# The Composite Approach as a Hybrid Approach to Business Process Modeling: Proposition and Empirical Evaluation

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**Abstract**

**Purpose –** Business process modeling faces a difficult balance: on the one hand, organizations seek to enact, control and automate business processes through formal structures (procedures and rules). On the other hand, organizations also seek to embrace flexibility, change, innovation, value orientation, and dynamic capabilities, which require informal structures (unique user experiences). Addressing this difficulty, the authors propose the composite approach, which integrates formal and informal process structures. The composite approach adopts a socio-material conceptual lens, where both material and human agencies are supported.

**Design/methodology/approach** – The study follows a design science research methodology. An innovative artifact - the composite approach - is introduced. The composite approach is evaluated in an empirical experiment.

**Findings** –The experimental results show that the composite approach improves model understandability and situation understandability.

**Research limitations/implications** – This research explores the challenges and opportunities brought by adopting a socio-material conceptual lens to represent business processes.

**Originality/value** – The study contributes an innovative hybrid approach for modeling business processes, articulating coordination and contextual knowledge. The proposed approach can be used to improve model understandability and situation understandability. The study also extends the social-material conceptual lens over process modeling with a theoretical framework integrating coordination and contextual knowledge.

**Keywords:** Business Process Management; Business Process Modeling; Process Structures; Process Stories.

**Paper type:** Research paper

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# 1 Introduction

Business process management (BPM) is a popular method for organizations to achieve efficiencies in business operations (Harmon, 2019). Playing essential roles in BPM, process models provide a representation of business operations (Van der Aalst, 2013a; Weske, 2007). Process models enable organizations to formalize business processes, optimize business operations, develop software to automate business processes, communicate with stakeholders, and support decision-making (Trkman, 2010; Van der Aalst, 2013a; Winter et al., 2023). Process models have been applied in multiple domains, from warehouse management to healthcare administration and simple to knowledge-intensive operations (Goni & Van Looy, 2022; Pufahl et al., 2022).

Most common process modeling approaches adopt formal structures (abstract procedures and rules) to represent business operations (Abdulkader et al., 2020; Dumas et al., 2013; Mendling et al., 2020). Consequently, a formal, abstract characterization of the process is imprinted by design in the different uses that organizations find for process models. However, this type of characterization can conflict with more idiosyncratic views over business processes, often driven by contextual vagaries, individual sensemaking, and situated action (Bietti et al., 2018; Haggège and Vernay, 2019; Thuan et al., 2022). Formal and abstract characterizations can also create barriers to organizational change and innovation (Goni and Van Looy, 2022).

Recently, it has been suggested that process modeling approaches need more informal structures capable of representing different practices, viewpoints, and contexts. Informal structures are critical when organizations deal with innovation, flexibility, unique or exceptional cases, market changes, and dynamic capabilities (Goni and Van Looy, 2022). Informal structures are also valuable in knowledge-intensive situations, where organizations often lessen control to increase business value (Vom Brocke et al., 2010). Therefore, the literature has called for new hybrid modeling approaches integrating formal and informal structures (Andaloussi et al., 2020; Andaloussi et al., 2019; Hewelt & Weske, 2016; Slaats, 2020).

Addressing this call, the main goal of this study is to propose and evaluate a hybrid process modeling approach, labeled *composite approach*, which integrates formal and informal process structures. The study suggests that the composite approach increases process understandability.

The study follows a design science methodology (Hevner et al., 2004; Peffers et al., 2007). It contributes an innovative approach to modeling business processes, considering users' experiences. The study also contributes a comparative experiment to evaluate the composite approach. The experiment concerns users making decisions about the process in two conditions: one using formal and informal structures, and another using formal structures. As understandability is a crucial attribute to assess the value of process models (Adamo et al., 2021; Lübke et al., 2021; Zugal et al., 2015), we use this attribute to evaluate the composite approach. Two aspects related to understandability are assessed: model understandability and situation understandability. The experiment was conducted with 129 participants. The results show that the composite approach increases both model understandability and situation understandability. The results show that the composite approach performs better in non-routine business situations regarding situation understandability.

The remainder of this paper is structured as follows: Section 2 sets up the theoretical background of the research. Subsequently, the chosen methodology is justified (Section 3). Section 4 proposes and describes the composite approach. Section 5 presents the evaluation of the composite approach. Section 6 discusses the findings, and Section 7 provides some concluding remarks.

# 2 Background

Process models are vital for organizations to quickly deploy business processes, deliver products and services, and manage stakeholder engagement and participation (Tsagkani and Tsalgatidou, 2022). Two conceptual lenses are essential to understand the roles of process models in organizations, material, and socio-material, which can be differentiated regarding modeling purpose, type of control, nature of the model, and modeled knowledge. Table 1 compares the two lenses, which are further discussed below.

| **Conceptual lens** | **Modeling purpose** | **Type of control** | **Nature of model** | **Modeled knowledge** | |
|---|---|---|---|---|---|
| | | | | **Structure** | **Contents** |
| **Material** | Material agency: process models (and associated artifacts) act on their own to build organizational reality | Process models are used to control human actions | Situations and actions are defined at design time and applied at execution time | Formal | Coordination knowledge |
| **Socio-material** | Human and material agencies: process models (and associated artifacts) and humans act together to build organizational reality | Control is ongoing and can be exerted both ways | Situations and actions are defined at execution time | Formal and informal | Coordination and contextual knowledge |

**Table 1.** Material and socio-material lenses over process models

## 2.1 Material lens

According to this lens, the primary purpose of process models is to provide the basis for exercising material agency, in which process models and associated artifacts (e.g., information systems) control human participation in the business operations (Leonardi, 2011). Control refers to applying managerial oversight over events, actions, and relationships. Control is based on coordination knowledge, which expresses the precise process execution using a set of procedures and rules (Romero et al., 2015; Tregear, 2015; Van der Aalst, 2013b).

Situations and actions are captured and imprinted in process models at design time and are enacted (usually with information systems support) at execution time. As so, the knowledge structure of process models is formal and stable (Andaloussi et al., 2020). Formalization and stability increase transparency and avoid conflicts (Albuquerque and Christ, 2015). Formal structures also help translate concepts from the business domain to the technology domain, where process models are expected to feed or be embedded in information systems (Rosemann & vom Brocke, 2015; Tsagkani & Tsalgatidou, 2022).

However, complete dependence on formal structures can be problematic in various situations. In particular, formal structures can be challenged by emergent, dynamic, and unexpected contexts (Antunes and Tate, 2022). For instance, many formal procedures were stopped or disrupted by the COVID-19 epidemic and had to be rapidly rethought in light of entirely different social and economic environments (Elia et al., 2022). Further, knowledge-intensive situations can also challenge formal structures (Vom Brocke et al., 2010). Organizations may value situated decisions, improvisation, emergence, and innovation in such situations more than formalization, normalization, and control. All these situations highlight the need for considering the socio-material lens over process models.

## 2.2 Socio-material lens

According to this lens, the purpose of process models is to empower humans and technology to make their own decisions regarding business operations (Goni and Van Looy, 2022; Leonardi, 2012). Both material and human agencies (human capacity to formulate goals and act accordingly) can change in relation to one another. Therefore, both have a range of options (Albuquerque and Christ, 2015; Crick and Chew, 2017).

Control is ongoing and requires interaction between humans and technology (Leonardi, 2011). Control can be adjusted at execution time, where human and technological entities ask: “What is going on here?” and “What do I do next?” (Svejvig and Jensen, 2013). A combination of formal and informal knowledge structures is necessary to explain the process.

Complementing formal structures, informal structures support sensemaking, alternative viewpoints, contextualization, and situated decision-making (Andaloussi et al., 2019). This dualistic nature creates a hybrid knowledge structure that enables flexibility in process execution, as the process execution can vary in a range of situations (Antunes and Tate, 2022). Informal structures utilize contextual knowledge, considering various individual, organizational, and environmental elements that help make sense of the real-world (Antunes et al., 2020; Vom Brocke et al., 2016).

