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Evelyne Batista Duarte

APPLYING A SEMIOTIC ANALYSIS TO BUSINESS PROCESS MODELING

Recife, 2023

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Applying a Semiotic Analysis to Business Process Modelling

Supervisor: Dr. Denis Silva da Silveira

Dissertation presented as a complementary requirement for obtaining a Master's degree in Administration, focus area Information Technology, of the Postgraduate Program in Administration from the Federal University of Pernambuco.

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EVELYNE BATISTA DUARTE

APPLYING A SEMIOTIC ANALYSIS TO BUSINESS PROCESS MODELING

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To the woman who barely finished elementary school, but managed to educate a granddaughter up to her masters, and a grandson to his doctorate. No matter what happens, I love you, grandma.[1]

[1] *Translation*: À mulher que mal terminou a quinta série e conseguiu formar uma neta mestre e um neto doutor. Independente do que aconteça, eu te amo, voinha.

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To my parents who did the impossible so that there was no shortage of food on the table and quality education for their children.

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[2] *Please, allow me to add the aknowledgments in Portuguese in this page, same as done with the inscription, so my loved ones can read and understand how important they were for this work to be completed. Afterwall, research can't be done alone.*

Por fim, não posso esquecer de agradecer a mim mesma, por continuar um dia após o outro me aceitando, perdoando e por não desistir de mim;

“*It is only with the heart that one can see rightly; what is essential is invisible to the eye*.”

Antoine de Saint-Exupery

ABSTRACT

Business Process Modelling (BPM) has been under considerable attention from business and information technology (IT) communities. It is an important asset in the quest to decrease the gap in communication between these two groups. Intending to contribute to decrease this gap, the dissertation presented here executes a *quasi*-experiment to verify whether the signs used as Business Process Modelling Notation's (BPMN) graphical elements represent their semantics. Data was collected in the form of questionnaires with the 104 participants divided in two groups: participants who had previous knowledge of the notation (Phase 1) and those who hadn't had contact with it (Phase 2). This way it was possible to avoid comparative bias between signs already in use by the notation and graphical elements suggested during Phase 1 of research's design operation stage. This data went through a descriptive qualitative semiotic analysis, and hypothesis were tested with the Chi-square test. These analyses have shown that the signs used by BPMN are symbolic signs, thus a generalization constructed by humankind, while participants demonstrated preference for iconic signs, those that share a visual relation to the object they are representing. This demonstrates that semiotically analysing graphical elements, signs, that are going to be used in notations is essential for designing comprehensible business process diagrams.

Keywords: Business Process Models, BPMN, Semiotic Analysis, *Quasi*-Experiment.

RESUMO

A Modelagem de Processos de Negócios (BPM) tem recebido atenção considerável das comunidades de negócios e de tecnologia da informação (TI). Sendo um trunfo importante na busca de fechar a lacuna na comunicação entre esses dois grupos. Com o intuito de contribuir para diminuir essa lacuna, a dissertação aqui apresentada realiza um quase-experimento para verificar se os sinais utilizados como elementos gráficos da Notação de Modelagem de Processos (BPMN) representam sua semântica. Os dados foram coletados na forma de questionários com os 104 participantes divididos em dois grupos: participantes que tiveram conhecimento prévio da notação (Fase 1) e aqueles que não tiveram contato com ela (Fase 2). Dessa forma, foi possível evitar viés comparativo entre signos já em uso pela notação e elementos gráficos sugeridos durante a Fase 1 da etapa de operação do desenho de pesquisa. Esses dados passaram por uma análise semiótica descritiva qualitativa e as hipóteses foram testadas por meio de um teste Qui-quadrático. Essas análises mostraram que os signos utilizados pelo BPMN são signos simbólicos, portanto uma generalização construída pelo homem, enquanto os participantes demonstraram preferência por signos icônicos, aqueles que compartilham uma relação visual com o objeto que estão representando. Isso demonstra que analisar semioticamente elementos gráficos, signos, que serão usados em notações, é essencial para projetar diagramas de processos de negócios compreensíveis.

