practices from prior studies [e.g. 44, 53] ***control variables*** are considered and included. In this study, level of *task characteristic* (the complexity of the case scenario to be modelled) and the *characteristics of the modeller* (participants) in terms of individual difference, modelling experience and domain knowledge are treated as control variables.

3.2 Research Hypotheses and Supporting Theoretical Lenses

As evident from the introductions of BPMN (Section 2.1) and S-BPM (Section 2.2), the two are very different modelling approaches affording different processes of process modelling (Section 2 of the Supplementary-Material provides a further a summary overview of the key differences between S-BPM and BPMN).

We apply cognitive load theory to formulate our hypotheses targeted at addressing our two research questions. Cognitive theories offer a theoretical basis for the explanation of observed differences in modelling effectiveness and efficiency of different modelling languages, and have been applied in previous studies conducted to comprehend why modelling languages might perform in different ways [54-57].

Cognitive load theory refers to the way cognitive resources are used and focused during problem solving and learning activities [58]. The limited capacity of human working memory constitutes a bottleneck for the cognitive activities involved in the task of process modelling. The cognitive load theory points out that when working memory is overloaded, there is no space for learning (i.e., diagram creating) and accuracy and speed of information processing decreases [59, 60]. In other words, cognitive overload has a negative impact on the effectiveness and efficiency of the modelling performance. Cognitive load is determined by the number of elements needed to pay attention to, at a point in time. Short-term memory has a natural limited capacity which is around approximately 7 +/- 2 elements when constructing a model [61]. If more than seven different aspects of reality need attention to create models, then some of these items should be kept in long-term memory. This might be an indication of both greater potential for errors, as well as greater effort to produce the models. This increases possibilities of errors and demands more effort to produce the model and in consequence negatively influence the modelling effectiveness and efficiency.

It is expected that the complexity of a modelling language (i.e. number of notational elements and associated syntax rules) influences the model development process, as it affects the cognitive overload of the process modeller. Based on the significantly lower number of elements in S-BPM [62] we argue that the BPMN model used in this study has higher apparent modelling complexity in the number and semantics of different constructs in the model (which positively affects cognitive overload [57]) than the one in S-BPM[1].

Based on the design and application principles underlying S-BPM (as introduced in 2.2), one can argue that the simplicity of S-BPM language and its modelling methods

[1] Table Supp **Error! Main Document Only.**, presented in Section 2.1 of the Supplementary-Material, summarizes the differences between the apparent complexities of S-BPM and BPMN model which have been used in this study.

positively impact modellers' ability to create a process model compared to other modelling approaches which are more comprehensive. Following the conceptual framework presented above and considering the differences between the two approaches, four study hypotheses are derived. H1, H2a and H2b pertain to RQ1, while H3 relates to RQ 2. We rationalize our hypotheses by emphasizing the differences and then considering cognitive research in order to predict the effect of a language's expressiveness (the differences between the methods) on the effectiveness of its use by individuals (i.e., understanding the model presented to the participants). The rationale for our hypotheses are presented below.

H1: Participants create models with S-BPM faster than with BPMN

Given the simplicity of S-BPM, it is expected that S-BPM modelling is performed faster than with BPMN. Furthermore, S-BPM modelling is performed in two stages which result in two diagrams (SID and SBD). The SID diagram is created collaboratively and need participants to negotiate to define the message that they exchange. Modelling SBDs is performed individually, without interfering with other participants (thus, no idle time). In contrast, BPMN modelling tightly interconnects the negotiation of interactions (in terms of messages across pools or sequence flows between lanes) between participants and their individual behaviour specifications. This approach brings latency to finishing the overall process, since while participants model their own internal behaviour they may get distracted by fellow modellers when there is a need for negotiation. Thus, it can be expected that modelling takes less time when modelling in S-BPM.

H2.a: Participants create S-BPM models with higher syntactical quality than BPMN models

H2.b: Participants create S-BPM models with higher semantic quality than BPMN models

We formulate H2.a and H2.b based on the fact that S-BPM has fewer modelling elements and less complex rules for modelling. From a cognitive load perspective, when a model requires a larger number of simultaneous elements to be constructed, the model's quality can be affected (compared to a modelling approach that needs fewer elements) [50]. In other words, the more symbols there are to remember, the greater the cognitive load and therefore likelihood of errors. Therefore, it can be expected that the accuracy of the models produced using S-BPM is higher than the ones produced in BPMN.