Even though the BPM research literature highlights the relevance of socio-materiality, it has yet to impact process modeling substantially (Andaloussi et al., 2019; Slaats, 2020; Winter et al., 2023). In particular, knowledge about hybrid process representation needs to be improved. As noted by Andaloussi et al., “little is known about the synergies and overlaps between the languages [structures] composing these hybrid representations” (Andaloussi et al., 2020, p. 23). Little is known about the new capabilities of hybrid process models (Hewelt & Weske, 2016; Slaats, 2020; Winter et al., 2023). Slaats (2020) also notes that “work on the understandability of hybrid process notations is even more limited”

(p. 14). Considering these research gaps, we propose the composite approach to process modeling. The composite approach integrates formal and informal structures, considering coordination and contextual knowledge.

# 3 Design Science Methodology

The development of the composite approach follows the design science methodology (Hevner et al., 2004). We choose the design science methodology for two reasons. First, design science is suitable for developing new, first-of-a-kind artifacts, including new methods and approaches (Hevner et al., 2019; Thuan et al., 2019). Translating to the current study, we propose a new composite approach to business process modeling. Second, design science balances artifact and knowledge contributions (Baskerville et al., 2018; Johnson et al., 2022). This aligns with this study's objectives to propose the composite approach to address identified needs in business process management, and to contribute to knowledge in the business process management field. As so, we adopted a well-known design science process by Peffers et al. (2007), which informs the four main steps of our study: problem identification, solution objectives, design, and evaluation. Figure 1 presents the adopted design science methodology and detailed steps.

In the first step, we identify the problem being addressed. As presented in the introductory section, the sole reliance on formal structures creates certain constraints, highlighted by the socio-material lens (Andaloussi et al., 2020; Zugal et al., 2015). In the second step, we define the objectives of the desired solution. In particular, as suggested by the socio-material lens, the preferred modeling approach should integrate both formal and informal structures and foster process understandability (Section 2). In the third step, the composite approach is developed. It contemplates three parts: structure, content, and representational vehicle. These parts are discussed in the next section. In the fourth and final step, the composite approach is evaluated in an empirical experiment. A controlled experiment is adopted to test the composite approach. Section 5 presents the details of the experiment.

The steps delineated above were conducted as part of a two-year research project. The current paper communicates the outcomes of the research project.

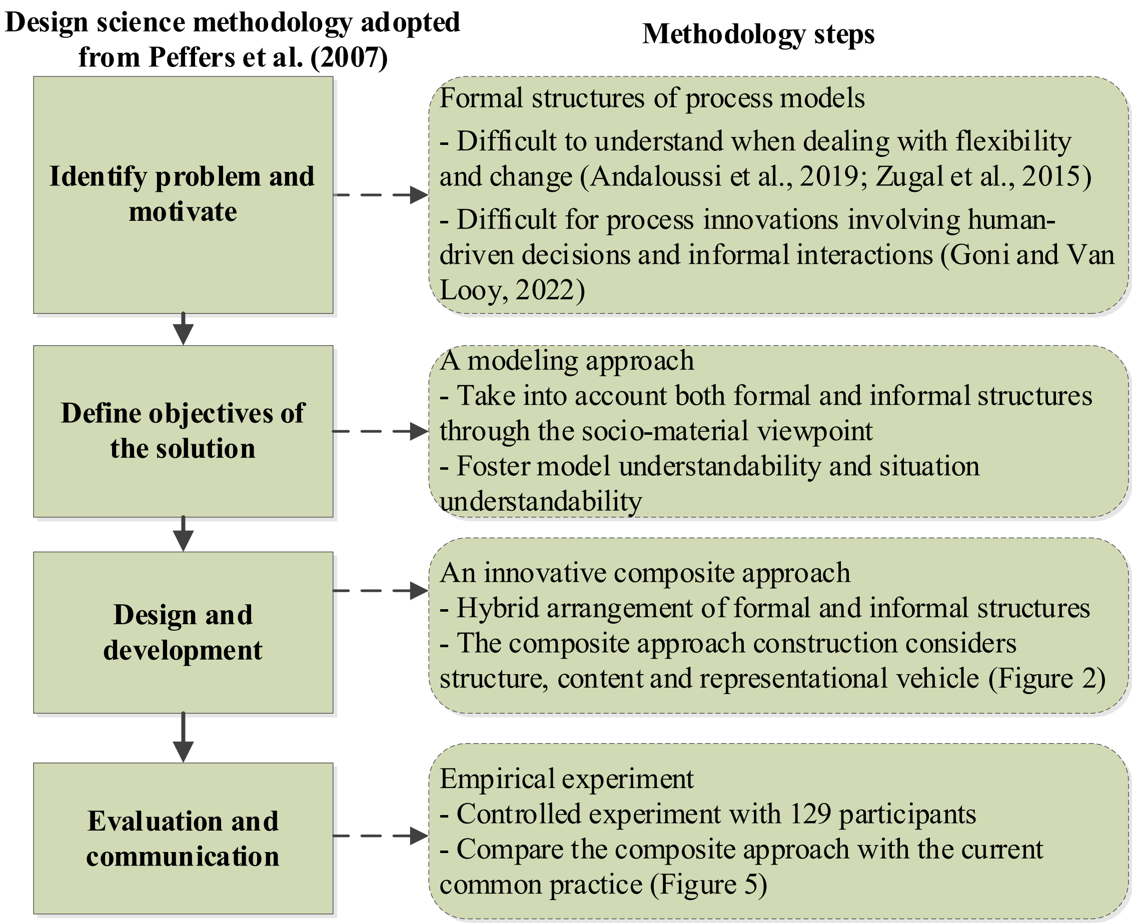


**Figure 1.** Design science methodology (adapted from Peffers et al. (2007))

## 4 The Composite Approach

We conceptualize the composite approach in three levels considering structure, content, and representational vehicle (Figure 2).