Palavras-chave: Modelos de Processos de Negócio, BPMN, Análise Semiótica, *Quase*-Experimento.

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List of Abbreviations

BPD	Business Process Diagrams
BPM	Business Process Management
BPMI	Business Process Management Initiative
BPML	Business Process Modelling Language
BPMN	Business Process Model and Notation
DMSL	Domain-Specific Modelling Language
IT	Information Technology
OMG	Object Management Group
YAWL	Yet Another Workflow Language

Table of Contents

1. Introduction

This chapter aims at contextualizing the development of the work presented, as well as the research question addressed. In addition, there are the objectives to achieve and a short description on how this work is organized.

1.1 Motivation

Business Process Management (BPM) is widely used by organizations to promote improvements in business strategies and obtain competitive advantages in the market (DUMAS *et al*., 2018). Moreover, it serves as a valuable tool for eliciting information systems requirements (MENDLING *et. al.*, 2018). From this perspective, business process modelling has been under considerable attention by the information technology (IT) community for a while now, being it always at the centre of organizational design (SCHALLES, 2012).

In essence, BPM involves a set of activities aimed at visually depicting well-grounded models of organizations' processes. This visual depiction enables the analysis, monitoring, and improvement of processes and their overall expected value (DUMAS *et al*., 2018), ultimately leading to increase the quality of products and services. Besides its objective being on understanding, transforming and documenting the business, which, through business process modelling, enables a logical view of the organization's activities.

Business process modelling is a truly interdisciplinary field, drawing from various paradigms and methodologies from diverse areas such as organization management theory, computer science, mathematics, linguistics, semiotics, and philosophy, as highlighted by Ko (2009). Its aim is to build Business Process Diagrams (BPD) with abstract representations of processes, using, for example, technical drawings that depict a network of graphical elements (SINDRE, 2006). These diagrams, serving multiple purposes (such as identifying *who* is offering *what* to *whom* and *what* is expected in return), facilitate communication among various types of stakeholders (HOLT, 2009).

Within this context, a process is defined as a set of activities ordered in time and space, fuelled by resources, aimed at fulfilling specific goals of particular stakeholders, with beginning and end, well-defined inputs and outputs (DUMAS *et al.*, 2018). Thus, a process can be formally documented or defined only informally. But, regardless of their nature, processes have characteristics (various graphical elements) that make them suitable for the use of modelling techniques.

As mentioned, these BPDs are often used for communication with different types of stakeholders. For this communication to be effective, business professionals and other stakeholders need to have a common understanding of the processes (MENDOZA *et al.*, 2018). However, a prevailing challenge is the difficulty to communicate, which may introduce validation errors when a stakeholder incorrectly understands the BPD and accepts a specification that does not meet their needs. This situation can compromise, for instance, the correct specification and implementation of an information system.

The Chaos Report (2018), internationally recognized studies on success rates in IT projects, indicates that one of the main reasons for project failures is the struggle to establish a common understanding between business specialists and IT professionals, which also causes stakeholders' lack of involvement. Besides factors such as socio-cultural background, there is a linguistic disparity between IT professionals and business specialists that affects how they communicate with each other. This disparity can be exemplified by the different acronyms and technical terms in each area, which logically creates a communication gap between these two groups in organizations (EVANS, 2003). As business specialists describe their needs, IT professionals have to replicate those into documentation that can actually be understood by the first so they can help each other clarify requirements. Being extremely costly to projects when this communication is not successful (CAIRE *et al.*, 2013; PRESSMAN, 2014; SOMMERVILLE, 2016). Therefore, it is crucial to establish a shared vocabulary to integrate both universes.

In this context, an analysis and verification of the communication's effectiveness in these BPDs are extremely important factors to ensure alignment between established objectives and achieved results. However, this analysis involves uncertainties, requiring the ability to handle imprecise and vague information while considering different views, attitudes, and opinions of stakeholders.

To evaluate the communicability characteristics of process models, it is necessary to analyse the graphical elements of a Business Process Modelling Language (BPML). However, several notations have been developed to represent process models since the introduction of flowcharts in the 1920s (INDULSKA *et al.*, 2009).