H3: Participants perceive modelling with S-BPM to be easier than modelling with BPMN

S-BPM has fewer constructs and simpler rules than BPMN (cf. Section 2.2), which is expected to reduce the cognitive load and makes it easier to model than with BPMN. Since it is assumed that participants experience higher cognitive load when modelling with BPMN in comparison to S-BPM, it is predicted that they perceive modelling with BPMN to be more difficult than modelling with S-BPM.

3.3 Experiment Design

We report on the experiment design following Jedlitschka, Ciolkowski and Pfahl [63] detailed guidelines on reporting an experimental study, detailing the (i) design and measures, (ii) participants, (iii) procedures, and (iv) materials.

Design and Measures. We use a two-group design with one between-group factor: the modelling language. The between-group factor has two levels: S-BPM and BPMN. We examine three outcome measurements: (i) model quality (semantic and syntactical quality), (ii) modelling efficiency and (iii) perceived ease of modelling. And also have control variables. Each are carefully operationalised as outlined below.

Model quality (semantic and syntactic quality): In order to evaluate the quality of the developed models, the models are reviewed and evaluated based on different error types and their severity defined. We follow Lindland, Sindre and Sølvberg [48] framework (applied and extended in [in 64]). A list of errors associated with syntactic and semantic correctness based on the notations and syntax rules of each language are developed, tested and further enhanced with further expert input). See Supplementary-Material Section 3.1 for the related formula and Section 3.2 for the related marking schemes used.

For evaluating the syntax quality, violation and the degree of complexity of the model is checked. The degree of complexity is evaluated based on the total number of elements in the model created by the modellers. By dividing the total number of major and minor syntax errors found in applying the grammar by the total number of elements in the constructed model the degree of violation is determined. Evaluation of semantic quality is based on the validity and completeness of the model created by the modeller. This is calculated by the number of major and minor semantic errors found in the constructed model divided to the “correct” model (reference model) developed by the experimenter.

Syntactic and semantic quality of each model prepared by the subjects are assessed by two graders independently. One grader is the experimenter and the other one is a faculty member experienced in process modelling. The degree of correctness is based on the set grading scales described above and applying the penalty identification schemes mentioned above. The average of the given scores from both reviewers is counted as the final result of the syntax and semantic quality.

Modelling efficiency: The modelling time is measured objectively in minutes by the experimenter who recorded the starting and finishing times of every team.

Perceived ease of modelling: The perceived ease of modelling (PEOM) construct is measured subjectively by using a three items Likert scale (see Section 3.3 of the Supplementary-Material). This scale is adopted from Recker and Rosemann [65] who adopted it from Davis [52] work, and it has been used in previous modelling studies [66, 67]. The PEOM is measured individually for all the participants in each modelling group.

Control Variables: Task characteristics are controlled by utilizing the same modelling case for the two languages. *Participant characteristics* are controlled by a number of aspects namely; experience and familiarity with process modelling, pre-existing knowledge and potential communication barriers.

Recognizing that *experience and familiarity with process modelling* may affect modelling studies [68], this study targets inexperienced modellers. Thus, participants are screened for their previous modelling knowledge before the experiment and only the ones who have expressed that they have not been trained or exposed to process modelling are selected to participate in the study. Also, even though participants are provided with a correct description of the process been modelled and hence don't have to rely on *pre-existing knowledge*, it is reasonable to argue that comprehensive pre-existing domain knowledge would facilitate modelling. Hence, the participant's domain knowledge is captured using a self-assessment, measured by a single item seven-point Likert scale (following Burton-Jones and Meso [69]). Furthermore, as Recker and Dreiling [70] observed, English as a Second Language (ESL) affects model understanding and interpretation - as the process of model creation contains understanding and validating the model as well. Thus, participants are also asked whether English is their first language or not. See Section 3.4 of Supplementary-Material for details on how these screenings are operationalised.