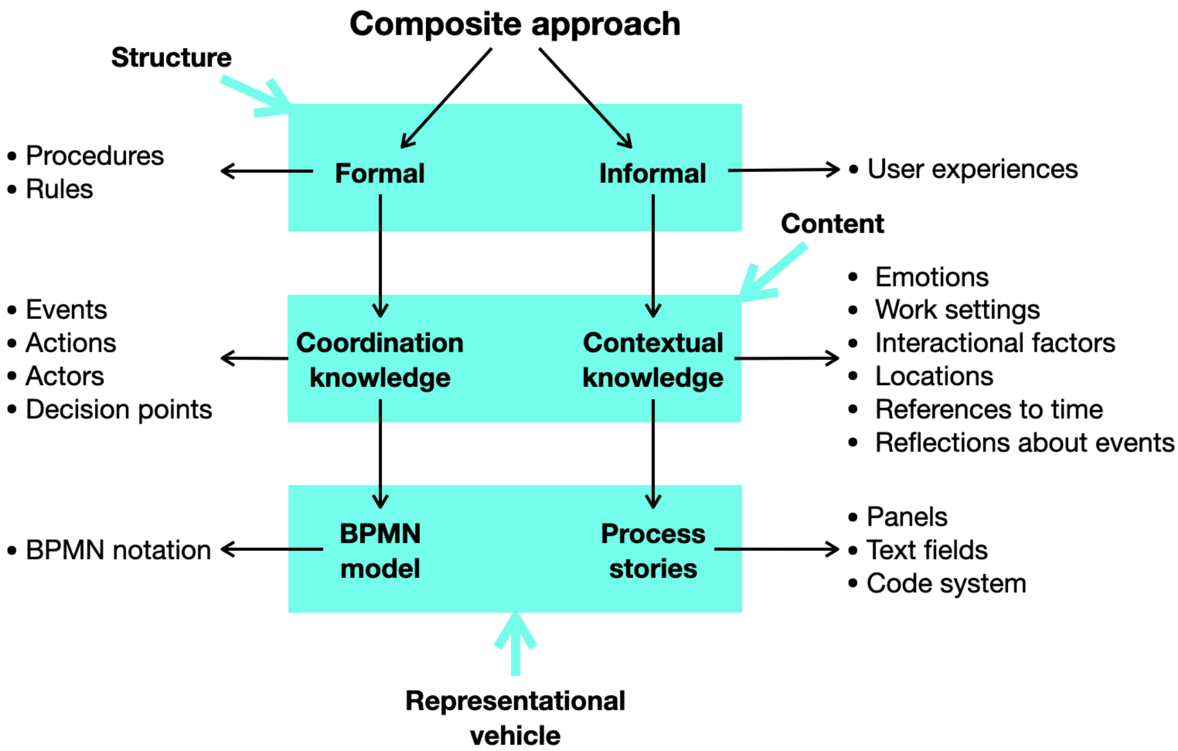


**Figure 2.** Conceptual framework of the composite approach

## 4.1 Level 1: Structure

Embracing socio-materiality, the composite approach combines formal and informal structures. Formal structures codify procedures and rules (Chinosi and Trombetta, 2012). Informal structures codify real-life experiences, viewpoints, and situations lived by users. Informal structures are unconstrained by formal structures, given that they capture reality in flight (Pentland et al., 2017).

By integrating the two structures, the composite approach can be classified as a hybrid knowledge structure (Andaloussi et al., 2020; Hewelt and Weske, 2016). It uses formal structures to outline behavioral patterns and give coherence to otherwise mindless actions. It also uses informal structures to codify how users live business processes.

## 4.2 Level 2: Content

The composite approach combines two types of content: coordination knowledge and contextual knowledge. Coordination knowledge provides formal structures using a set of process modeling elements, which help determine how the process unfolds using a particular ontology (Lu and Sadiq, 2007). Common ontologies include events, activities, actors, and decision points (Antunes and Tate, 2022). Contextual knowledge provides informal structures using a set of contextual elements, which help frame the coordination knowledge in a particular context (Vom Brocke et al., 2016). These include emotions, work settings, interactional elements, decision factors, locations, references to time, and reflections on events (Antunes et al., 2020).

## 4.3 Level 3: Representational vehicle

A representational vehicle is required to carry process content and structure. The adopted representational vehicle is shown in Figure 3. The Business Process Modeling Notation (BPMN) (Chinosi and Trombetta, 2012) is used to deliver coordination knowledge (Figure 3, bottom). Process stories (Antunes et al., 2020) provide contextual knowledge (Figure 3, top). Using multiple process stories enriches the contextual knowledge about a process. Figure 3 only illustrates the overall combination of BPMN and process stories; it does not show the detailed alignment between elements in process stories and process models. We refer readers to Appendix A for a detailed example.

A process story is a sequence of panels describing a case as experienced by a user. Each panel portrays a typical business situation, such as signing a document. The panels forming the process story operate metaphorically, placing the user in the story. Each panel contains pictures and text that help identify the business situation, participants, associated events, and thoughts and feelings. This way, process stories allow users to intuitively understand the process, “filling in the gaps between panels” (McCloud, 1994). Combining visual and textual elements helps put the story together (Antunes et al., 2020; Simões et al., 2018, 2016).

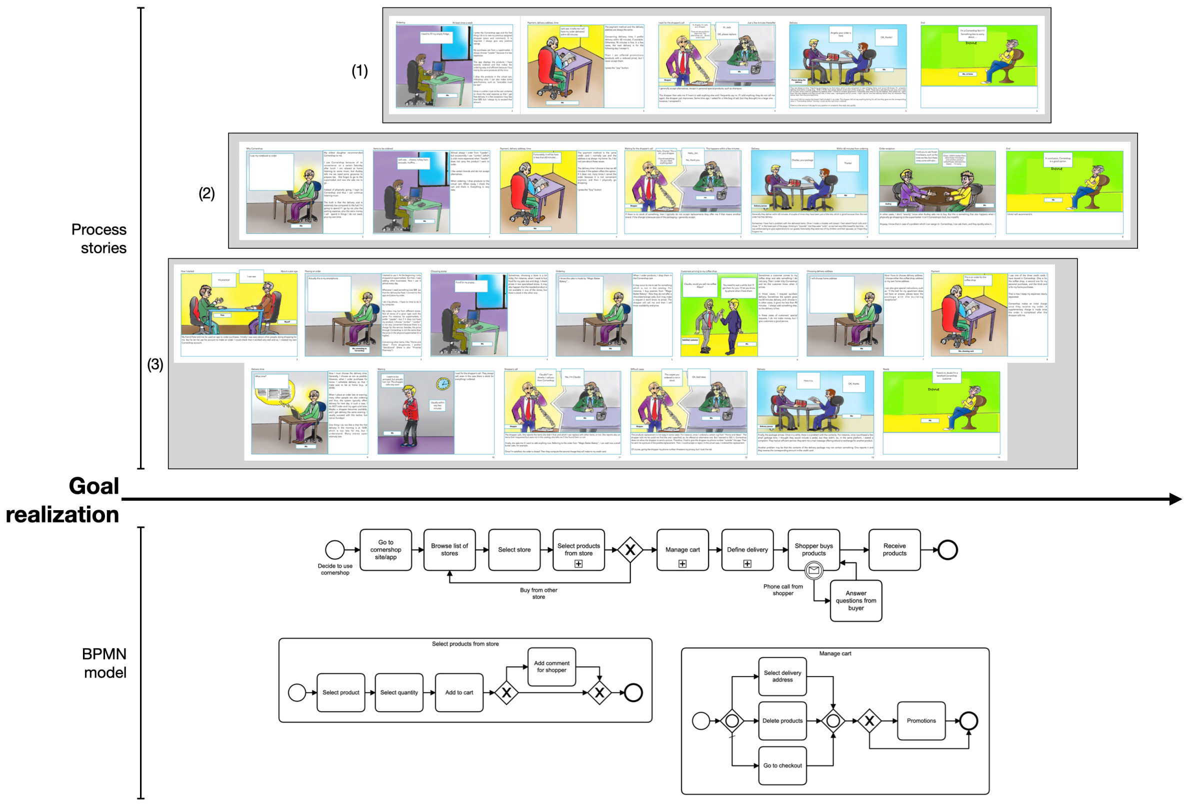


Figure 3. Representational vehicle (illustrative example, refer to Appendix A for full details)

## 4.4 Aligning the BPMN model and process stories

We now discuss the alignment between the BPMN model and process stories in the composite approach. As users can participate in different process slices and experience the process in different ways, we choose a loose approach to align the BPMN model and process stories. The alignment involves assigning codes to selected information elements, a common practice in qualitative data analysis (Miles et al., 2014).

The coding procedure involves identifying relationships between narrative elements in process stories and control-flow elements in the BPMN model. The following types of relationships can be coded:

- Generalization (GE): The element in the process story is more generic than the corresponding element in the BPMN model.
- Refinement (RF): The element in the process story is more detailed than the BPMN element.
- Extension (EX): The element in the process story is outside the scope of the BPMN model.
- Similarity (SI): The element in the process story is similar.
- Contradiction (CO): The element in the process story contradicts the element in the BPMN model.
- Omission (OM): The process story is missing an element in the BPMN model.

For illustration purposes, Figure 4 shows a coded panel. This type of coding enriches process knowledge by pinpointing the diversity of viewpoints, narratives, and experiences appearing in process stories in direct comparison to what is expressed in the BPMN model.