Thus, depending on the particular BPML, different syntactic and semantic constructs are used to represent concepts regarding processes, namely actions, flows of control, data, or resources. Nonetheless, for some time now, the Business Process Model and Notation (BPMN) (OMG-BPMN, 2014) has been the most used BPML among business professionals to describe business behaviour (HARMON; WOLF, 2011). Therefore, in the context of this dissertation, BPMN was the chosen modelling language.

Such use of graphical elements to express meaning is characterized by the use of signs. According to the Merriam-webster dictionary (2023), a sign, among other meanings, stands for a linguistic entity that designates an object and/or relation, or owns an essentially syntactic function. It also signifies a mark that possesses an ordinary meaning and is used in place of words to represent complex notions. Therefore, it is clear that signs do play an important role as artifacts in BPDs.

It should also be noted that the use of signs, although always present, has been growing due to electronic and digital revolutions. This makes it necessary for users to be able to read and discuss them. Peirce's semiotics (2017) equips us with ammunition to study the relation between business process diagrams and their signs, as it deals with definitions and how signs behave, providing an inventory of types and mixtures, both verbal and non-verbal gradations (SANTAELLA, 2018).

Within this context, the present dissertation has its main focus on the quality of communication between stakeholders, here represented by business and IT students and professionals. So, the communication of process models depends on the representation's quality of the signs used as BPML artifacts. Thus, the following research question arises here:

Are the signs used in BPMN *representative for business and information technology professionals*?

1.2 Objectives

In this section, the goals that guide this research are described, transmitted through the general and specific objectives.

1.2.1 General Objective

Considering the context presented here, the general objective of this dissertation is to evaluate how representative the signs used in BPMN are considered by professionals (*e.g.*: business users and software developers) that use this notation. Thus, the objective presented here is to evaluate the impact of signs used in BPMN on the understanding of this notation.

1.2.2 Specific Objectives

The specific objectives of the study, placed as consequence of the general objective, consist of:

- Analyse related work on understanding signs through semiotic analysis;
- Study the semantics of the main BPMN artifacts;
- Define a *quasi*-experiment to be applied to a relevant sample of individuals from the process area (*e.g.*, professionals and students from the business and systems development area);
- Execute the proposed *quasi*-experiment;
- Analyse data collected from the *quasi*-experiment;
- Share findings of the research with the community.

1.3 Text Organization

In order to achieve the objectives proposed by this research, this text is structured from this Introduction in six more chapters. As mentioned, the Introduction is the first chapter. The second chapter presents the main concepts related to the context of this research. The third chapter mentions works related to this research. Fourth chapter relates to the methodological procedures presenting the adopted research design and describing the steps taken in the execution, monitoring and methodological care taken throughout the research. The fifth chapter details the *quasi*-experiment and steps taken in its development. Chapter six talks about the results and discussions. Finally, the seventh chapter brings a summary of the research, its limitations and the proposed future work.

2. Background

This chapter highlights some of the main concepts in the literature considered fundamental for the foundation and development of this dissertation. Thus, this chapter is structured into two main sections: 2.1 Business Process Management and 2.2 Semiotics.

2.1 Business Process Management

Business process management's concept emerged as a possibility to structure and manage organizations, thus meeting the new demands of the globalized market and the strong competition between organizations (SILVEIRA, 2009). It is a set formed by methodologies and technologies, with the objective of enabling the continuous improvement of the management of events, activities, and decisions that add value to the organization and its customers to optimize the results of organizations, bringing countless benefits, such as improving productivity and reducing costs (DUMAS *et al*., 2018).

In this scenario, processes refer to a chain of interconnected events and activities that have an impact on an organization's customers (WESKE, 2012). These processes can be characterized as a well-organized sequence of activities strategically arranged in both time and space, with the purpose of achieving specific objectives for various stakeholders (MELÃO; PIDD, 2000; LU; SADIQ, 2007).