Participants. Following prior work and recommendations of Batra and Davis [42] and Gemino and Wand [44], students (not practitioners) are used in this study. One reason for this was to minimise the influence of any prior modelling experiences; as.the results may have been confounded if participants had prior experience in business process modelling (and BPMN in particular) [71]. The focus of this study is on the novice modellers (and domain experts), so university students can be a good representative of the target domain which includes process participants and domain experts without process modelling knowledge. This experiment is conducted at the principal author's university. In total, 30 students took part and were divided into 10 teams, where each consisted of three members participating in the final study. A two-group design with one between-group factor (modelling language) was decided upon. While we acknowledge that being able to compare how the same group modelled a single process using the two different approaches would have been insightful, this was not practically feasible. For if the experiment was set for each participant to model in both approaches, then the participants would have naturally derived the second model easier (given their familiarity with the modelled process and team etc.) thus, interfering with the study intensions. Every participant was given a questionnaire to capture their demographics and prior domain knowledge. See Section 3.4 of Supplementary-Material to view the demographic questionnaire used (3.4.1) and for a descriptive overview of the participants' characteristics (3.4.2).

Procedures. Several sessions were set up in which students in their allocated groups (in S-BPM or in BPMN) were invited to participate in the modelling task.

In the S-BPM group, participants firstly model the SID. Participants, assuming the allocated subject's 'role', model their part individually as separate SBDs. In the final stage, the roles/participants validate their model by making sure that all the received and sent messages in the behaviour diagrams match with the ones they defined in the SID diagram (see Figure Supp 4 within Section 3.5 of the Supplementary-Material for an illustration of an S-BPM modelling session).

In the BPMN group, participants firstly read the description of their role in the model and identify who should be presented as a 'lane' and who should be presented as 'pool'. Although each role has access only to the description of his/her role in the process, they are encouraged to negotiate and discuss with each other during the modelling process to synchronize in-going and out-going message flows and sequence flows between lanes and pools, and integrate different viewpoints into one model (see Figure Supp 5 under Section 3.5 of the Supplementary-Material for an illustration of a BPMN modelling session).

The experimenter records the starting and finishing times for every session. The finishing time is considered as soon as the team members agree on validation of the model and announce that they have finished modelling. After completing the modelling exercise, the respondents are asked to respond to a questionnaire about their perceived ease of modelling (see Section 3.3 of Supplementary-Material).

In total, the experiment took approximately 60 minutes for both groups. After finishing each modelling session, a photo of the created model was taken, to be further evaluated and graded by the reviewer (for syntax and semantic quality).

Materials. There is no common software tool supporting both S-BPM and BPMN modelling. To mitigate potential bias causes by using different tools with different tool complexities, we use modelling cards to make sure that complexity of modelling environment is equal for both groups. Also, given that participants have different educational background and hence different levels of familiarity with software tools, we eliminated tool related barriers by not introducing a tangible modelling tool. For BPMN modelling notations we created BPMN toolkit cards, following those that had been developed and tested by Luebbe [72]. The processes are modelled on a table using the cards and dry erase markers. S-BPM cards for representing S-BPM elements are developed by considering a comparable use of colours and size (see Figure Supp 6 under Section 3.5 of Supplementary-Material).

4 Results

4.1 Results of evaluating the control variables

Overall 10 teams of three participants (a total of 30 participants) joined the experiment. Participants are randomly assigned to one of the two modelling groups. Five teams participate in the BPMN modelling group and five teams participate in the S-BPM modelling group. The average age of participants is 28.26 (SD 3.53), with a gender distribution of 13 males and 17 females. The level of domain knowledge is moderate with an average response of 4.2 on a seven-point Likert scale (SD 1.4). The majority of participants - 77% are postgraduate and 23% are undergraduate. Lastly, only 10.3% are native English speakers. A t-test is performed to identify systematic differences between the modelling groups at the individual level. The results depict that the two datasets are similar across the control variables, confirming that the participants' demographics had no effect on the results.

4.2 Modelling time

Modelling time (efficiency) for each modelling team is captured in minutes, so in total there are 5 modelling time values for BPMN and 5 modelling time values for S-BPM (see Figure 4). Modelling time is captured for each team in each group separately.