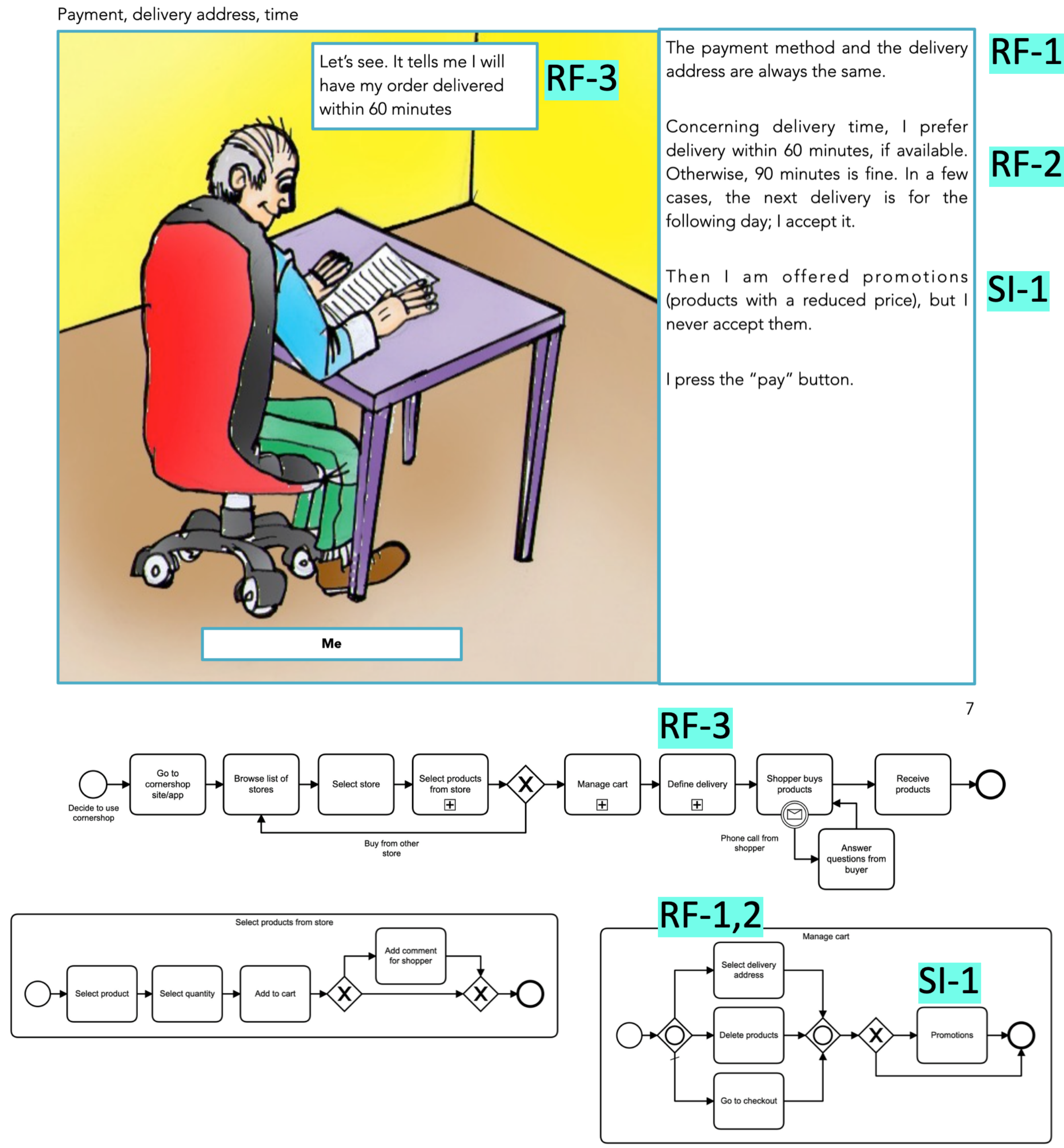


**Figure 4.** Relationships between narrative elements in process stories and control-flow elements in the BPMN model

## 5 Evaluating the Composite Approach

The composite approach is evaluated in an empirical experiment. The experiment follows the guidelines suggested by Montgomery (2012). Next, the experimental method, pilot experiment, experimental execution, and experimental results are discussed.

### 5.1 Experimental method

The experiment seeks to evaluate how users make decisions related to a process model presented to them. We adopt a comparative experiment using treatment and control groups for that purpose. Users in the treatment group make decisions based on the composite approach, which combines BPMN models and process stories. In contrast, users in the control group make decisions based on BPMN models only.

The experimental design is summarized in Figure 5. Users are randomly divided into two groups. One group (reference) is supplied with a BPMN model, while the other group (composite) is provided with a composite structure containing the BPMN model and process stories. Both groups accomplish two exercises requiring process analysis and decision-making in two situations: routine and non-routine. Routine situations concern pre-specified, repeatable, and well-structured activities and workflows (Reichert and Weber, 2012). Non-routine situations concern dynamic, emergent, exceptional, and often creative actions and trajectories (Cognini et al., 2018). These two exercises avoid biasing the experiment towards the strengths of informal structures (e.g., creative, exceptional decisions in non-routine situations) rather than the strengths of formal structures (e.g., recurrent decisions in routine situations).

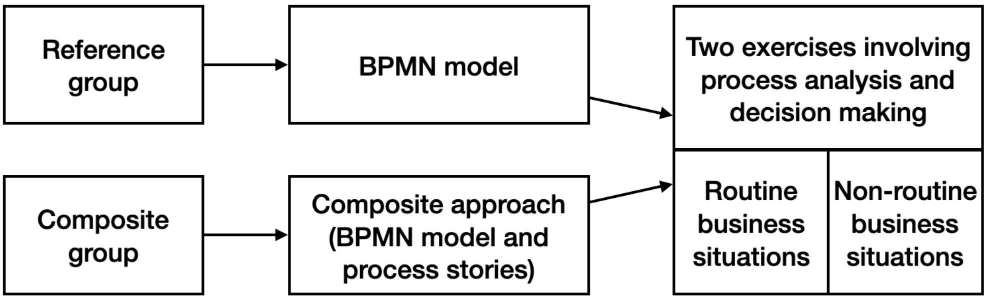


Figure 5. Experimental design

We ask users to analyze the business process using the supplied information pack for each exercise and answer four what-if questions. The four questions consider what users should do in a range of circumstances. The questions focus on the supplied information rather than the user's experience to avoid biases caused by making decisions based on individual experience. Since users must complete the two scenarios, the delivered questionnaire contains eight questions. Details about the selected business process, associated BPMN model, and process stories are presented in Appendix A.

We use two indicators to evaluate users' performance: situation understandability and model understandability. More details about these indicators are provided in Appendix B. In particular, situation understandability is the capacity to interpret the situational and contextual factors involved in a process model (Khorasani, 2018; Röder et al., 2015). We measure situation understandability by counting the scenarios and events users identify in their answers. We define an event as any element that changes the process state; and define a scenario as a sequence of events that takes the process into a trajectory. Our rationale is that if users can identify more scenarios and events, they can better use the process model, from a socio-material lens.

Model understandability is the capacity of users to understand a model (Andaloussi et al., 2020; Avila et al., 2020; Corradini et al., 2018; Figl et al., 2020; Reijers and Mendling, 2011; Wang et al., 2022). We evaluate model understandability through qualitative assessment of the answers provided by the users. A score was developed to indicate the level of engagement of a user with the supplied information pack when answering a question. This includes understanding the business procedures and rules and making good decisions based on the information provided. The score uses a 3-point scale (0- unable to answer, or irrelevant answer; 0.5- the answer does not reflect the information provided to the user, yet it is reasonable; 1- correct answer, with appropriate link to information provided to the user). Other studies have used similar assessment scores to measure model understandability (Adamo et al., 2021).