For Gonçalves (2000), a process is any activity, or set of well-defined activities, that follows a certain sequence and depends on others in a clear succession, taking inputs and adding value to them to provide outputs to a specific customer. Based on this definition, it is possible to infer that how processes are designed and implemented can affect the quality perceived by those stakeholders of the process in relation to their efficiency.

These processes are formed by a set of manual or automated activities that occur within organizations. Thus, a process can be defined as a set of sequential activities, whether performed by humans or machines, with an input flow (input), processing, and output (final product/service), to obtain one or more results that add value to a customer (ABPMP, 2015). To corroborate this premise of added value, Alves Filho (2011) states that the process' operational logic must be aligned with the good quality of its products and services.

Thus, organizations perform their work through business processes, using them to add value to their partners and customers, internally and externally, respectively (LAUDON; LAUDON, 2017). In this perspective, processes can also be defined as organizational routines (LAUDON; LAUDON, 2006), which, regardless of their nature, have characteristics that make them suitable for the use of modelling techniques.

Business process modelling is, nonetheless, the set of activities conducted to visually represent qualitatively grounded models of processes so that they can be analysed, monitored, and improved in relation to the expected value (ABPMP, 2015). In this sense, the objective of business process modelling is to build BPDs (WESKE, 2012), which should provide a better understanding of the processes, allowing a more appropriate analysis (RECKER, 2010).

Since BPDs are used to support activities of different stakeholders with varying technical experiences (*e.g.*, requirements analysts, business designers, managers, customers, *etc*.), they must be suitable, among other purposes, to facilitate everyone's understanding. However, stakeholders only understand such diagrams once they are able to explain them (FIGL; LAUE, 2011). In other words, there is understanding when the reader can explain the structure, behaviour, and effects of a BPD within its context. On the other hand, comprehension is not an intrinsic property in a BPD but something that must be considered in its representation by modelling languages.

These diagrams can be used for simple to complex organizational situations. For instance, it is possible to design the process a company uses to hire a new employee, from gathering internal information to the necessity of posting the vacancy, until onboarding the new collaborator. In other words, they ensure that regardless of the person in charge of hiring, the process will be followed exactly as designed, ensuring productivity, efficiency, and transparency.

In summary, a process has characteristics that make it suitable for modelling techniques' use. In this context, process modelling is the set of activities conducted to visually represent BPDs, so that processes can be analysed, monitored, and improved in relation to their expected value. Thus, process models are intended to support the activities of stakeholders with different roles, making them suitable for facilitating communication between these stakeholders (FILIPOWSKA *et al*., 2009; ROSEMANN, 2006; GULLA; BRASETHVIK, 2000).

2.1.1 Business Process Languages

In this dissertation, the modelling languages must represent both the dynamic and structural (or static) aspects of process models, expressing the essential characteristics of all business artifacts. According to Dumas *et al*. (2018), a modelling language should mainly consist of three parts: (*i*) syntax, which defines a set of constructs and rules, describing how constructs can be combined; (*ii*) semantics, which defines the meaning of the constructions defined in the syntax; and (*iii*) the notation, which defines a set of graphic symbols, used in the representation of the business process diagrams.

BPDs are important for documenting business processes and specifying the requirements of information systems under development. Since the introduction of flowcharts in the 1920s (INDULSKA; ZUR MUEHLEN; RECKER, 2008), several notations were developed to represent process models. In Mili *et al.*, 2010, these notations are classified into two categories:

- Semi-formal: languages that share understandability concerns and are amenable to various informal or heuristic analysis, *e.g.*, BPMN (OMG-BPMN, 2014), UML Activity Diagram (OMG-UML, 2017), and Event-Driven Process Chain (EPC) (SCHEER; NÜTTGENS, 2000);
- Formal/executable: languages in which syntax and semantics are precisely defined and/or executable, *e.g.*, Business Process Execution Language (BPEL) (ALVES *et al.*, 2007), Petri Nets (PETRI, 1962), Yet Another Workflow Language (YAWL) (HOFSTEDE *et al*., 2009), and Subject-Oriented Business Process Management (S-BPM) (FLEISCHMANN, 2010).