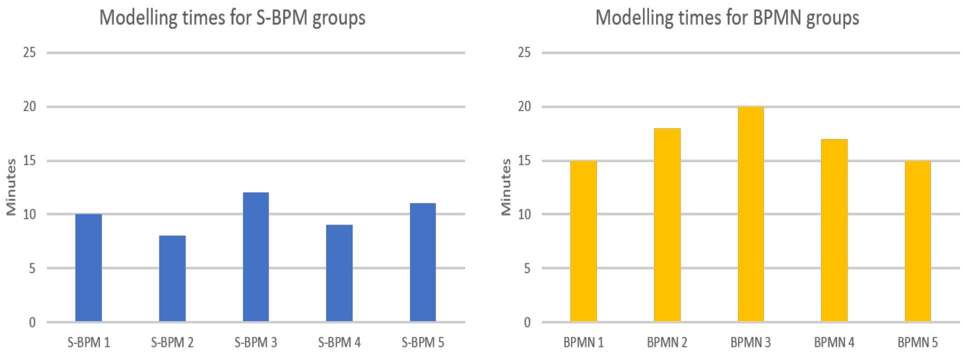

Figure 4: Modelling times for S-BPM and BPMN groups

The results as presented in Exhibit 1, denotes a statistically significant difference in the mean modelling times for S-BPM (10 min) and BPMN (17 min). This corresponds to a 40% reduction in modelling effort when using S-BPM instead of BPMN. A 95% confidence interval for the difference of means is shown in Part a of Exhibit 1. This interval involves positive numbers, which implies that the mean of the first group (BPMN) is greater than the second group (S-BPM). Therefore, it can be concluded that S-BPM users complete a modelling task faster than BPMN users. This confirms Hypothesis H1 that states that participants would create models with S-BPM faster than with BPMN.

Part a. Descriptive statistics for modelling time

Group	N	Means [min]	Std. Deviation	Minimum	Maximum	Range	Variance
BPMN	5	17	2.12132	15	20	5	4.5
S-BPM	5	10	1.58114	8	12	4	2.5

Part b. T-test for differences in modelling time

Levene's test for equality of variances		T-test for equality of means						
							95% Confidence Interval	
F	Sig.	t	df	p (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
0.4	0.545	5.916	8	0.000	7	1.18322	4.2715	9.7285

Exhibit 1: Analysis results pertaining to modelling efficiency (modelling time)

4.3 Syntactic Quality

The results of assessing syntactic correctness of the process models are presented in Exhibit 2. Based on the t-test, there is a significant difference in the syntactic correctness of the S-BPM and BPMN models produced. In order to get more insights about the type of the errors in both modelling groups, a categorization of the errors is performed. In the BPMN group, most of the syntax and semantic errors are related to 'deadlocks[2]' and the use of wrong gateways[3], while in S-BPM it is the error of incorrect sequencing and wrong notations. These results confirm Hypothesis 2a that states that participants would create S-BPM models with higher syntactic correctness than BPMN models.

[2] A deadlock is a combination of mismatching splits and joins that prevents the process from (logically) progressing.

[3] Symbols for splits and joins.

Part a. Descriptive statistics for syntactic correctness

Group	N	Means	Std. Deviation	Minimum	Maximum	Range	Variance
BPMN	5	89.4049	3.41882	86.25	93.33	7.08	11.688
S-BPM	5	95.6838	1.05431	94.19	96.93	2.74	1.112

Part b. T-test for differences in syntactic correctness

Levene's test for equality of variances		T-test for equality of means						
							95% Confidence Interval	
F	Sig.	t	df	p (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
12.907	0.007	-3.924	8	0.004	-6.27891	1.6	-9.96851	-2.58932

Exhibit 2: Analysis results pertaining to syntactic correctness

4.4 Semantic Quality

Based on the results of assessing semantic correctness (see Exhibit 3), the difference in the semantic correctness of S-BPM and BPMN models is statistically significant. Models that are created with S-BPM are semantically more correct than those in BPMN. This confirms Hypothesis H2b that states that participants would create S-BPM models with higher semantic correctness than BPMN models.

The assignment of the role in both groups (i.e. identifying subjects, pools and lanes) are the minimum error types in both groups, which indicates that in both languages the identification and mapping the concept of roles (the "who") to the modelling notations is clear.