We employ students to play the role of users in the experiment. We recognize that relying on students could be a limitation. However, three main reasons support this decision. The first reason is that a genuine evaluation of the composite approach requires users to answer the questions based on the supplied information pack; otherwise, their organizational and contextual knowledge will bias their answers. Therefore, using students may provide more reliable comparative results than subject-matter experts. The second reason is that students with knowledge of process modeling serve as adequate proxies for users of process models (Figl et al., 2020). Even though they lack organizational and contextual understanding, they have more theoretical knowledge regarding process modeling (Mendling et al., 2012). Besides, they will form the future generation of users. Finally, employing students to evaluate modeling approaches is already a well-established research practice (Adamo et al., 2021; Baklizky et al., 2017; Figl et al., 2020; Mendling et al., 2012).

The measurement procedure is accomplished as follows. First, we measure the three variables for each answer a user provides. We then aggregate the measurements obtained for each exercise completed by a user. Finally, we average the measurements obtained for each user to determine the group results. Table 2 summarizes the used indicators and variables.

| Indicators | Variables (and range) | Description |
|---|---|---|
| Model understandability | Score ([0, 0.5, 1] per question) | Level of engagement with the supplied information when answering a question |
| Situation understandability | Number of scenarios (> 0 per question) | A scenario is a sequence of events that take the process into a trajectory |
| | Number of events (> 0 per question) | An event changes the process state |

Table 2. Indicators and variables

Given these variables, we detail and test the following hypotheses:

**Hypothesis 1:** The composite approach increases model understandability.

**Hypothesis 2:** The composite approach increases situation understandability.

**Hypothesis 2A:** The composite approach will allow users to identify more scenarios.

**Hypothesis 2B:** The composite approach will allow users to identify more events.

## 5.2 Pilot experiment

Before the main experiment, a pilot experiment was conducted with 19 participants to refine the experimental design (Dennis and Valacich, 2001). The results highlighted two points. First, the results suggested the appropriateness of the selected measurements. For instance, model understandability could be measured using the score. Second, the results indicated that the composite approach likely improved model understandability and situation understandability. Although the number of users needed to be larger to confirm the hypotheses, the results were promising for further testing the hypotheses in the main experiment.

## 5.3 Experiment

The experiment was conducted in a university setting. The participants were university students studying information systems and computer science in their second/third year. All participants were familiar with process modeling. Two similar classrooms were used, ensuring the same conditions for all users. The convenience sample comprised undergraduate students in information systems and computer science with BPMN familiarity. Two sessions were assembled. Users were randomly assigned to the reference and composite groups in each session. Both groups accomplished the same exercises (with both routine and non-routine business situations). The only difference between the two groups was the supplied information packs. One group received a BPMN model, while the other group received the composite structure with the BPMN model and process stories (see Appendix A). The number of users per session and group is presented in Table 3.

| Session | Number of users | Reference group | Composite group |
|---|---|---|---|
| 1 | 63 | 33 | 30 |
| 2 | 66 | 33 | 33 |
| Total | **129** | **66** | **63** |

Table 3. Number of users per session

## 5.4 Experiment Results

Overall, the experiment involved 129 users. All answers were recorded and coded. We started the analysis by testing the normality assumption of the sample. As the measurements (events, scenarios, and score) were treated as discontinuous measures (the minimum difference between two scores is 0.5), we expected that the normality assumption might not hold, and this was confirmed by the Shapiro-Wilk tests with p-values $< 0.05$. These results firmly guided our choice of statistical tests.

We started our analysis by examining the directions of measures within each session. Table 4 shows descriptive statistics of the samples, comparing the means between reference and composite groups. Data are presented for the two exercises, considering routine and non-routine business situations. Overall, the directions of all measures aligned with our expectations for all hypotheses in the non-routine business situation, i.e., the composite group outperformed the reference group in all measurements.

Regarding the routine business situation, the composite group topped the reference group in session 1, but the results were reversed in session 2.

| | **Reference group Mean (Std.)** | | | **Composite group Mean (Std.)** | | |
|---|---|---|---|---|---|---|
| | Situation understandability | | Model understandability score | Situation understandability | | Model understandability score |
| | Events | Scenarios | | Events | Scenarios | |
| **Exercise: non-routine business situation** | | | | | | |
| Session 1 | 3.21 (1.76) | 2.55 (1.33) | 1.05 (0.47) | 6.03 (1.94) | 5.17 (1.68) | 1.92 (0.59) |
| Session 2 | 4.24 (1.89) | 3.39 (1.34) | 1.27 (0.40) | 4.93 (1.92) | 3.91 (1.38) | 1.59 (0.44) |
| **Exercise: routine business situation** | | | | | | |
| Session 1 | 8.40 (4.79) | 3.21 (1.43) | 2.00 (1.02) | 9.37 (3.67) | 4.03 (1.47) | 2.13 (0.64) |
| Session 2 | 11.93 (5.01) | 3.93 (1.14) | 2.28 (0.72) | 8.81 (4.65) | 3.45 (1.25) | 1.88 (0.87) |

Table 4. Descriptive statistics

Before integrating data from these sessions, we checked the potential differences in the scores among sessions. As the datasets were not normally distributed, we used the non-parametric Mann-Whitney tests, an acceptable alternative to T-tests in cases where datasets come from non-normally distributed populations. The results showed no significant differences between the two sessions for all measures at 0.05. These results allowed us to analyze the datasets in an integrated way.

Considering the integrated dataset, we then tested each hypothesis. We chose Mann-Whitney tests to compare the decision performance between the reference and composite groups because, first, the tests were appropriate given the non-normality of the measures (Anderson et al., 2011). Second, the distribution-free nature of the Mann-Whitney tests placed few restrictions on the dataset and thus allowed us to analyze the integrated dataset using the two sessions. A similar use of the Mann-Whitney tests for analyzing integrated datasets has been reported by others (Mendling et al., 2012).

Mann-Whitney tests were applied to the integrated dataset. We ran the tests using SPSS version 25.0. The results of the Mann-Whitney tests are presented in Table 5, Table 6, Table 7, and Table 8. Regarding model understandability, as seen in Table 5, the composite group outperformed the reference group (3.74 vs. 3.30). The result is statistically significant at the significance level of 0.05 (p-value =0.03). This allows us to accept Hypothesis 1. To further support Hypothesis 1, Figure 6 shows the score distribution by the two groups. The figure highlights that the composite group performed better than the reference group. Together, the results show that the composite approach increases model understandability.

| | **Reference group (N=66)** | **Composite group (N=63)** |
|---|---|---|
| **Mean** | 3.30 | 3.74 |

| | | |
|---|---|---|
| **Std.** | 1.03 | 1.05 |
| **Mean Rank** | 58.22 | 72.10 |
| **p-value** | 0.03 (0.017) | |

The p-value of the t-test is shown in parentheses for comparison purposes.