Hence, semi-formal notations, such as UML, focus on having a defined syntax, while the formal ones have precise syntax and semantics (GUESSI *et al*., 2019). The choice of a notation's formalism, therefore, depends on the main target audience that will interpret the message represented in it.

So, the intention of the research presented here is to understand the role that signs play in the construction of meaning within the context of a semi-formal business language. As they do share concerns with understanding, as stated by Mili *et al*. (2010). Hence, BPMN (OMG-BPMN, 2014) is one of the most comprehensive (INDULSKA; ZUR MUEHLEN; RECKER, 2008) and widely used among process modelling professionals (HARMON; WOLF, 2011).

2.1.2 Business Process Models

Modelling is an economically way of using models, which are results of simplified reality mapping that serve a specific purpose, focusing on a cognitive objective (SILVEIRA, 2009). Within this context, a model is historically defined as a description of the phenomena in a domain at some level of abstraction. Models are commonly simpler and more cost-effective compared to their real-world counterparts (MELLOR, 2004). For instance, a building mock-up serves as a model that allows potential investors to visualize the construction without the need to actually build it, offering a practical and cost-efficient solution for showcasing the intended outcome. Models are a simplification of some concept or situation that intends to observe, manipulate and/or understand. Both aforementioned authors, explain that models must have three qualities:

i. *Formatting* is establishing a representation that can be the model itself;

ii. *Abstraction* is focusing only on the relevant parts of a problem at a certain level of generalization;

iii. *Purpose* is highlighting that models are used by designers in place of the original plan at a given time and purpose.

Thus, as already noted, simplified models that highlight some aspects of a given domain in the detriment of others are particularly useful. Because, as Pressman (2014) reminds us, humans have limited cognitive capacity, it is generally difficult to understand complex environments in their entirety, so using models can help. When understanding is concerned, Reijers and Mendling (2011) believe it is the ability to comprehend the information a model contains, which implies its investigation from two angles: personal factors (related to the reader) and the ones related to the model itself. The understanding of a BPM, then, is a function that relates to characteristics of a model with the readers (stakeholders) who interpret it (MENDLING, STREMBECK and RECKER, 2012).

Therefore, understanding is a prerequisite for stakeholders to perform many tasks, such as: communication, design, organizational reengineering, project management, end-user consultations, among others. Besides that, Figl and Laue (2011) define that stakeholders understand a process model when they are able to explain it, the structure, behaviour and its effects within a context. In summary, business models serve the purpose of abstracting diverse perspectives of a business in a manner comprehensible to both business users and software developers.

The primary focus for business users is not to comprehend the technical intricacies of system creation, but rather to grasp how it will fulfil their needs. On the other hand, business models provide software developers with a more effective means of capturing and conveying their requirements (ALOTAIBI; LIU, 2017; GRUHN; LAUE, 2009). Therefore, it is salutary that efforts are made to impose quality characteristics on process models. In this scenario, to evaluate the representation of graphical elements of process models, this research, as already highlighted, opted to use BPMN models (OMG-BPMN, 2014), given that BPMN has been the most widely used notation by the community for some time (KOSSAK *et al.*, 2014).