Part a. Descriptive statistics for semantic correctness

Group	N	Means	Std. Deviation	Minimum	Maximum	Range	Variance
BPMN	5	81.5102	5.04994	74.08	87.55	13.47	25.502
S-BPM	5	87.4286	3.94341	82.46	91.59	9.13	15.551

Part b. T-test for differences in semantic correctness

Levene's test for equality of variances		T-test for equality of means						
							95% Confidence Interval	
F	Sig.	t	df	p (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
(No equal variances assumed)		-2.065	7.556	0.003	-5.91837	2.86539	-12.5942	0.75744

Exhibit 3: Analysis results pertaining to semantic correctness

4.5 Perceived Ease of Modelling

Perceived ease of modelling is tested for every individual participant. The results, as depicted in Part a of Exhibit 4, indicate that the average mean of perceived ease of modelling of S-BPM is less than that for BPMN. To examine whether the difference between perceived ease of modelling of S-BPM and BPMN is indeed statistically significant, a 2-tailed t-test is conducted. With p = 0.055 (see Part b of Exhibit 4), it is concluded that there is no significant evidence of a difference between the means of perceived ease of modelling for S-BPM and BPMN.

Part a. Descriptive statistics for perceived ease of modelling

Group	N	Means	Std. Deviation	Std. Error Mean
BPMN	15	5.0889	1.34794	0.34804
S-BPM	15	5.8667	0.58824	0.15188

Part b. T-test for differences in perceived ease of modelling

Levene's test for equality of variances		T-test for equality of means						
							95% Confidence Interval	
F	Sig.	t	df	p (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
6.584	0.016	-2.084	19.146	0.055	-0.77778	0.37973	-1.57216	0.1660

Exhibit 4: Analysis results pertaining to perceived ease of modelling

5 Discussion

Based on the results of testing Hypothesis 1 it can be concluded that modelling efficiency in S-BPM (in the context of this study, an example communication based modelling approach) is higher than in BPMN (an example of control flow based modelling approach). BPMN models (even using only the basic set of modelling concepts) have more elements than S-BPM models, so to model a complete process model, participants need more time to select the correct element from a larger set of model elements available. Furthermore, the tightly coupled behavioral and communication perspectives in BPMN (through interleaved control and data flow) require the participants to simultaneously attend to the common process diagram. Participants are therefore less able to focus on modelling their own behavior independently of the others. This has the effect that efficiency gains enabled by concurrent modelling cannot be exploited, leading to overall extended modelling time. Furthermore, the integration of sequence flow and gateways between the two lanes can be challenging to some (especially novices) in BPMN and requires negotiation and clarification between the participants involved. This could also explain the increased modelling time observed for novice BPMN modellers.

With regards to Hypotheses 2a and 2b, it can be concluded that S-BPM has higher modelling effectiveness - with more syntactic and semantic correctness of models created in S-BPM than BPMN for novice modellers. Also, it can be argued that the higher apparent complexity and more complex modelling rules of BPMN, in comparison to S-BPM might have affected the learning and performance of the BPMN modeller and lead to decrease the accuracy of their produced model. These findings are congruent with previous studies, which found that longer modelling times are an indication of lower model quality [73].

Hypothesis 3 states that participants would perceive modelling with S-BPM to be easier than modelling with BPMN. But on the contrary to expectations, the statistical analysis did not provide support for this hypothesis, as the difference between these two groups are not significant. There may be several feasible explanations to support this result, which are presented below.

Overall, as indicated in the descriptive analysis for Hypothesis 3 in Section 4.5, the participants in the S-BPM group report a higher level of perception for ease of modelling than the group modelling with BPMN. Also, as depicted in Table 1 below, further analysis of each item in the ease of modelling indicates that for all of the three items, the mean value is higher for the S-BPM group.

				95% Confidence Interval	
Dependent Variable	**Group**	**Mean**	**Std. Error**	**Lower Bound**	**Upper Bound**
Ease of Learning	BPMN	5.067	.355	4.339	5.794
	S-BPM	**6.000**	.355	5.273	6.727
Ease of Creating	BPMN	5.133	.232	4.657	5.609
	S-BPM	**5.733**	.232	5.257	6.209
Ease of Modelling in the Intended Way	BPMN	5.067	.319	4.414	5.720
	S-BPM	**5.867**	.319	5.214	6.520

Table 1: An analysis of the Ease of Modelling items

Based on the amount of the resulting significance ($p = 0.055$) and the above observation, it can be argued that the small sample size could explain for missing significance and a larger sample set might have made the difference more obvious.