**Table 5.** Results of Mann-Whitney tests on the score

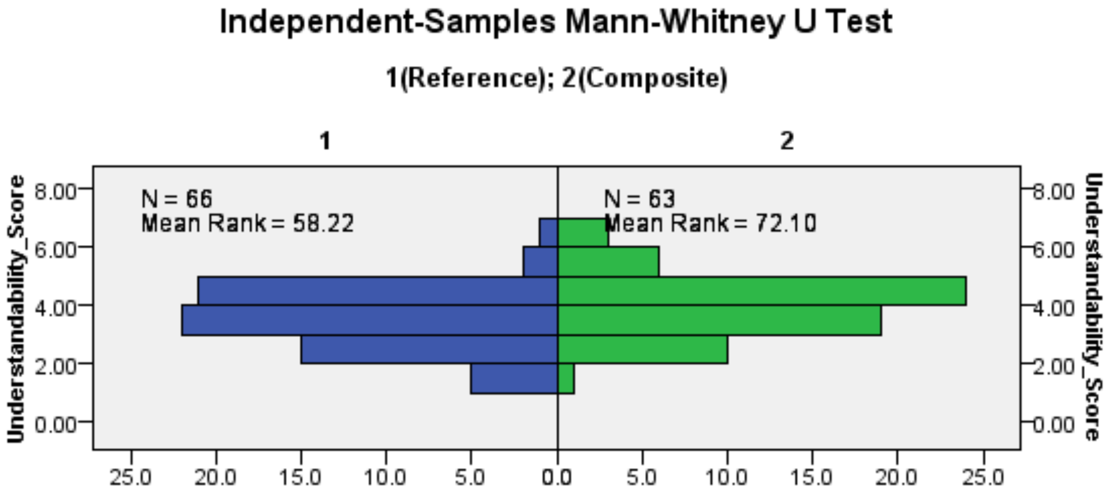


**Figure 6.** Score: distributions of reference and composite groups

Table 6 shows the results for the scenarios variable. The composite group outperformed the reference group (8.23 scenarios vs. 6.55 scenarios). The result is statistically significant at the significance level of 0.05 (p-value <0.001). This allows us to accept Hypothesis 2A. To further support Hypothesis 2A, Figure 7 shows the distribution of scenarios identified by the two groups. The figure highlights that the composite group identified more scenarios than the reference group, thus improving situation understandability. Together, the results suggest that the composite approach increases situation understandability, as it helps users to identify more scenarios.

| | Reference group (N=66) | Composite group (N=63) |
|---|---|---|
| **Mean** | 6.55 | 8.23 |
| **Std.** | 1.96 | 2.36 |
| **Mean Rank** | 50.96 | 79.71 |
| **p-value** | < 0.001 (< 0.001) | |

The p-value of the t-test is shown in parentheses for comparison purposes.

**Table 6.** Results of Mann-Whitney tests on the scenarios variable

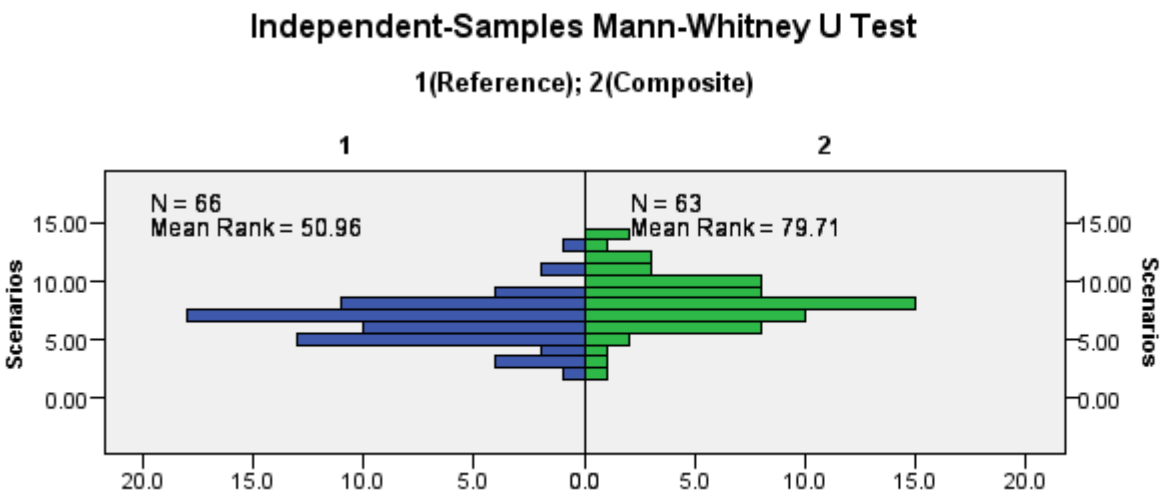


**Figure 7.** Scenarios: distributions of reference and composite groups

Table 7 shows the testing results for the events variable. The composite group slightly outperformed the reference group (14.54 events vs. 13.89 events). Yet, the difference is not statistically significant at the significance level of 0.05 (p-value = 0.59). This does not allow us to accept Hypothesis 2B.

| | Reference group (N=66) | Composite group (N=63) |
|---|---|---|
| **Mean** | 13.89 | 14.54 |
| **Std.** | 5.72 | 4.83 |
| **Mean Rank** | 63.28 | 66.80 |
| **p-value** | .59 (0.49) | |

The p-value of the t-test is shown in parentheses for comparison purposes.

**Table 7.** Results of Mann-Whitney tests on the events variable

This finding is consistent with the descriptive data regarding the events variable (see Table 4), which indicates that the composite group outperforms the reference group when the business situation is non-routine; the results are reversed when the business situation is routine. Considering these results, we further tested the events variable considering the routine and non-routine business situations. As seen in Table 8, no significant differences between groups were found when the business situation was routine. For the routine situation, the reference group even identified more events than the composite group (10.17 events vs. 9.08 events), which shows the opposite direction of Hypothesis 2B.

| | Reference group (N=66) | Composite group (N=63) |
|---|---|---|
| **Routine business situation** | | |
| **Mean** | 10.17 | 9.08 |
| **Std.** | 5.18 | 4.19 |
| **Mean Rank** | 68.83 | 60.98 |
| **p-value** | 0.232 (0.193) | |

| Non-routine business situation | | |
|---|---|---|
| **Mean** | 3.73 | 5.46 |
| **Std.** | 1.89 | 1.99 |
| **Mean Rank** | 50.33 | 80.37 |
| **p-value** | < 0.001 (< 0.001) | |

The p-value of the t-test is shown in parentheses for comparison purposes.

**Table 8.** Results of Mann-Whitney tests on the events variable regarding routine and non-routine business situations

However, for the non-routine situation, the composite group outperformed the reference group (5.46 events vs. 3.73 events). The result is statistically significant at the significance level of 0.05 (p-value <0.001). This allows us to accept Hypothesis 2B partly. In particular, the composite approach increases situation understandability when the users must decide on non-routine situations. Figure 8 shows the distribution of events identified by the two groups for the non-routine business situation. The figure highlights that when the business situation was non-routine, the composite group identified more events than the reference group, thus improving situation understandability.

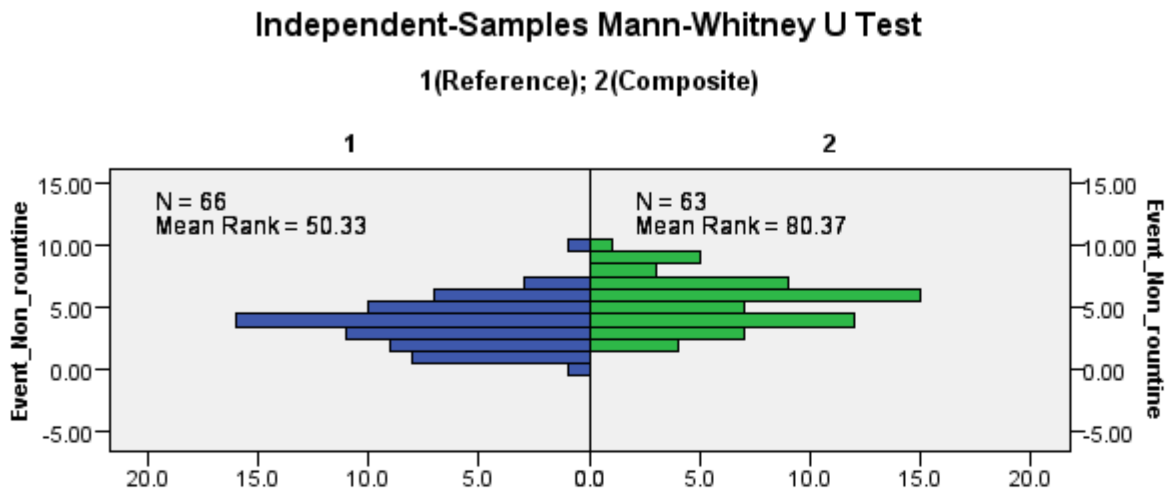


**Figure 8.** Distribution of events when the business situation is non-routine

From these results, we find support for Hypothesis 1, Hypothesis 2A, and partly Hypothesis 2B. That is, the composite approach increases model understandability and situation understandability regarding the number of scenarios. The composite approach also increases situation understandability regarding the number of events, but only when the business situation is non-routine.