Also, perceived ease of use relates to the required mental effort required to create process models by using a process modelling language and the effort required to remember and perform the task. It is expected that the higher complexity of the BPMN notation and rules in comparison to S-BPM would lead to a higher cognitive overload and higher effort for the novice participants to perform the modelling task. It can also be assumed that the more interactive engagement inherent in the BPMN approach (with discussion and collaboration of modellers in creating and evaluating the model when modelling across multiple swim lanes and pools), have reduced the negative impact of complexity of BPMN as both groups had almost similar perception levels about the ease of modelling with the two languages.

The participants' background could have been another factor that contributes to them not perceiving modelling with BPMN to be difficult (compared to S-BPM). Study participants are from the first year Bachelor of IT course and undergraduate and postgraduate students in the Business and Engineering Schools. The majority of participants (77%) are postgraduate and 23% are undergraduate. It can be argued that the participants had higher than average capabilities to deconstruct a process and depict it in a model using complex notations given their related trainings (i.e. with other forms of deconstructions and conceptualizations), thus they found BPMN to be not that difficult.

5.1 Study Limitations

Our findings and implications are bounded by several limitations. Participants of our experiment are students. This can limit the external validity of our results. At best, the participants are comparable to novice business analysts. However, the results may not generalize to highly experienced practitioners. The heterogeneity observed within the small sample size of experiment participants may have study implications (i.e. group-level influences) compared to a larger and more homogenous group of participants. Furthermore, our findings may be limited based on the selection of process cases that are modelled. The process used for modelling (see Appendix A) can be regarded as rather simple when compared to the industry-sized processes been modelled. The group factors and characteristics of the modellers and their interaction might have influenced the result as well. Finally, a larger sample size could certainly have presented more robust results. On the other hand, it is well known in statistics [74, p. 256] that large *t*-values – such as those found in this study – compensate for small sample sizes when it comes to minimizing Type 1 errors (false positives; i.e. finding differences significant when they are not). Therefore, the results are sufficiently reliable in their support for the hypotheses. Increasing the sample size would have been too costly for the scope of this research and statistically unnecessary.

5.2 Implications to Practice

S-BPM has shown to enable novices to produce more correct process models (confirmed by Hypotheses 2a and 2b) with lower effort (confirmed by Hypothesis 1). In particular, the 40% reduction of modelling time found for the small process example in the experiments may lead to huge cost savings for large processes in industry. Communication approaches like S-BPM may provide a tool for domain experts to formally articulate their work procedures even when they have not been trained in a particular modelling notation. According to Dumas, La Rosa, Mendling and Reijers [1] "[domain experts have detailed knowledge of the operation of the considered business process. They have a clear understanding of what happens within the boundaries of the process, which participants are involved, which input is required, and which output is generated." This closely matches the constituents of SBDs, i.e. what is done operationally ('function' states), what is needed from others ('receive' states) and what is provided to others ('send' states). It needs to be emphasized that S-BPM is not necessarily in opposition to BPMN: process analysts may use the set of SBDs produced by domain experts to transform them into BPMN models for the purposes of further analysis and design. Transformation rules between S-BPM and BPMN have been defined by Krenn and Stary [75]. This can also address one of the major challenges identified for process discovery [1]: the communication between domain experts and process analysts. Currently, this communication is usually established based on process descriptions in natural language, as many domain experts have difficulties understanding complex control flows [1]. Compared to natural language, communication-based process modelling provides a more precise, unambiguous way of modelling processes, without imposing the need to understand control flows. Therefore, S-BPM can serve as a bridge between tacit process knowledge and explicit workflows (modelled, for example, in BPMN).