## 6 Discussion

This study provides evidence about the utility of applying a socio-material lens to business process modeling. The proposed composite approach embraces the strengths of formal and informal structures, helping users better deal with routine and non-routine situations and addressing issues of knowledge representation, agency, and control.

At the approach's core, we integrate BPMN models and process stories, where process stories can be seen as an independent add-on component to BPMN models. As so, the composite approach does not require changes to BPMN models but adds contextual knowledge about the process. It also adds a set of relationships between coordination and contextual knowledge, which further helps better understand the process. The utility comes from using the two knowledge structures together and also comes from using the relationships between elements in both structures. The utility is increased for modeling experts, model users, and organizations. Modeling experts can work with a wide-ranging representational vehicle for designing business processes. Model users can rely on comprehensive, flexible knowledge sources integrating coordination and contextual knowledge. Organizations also have a method for managing process knowledge, which is not constrained to procedures and rules.

We conducted a controlled experience to evaluate the utility of the composite approach to model users. We evaluated utility using two indicators: model understandability and situation understandability. The results provide evidence that the composite approach increases model understandability (Table 5 and Figure 6). The results also provide evidence that the composite approach increases situation understandability, with some interesting discussion points.

For assessing situation understandability, we considered two indicators: the number of scenarios and events. Regarding scenarios, users performed better using the composite approach (Table 6 and Figure 7). But regarding events, users performed better when using the composite approach only under certain conditions (Table 8). We could find significant differences when users' decisions were about non-routine business situations. Still, we could not find significant differences when users' decisions were about routine business situations. One possible explanation for these mixed results is that BPMN models highlight the main events in a process by their structured nature.

On the contrary, process stories intersperse events with other contextual elements, making it cognitively more demanding for users to distinguish events from additional information. Therefore, users can more easily discern the relevant events in a process when deciding on a routine situation by analyzing the BPMN model. After all, the BPMN model is supposed to document well what is routine. On the contrary, when deciding about a non-routine situation, the cognitive effort brought by process stories is compensated by the ability to explore more information to make a better decision.

Therefore, we see adopting the composite approach as part of a tradeoff: organizations leaning towards routine scenarios may find the composite approach too burdensome or even a distraction, while organizations leaning towards non-routine scenarios may find the composite approach appealing. The composite approach is a good option for organizations transitioning from routine to non-routine scenarios, increasing model and situation understandability.

Of course, as organizations start facing more exceptional, emergent, and knowledge-intensive situations (Antunes and Tate, 2022; Sid et al., 2019), the composite approach enables more flexible decisions based on hybrid knowledge about the process. Furthermore, the underlying modeling practices remain the same. It allows organizations to move beyond BPMN models as single sources of truth about the process towards a richer conceptualization, where the process is codified using a variety of user experiences.

In addition to our quantitative analysis, we further qualitatively examined the participants' answers. An interesting finding is that when process stories were unavailable, the users responded to the questionnaire with a fixation on the BPMN model. For instance, when asked how to deliver an order at a specific time and place, some users in the reference group mentioned doing that through delivery confirmation. In contrast, some users in the composite group said they could chat over the phone with the shopper. The study of fixation and other biases in process modeling is a recent topic of interest (Razavian et al., 2017; Weber et al., 2016; Zimoch et al., 2017). However, fixation on BPMN models has not been studied. Therefore, this study contributes to this emerging body of knowledge.

Future work could also explore adopting the composite approach to improve process design and execution (Gross et al., 2021; Zimoch et al., 2017). An essential aspect of socio-materiality is that the composite approach supports human and material agencies. However, further research is necessary to understand better how the composite approach may improve material agency.

## 6.1 Limitations

We identify some limitations in this study, which should be addressed in future work. First, we note some fundamental constraints resulting from the adopted experimental approach. Decisions in organizations can be affected by various factors, including organizational and contextual knowledge, recognized practices, autonomy, and time pressure. As such, the impact of the composite approach can be diluted or overtaken by other elements influencing decision-making. On the other hand, a naturalistic evaluation of the composite approach can also be challenging to accomplish because the impact of the composite approach would necessarily be diluted in a mix of factors and conditions.

Using students as proxies for subject-matter users can also be considered a limitation. Yet, this has been an acceptable practice in evaluating new tools and approaches. A review by Sjøberg et al. (2005), analyzing 113 experiments, shows that "87 percent of the subjects were students" (p.751).

Another limitation concerns possible threats to validity caused by the selected measurements. In particular, measures may have been biased by our viewpoints about the process. Future research could consider using third parties to define more appropriate measurements. Other measurements could also be considered (Corradini et al., 2018). All in all, more research may be necessary to identify the best model and situation understandability measurements.

Finally, although our findings suggest that routine and non-routine scenarios could be investigated using an independent variable, we only considered the two scenarios to avoid biases in comparing the composite approach against the baseline. We leave the possible influence of a variable, which could be designated as knowledge demand about the process, for future research.

# 7 Conclusions

This study discusses the opportunities and needs for integrating formal and informal process modeling structures (Andaloussi et al., 2020; Slaats, 2020). This study proposes and evaluates the composite approach to business process modeling following design science methodology. The composite approach adopts a socio-material conceptual lens, where both material and human agencies compete to decide the best trajectory of process execution. While certain parts of the composite approach (BPMN model) contribute to material agency, other parts (process stories) contribute to human agency. The findings show that this integration increases model and situation understandability (Table 5, Figure 6, Table 6 and Figure 7). The combination of model and situation understandability allows users to contextualize better and decide about a process. The results suggest that the composite approach may be most useful when contextualizing and deciding about the non-routine aspects of a process.

This study contributes to both research and practice. From a research standpoint, it contributes a novel process modeling approach in which the focal innovation is integrating and aligning BPMN models and process stories. While existing studies have adopted either BPMN models (Lübke et al., 2021) or process stories for representing business processes (Bauer, 2019; Haggège & Vernay, 2019), this study combines the two structures. The evaluation shows that the composite approach improves process understandability.

From a more theoretical standpoint, this study extends the socio-material lens over process modeling. Socio-materiality has been mainly discussed using critical thinking, highlighting fundamental constraints in the material approach to process modeling. This study goes beyond critical thinking, resolving significant business process modeling constraints. These are explicated in a conceptual framework that operates at three levels reflecting structure, content, and representational vehicle.

Considering practice, organizations should try to represent processes beyond formal structures, moving away from creating a single source of truth about the process towards more diverse, even conflicting truths. One path in this direction is the adoption of the composite approach. We suggest that the composite approach enhances model and situation understandability, especially when business situations are non-routine (Table 8). In other words, when users find certain non-routine business situations hard to understand using traditional process models, they can rely on the composite approach as a source of knowledge. The composite approach does not require organizations to replace their existing process models. Instead, it enables integrating existing process models with process stories to enhance process knowledge, which can be a plus for organizations needing to implement significant changes.

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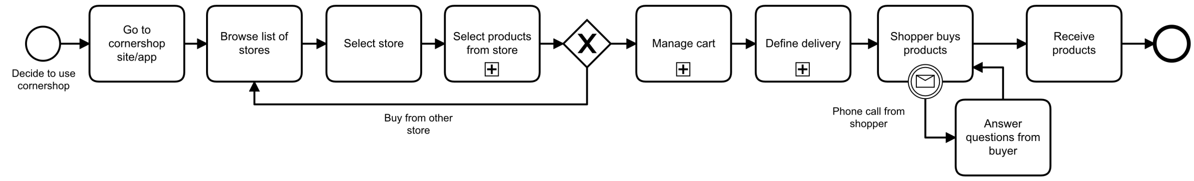
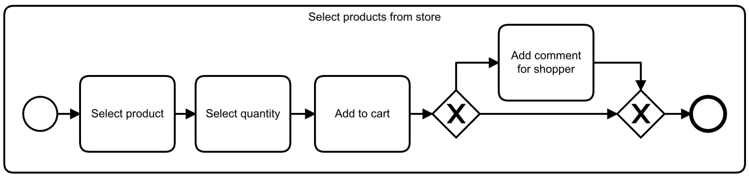
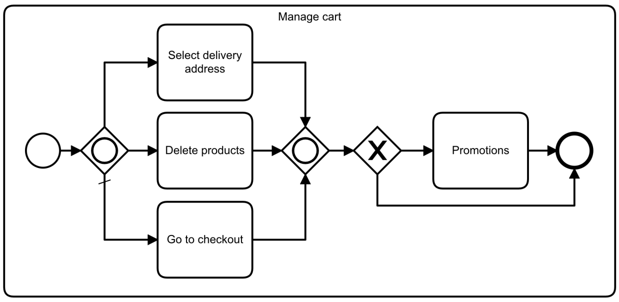
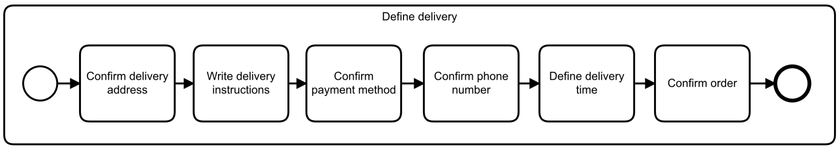
# Appendix A: BPMN model and client's story of Cornershop



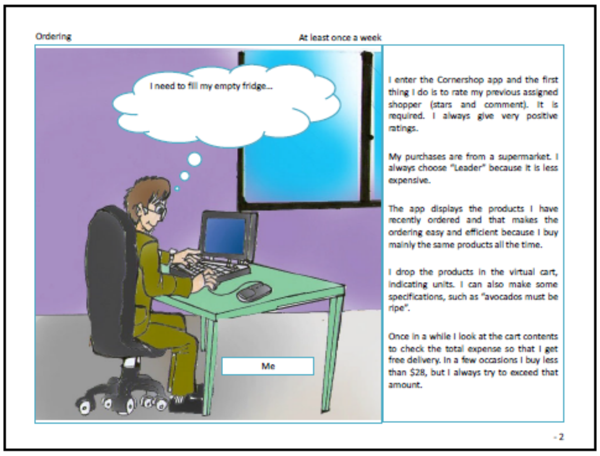



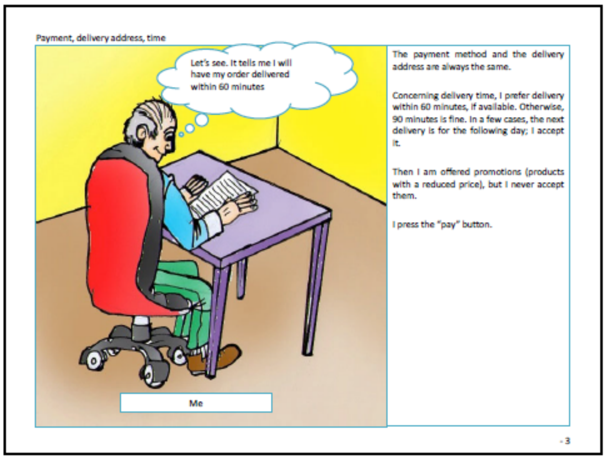



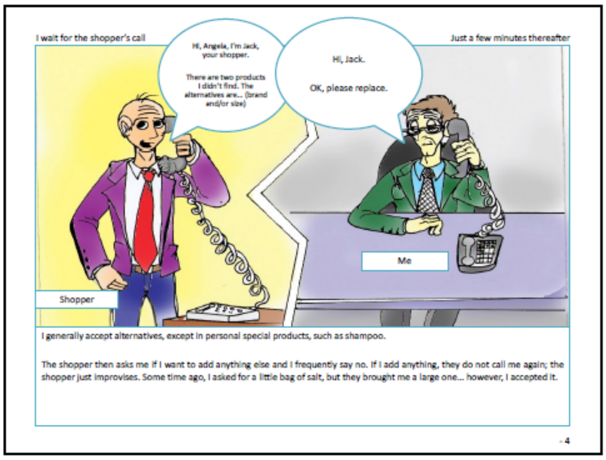



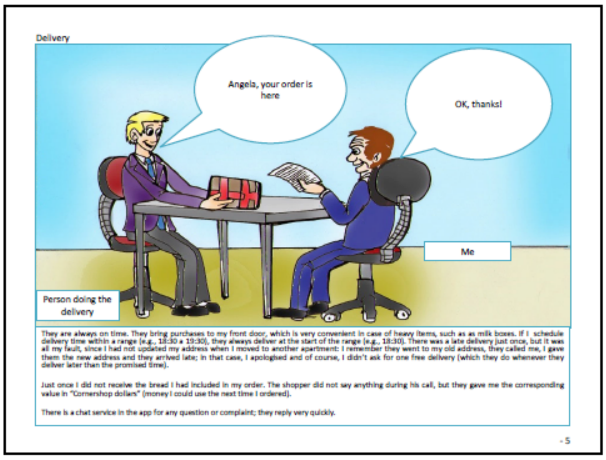

## Introduction

Angela is a young journalist. She is married, mother of two girls. She does not have much time available to do shopping. That was the main explanation of why she became a Cornershop customer… She is a "pop" customer (i.e., she gets free delivery if the purchase value exceeds $28). She uses the service about once a week.







## Appendix B: Evaluation Criteria

The literature discusses various process modeling evaluation frameworks. Some frameworks only consider a material lens. For instance, Lu and Sadiq (2007) develop an evaluation framework that assesses control flow (material lens) using five criteria: expressibility, flexibility, adaptability, dynamism, and complexity. Recker et al. (2009) identify a framework for assessing how process models fit information systems development (material lens), which uses criteria like completeness and clarity.

Other frameworks include the socio-material lens. In particular, De Oca et al. (2015) review the state of the art of process modeling with a focus on success at the organizational level. The authors refer that there is no generally accepted framework for evaluating success, even though two dimensions can be identified: the quality of the end product; and the quality of the modeling process. The authors mention that the most referred criteria for the end product are understandability, maintainability, and effectiveness for the modeling process. Abdel-Fattah et al. (2017) develop an evaluation framework relating organizational needs and process model characteristics. The framework suggests criteria like flexibility and ease of use.

In this study, we focus on two criteria for evaluating process models:

**Model understandability**. Model understandability is the capacity of users to understand a model. The importance of understanding process models has been highlighted by many researchers (Andaloussi et al., 2020; Avila et al., 2020; Corradini et al., 2018; Figl et al., 2020; Reijers and Mendling, 2011; Wang et al., 2022). Lack of understandability increases cognitive load (Mendling et al., 2012), generates problems with procedures and rules (Rosemann et al., 2005), and leads to inefficient executions (Ghani et al., 2008).

**Situation understandability**. Situation understandability is the capability to interpret the situational or contextual factors involved in a process model (Khorasani, 2018; Röder et al., 2015). Users can only effectively utilize process models if they can situate them in the proper internal and external contexts (Vom Brocke et al., 2016). Adequate contextualization is essential for effective decision-making and action. Furthermore, the capacity to adequately and swiftly respond to changes is critical for most organizations (Albuquerque and Christ, 2015; Cognini et al., 2018). Therefore, situation understandability is a highly relevant criterion for evaluating the composite approach.