This approach can also support activities traditionally viewed as part of the downstream phases of the BPM lifecycle. This is because S-BPM models generally exhibit high syntactic quality (confirmed by Hypothesis 2a) allowing their instant interpretation by an S-BPM execution engine [76]. Domain experts can then execute their process immediately after producing a model of it. Experiencing the effects of process execution in this way facilitates the detection of semantic errors in the modelled work procedures. Similar to the idea of rapid prototyping, domain experts can swiftly alternate between phases of process modelling, validation and improvement. This means that process analysts can be provided with pre-validated and pre-optimized (minimum viable) process models from the domain experts, leading to more effective overall process models produced in fewer iterations.

Finally, the process of process modelling, as it is done in practice, may benefit from a communication approach. This includes not only the direct involvement of domain experts in the creation of process models, but also the basic structure of the modelling process. The alternating phases of individual modelling and cooperative alignment [41] can accelerate the modelling process in two ways. Firstly, those modelling activities that can be done individually by different domain experts may be performed in parallel. Secondly, the models (SBDs) produced by different experts can be aligned with minimal effort, involving only the two parties involved in a message exchange according to the SID – not the complete team of domain experts. In addition, the experts can concentrate on aligning only the messages exchanged and do not need to understand each other's internal behavior models. Such a more lightweight process of process modelling may be supported, to some extent, by the BPMN notation [77] as well.

The insights gained through this study can help organisations take a more informed choice between control flow and communication based approaches for their process modelling projects. The pros and cons of each option can be derived from our empirical results, especially in the case of the emerging approach of S-BPM. This study demonstrated that S-BPM enables domain experts with no or minimal modelling training to model business processes with high accuracy and speed resulting in less cost and time than trying to use BPMN. Thus, we infer that when process models are created for the simple purposes of process transparency, then communication based approaches like S-BPM may very well be more suitable than the currently dominant (i.e. BPMN) control flow based approaches that require more effort and resources (i.e. for training and information elicitation). On the other hand, BPMN may suit better when the process models are to be used for more integrated modelling (e.g. basic process models converted to workflows), and choosing from the numerous tools supporting the standard becomes important. BPMN may be more complex, but it does allow one to model in a more expressive way integrating various contextual details about a process. Some may argue against the simplicity that modelling approaches such as S-BPM offer, for while simplicity may be useful initially, organisations may want to engage in more comprehensive forms of modelling as they mature with their process modelling practices, in which case BPMN may seem like a better option to start with from the outset. Using the full set of BPMN symbols, providing detailed information about various process aspects, can have advantages for the thorough analysis and optimization of the process, which may offset the higher modelling effort. It is important to note that these capabilities remained outside the scope of the study presented here which only used the basic set of BPMN modelling elements and was limited to the modelling phase. Some proponents of S-BPM [see 75] emphasize the simplicity and benefits of its ability to directly derive process models by domain experts and suggest that organizations start with less complex S-BPM models and later convert them to BPMN (modelling standards) as the need arises.

Overall, the study findings demonstrate the value for organisations in considering communication approaches like S-BPM, either as an alternative or as complementary to BPMN. In particular, the results are of interest for business analysts, process consultants, BPM project managers, tool vendors and modelling-related investment decision-makers. The discussions above presented how process analysts can better/differently engage with domain experts to elicit and document tacit knowledge more efficiently. The suggested alterations to the process-of-process-modelling will benefit process consultants in their service design and delivery approaches, and BPM project managers in their program designs. Insights into the benefit of applying different modelling approaches are insightful for tool vendors for modelling tool design and promotions. Decision-makers can use these insights to evaluate and approve fit-for-purpose modelling projects which may use diverse modelling approaches for different purposes and stages.

5.3 Implications for Research

This study's results demonstrated notable benefits of using a communication approach to process modelling, in alignment with recent academic interest in alternative approaches to process modelling that are more agile and stakeholder-oriented [9, 78]. We see this as a sound basis to propose future research.

The usefulness of any modelling notation depends on the particular purpose and context of use. Thus, we call for future research that presents typologies of modelling contexts and modelling purposes. Future research can then compare and map these with what different modelling approaches offer, to help modelling practice to select and deploy diverse modelling approaches to best suit specific modelling goals and contexts. More specifically, future research can expand this study's scope and design to also include evaluations such as; which modelling approach helps with diagnosing and implementing process improvement opportunities, and is better at assisting with organisational agitlity and transformation

In Section 5.2, we proposed the use of a communication approach to support process discovery by enhancing the involvement of domain experts in elicitation and modelling. This has the potential to address one of the challenges of modern BPM that has to deal with more complex processes in a hyper-connected world [78]: by speeding up the design and implementation of process models. One of the questions to be answered by academic research is whether this has more fundamental implications for our way of thinking about process modelling. For example, what is the value added of producing highly expressive process models in a sophisticated notation such as BPMN? Could it be traded off against the benefits of simpler representations such as S-BPM? In the conflict between the need for expressiveness and the need for efficient modelling [78], recent literature on S-BPM argues in favour of the latter. For example, Kannengiesser [62] proposes that for a tighter integration of life-cycle phases the focus of process modelling needs to be on simplicity and executability rather than expressiveness.

The outcomes and interpretations pertaining to Hypothesis 3 showed an unresolved discrepancy between objective and subjective measures related to modelling in S-BPM. Although, objectively, S-BPM modellers performed better than BPMN modellers, this is not reflected in their subjective judgments. Future studies are called to investigate this further and shed more light on the actual nature, difficulties and perceptions of process modelling in general. This paper's empirical base was limited to perceptions and outcomes related to novice modellers. This was to match the situation commonly found in organisations where domain experts are not modelling experts. However, we also see value in integrating the views and modelling outcomes of expert modellers in future research.

6 Conclusion

Given the increasing importance of process modelling, many different process modellign tools, languages and overall approaches are emergimg. This study was focused on providing a comparative evaluation of the dominant control flow based modelling approach with the emerging communication based modelling approach. To operationalize this, BPMN and S-BPM were used as representatives of the two modelling paradigms. This study designed and executed an exploratory experiment to compare the difference between S-BPM with BPMN with respect to the performance and the perception of the ease of modelling of novice and inexperienced modellers. In this study performance reflected in *modelling effectiveness* (- accuracy; syntax and semantic quality) and *modelling efficiency* - time*)*. The experimental results confirmed that S-BPM (a communication approach) is more effective for novice modellers to create semantically and syntactically correct models than the BPMN (a control flow approach and the defacto process modelling standard). Additionally, results indicate that novice process modellers are able to fully construct models faster using this approach. We also present future research directions to take this investigation further. In particular, these exploratory findings allow a whole new spectrum of process modelling research opportunities to emerge; to enhance popular control flow approaches. For example, based on these exploratory insights future research could consider the development of a next-generation, communication-based version (3.0) of the BPMN standard.

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Appendix A

This Appendix presents a simple 'University Application for admission' process (see below), which is also the process description used in the experiment of this study. The BPMN model and S-BPM models presented in the paper in Figures 1 and 2 are based on this university application process. Below, the process is described by the individual process participants' views, namely: the applicant, the admissions officer and a member of the academic committee.

Applicant: *When I want to apply for admission to University, I first prepare my application and submit it to the Admission Officer of the University. I then receive one of the below responses from the admission officer:*

- *An acceptance letter: In this case I sign the offer form in the letter and return it to the Admission Officer.*
- *A rejection letter: In this case, I do not do anything further and the process is finished for me.*
- *A request for clarification from the Admission Officer: In this case I prepare the required documents and send the clarification to the officer. I then get a response which might be one of the three types above.*

Admission officer: *When I receive an application from an Applicant; I first check the completeness of the documents. If the application is incomplete, I send a request for* *clarification to the applicant. Once I get this clarification, I check the application again for completeness. If I assess the application as complete I pass it on to the Academic Committee. In the meantime, I register the documents in my database. After the registration, I get a response from the Academic Committee, which can be either of the following:*

- *A notification of acceptance: In this case I prepare the acceptance letter and send it to the Applicant. I then receive the signed offer form from the Applicant, which concludes my process.*
- *A notification of rejection: In this case, I prepare the rejection letter and send it to the Applicant. The process is then finished for me.*

Member of Academic Committee: *When I get an application from the Admission Officer, I first assess the quality of the documents. If I assess the Applicant as qualified, I mark the application as accepted, validate the references on the CV, and send a notification of acceptance to the Admission Officer.*
If I assess the Applicant as unqualified, I mark the application as rejected and send a notification of rejection to the admission officer. In both cases I conclude the process by archiving the results of my assessment