2.1.3 Graphic Modelling Languages

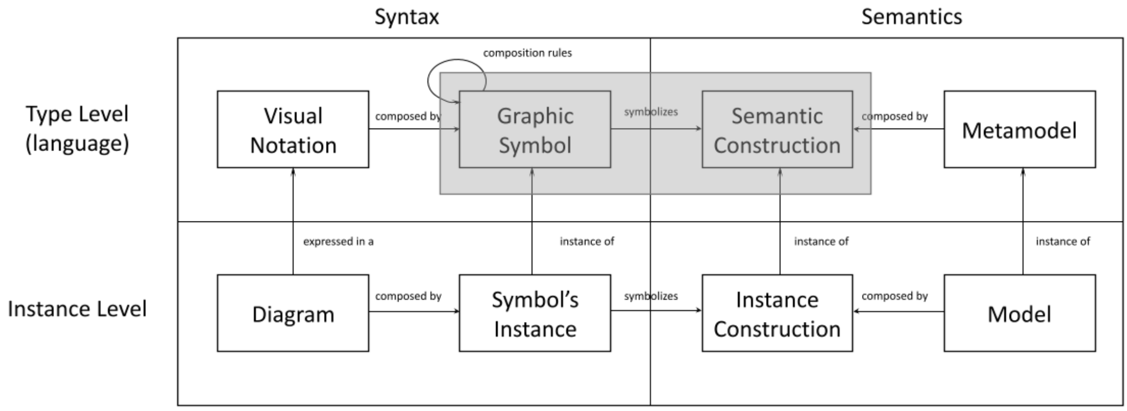
Graphical modelling languages are inherent to software engineering and are used in all phases of the system development process (MOODY, 2009). Figure 1 demonstrates how Moody (2009) focuses on two aspects of graphic languages: (*i*) *syntax*, which involves the graphic signs that constitute its visual vocabulary; and (*ii*) *semantics*, which represents the language composition rules.

Expanding this further, a graphic language must contain a *visual notation*, which consists of graphic symbols set, the language`s visual vocabulary. Also, it has a set of *composition rules* consisting of a visual grammar. Visual vocabulary (*graphic symbols*) along with visual grammar (*composition rules*) form the visual syntax. A graphic language must also contain visual semantics, defining the meaning of each symbol. Graphic symbols are used to symbolize (*e.g.: visually represent*) semantic constructs, their meanings are defined by mapping them to the semantic constructs they represent.

The *diagrams* are valid expressions in visual notations, composed of *instances of symbols*, arranged according to the rules of visual grammar (MOODY, 2009). Finally, symbol instances visually represent the *instance construction*, and therefore they unfold semantics (*e.g.:* meaning) into a *model*.

Finally, Figure 1 summarizes the scope of this research, highlighted in grey. This study is concerned with appropriate semantic constructions to increase stakeholders` cognitive effectiveness. It also represents what is not contemplated by this research: proposals for changes in the visual syntax of the BPMN graphic language. That is, this investigation evaluated the semiotic effectiveness of the graphic signs already defined for the notation mentioned previously.

Figure 1. Syntax and Semantics of Modelling Languages.

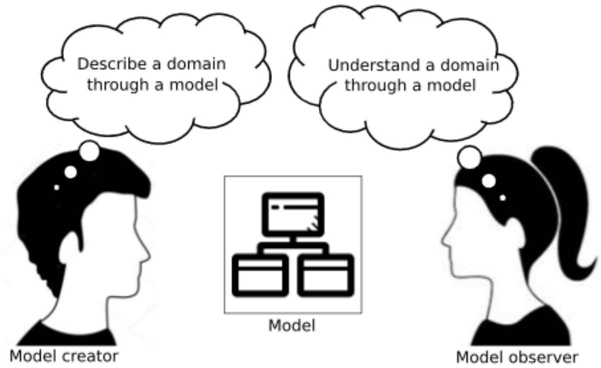


Source: Adapted from Moody (2009).

According to Gemino and Wand (2004), in process modelling, there are always two perspectives to any context, that of the creator (or designer) of the models and that of the observer. The first is responsible for the action of modelling and is concerned with both effort and conception time. These authors also mention that there are different criteria to evaluate the quality of a model, such as accuracy, precision, details, completeness, and correctness. As for the second perspective, it is that of the one who visualizes the model, focusing on understanding it.

Nevertheless, understanding can only be measured indirectly since it is not directly observable. The aforementioned authors say that this measurement can be done through problem-solving tasks, where the designed models must be used, or through context comprehension assessment. As a matter of fact, models from different graphic languages tend to have different interpretation efforts (FIGL; MENDLING; STREMBECK, 2009). However, there are theories that aim at making designs clearer, for instance, Norman's (1986) theory of action. Its premise is to make such a precise design that users would be able to understand it with a simple look. While the creator aims at communicating their understanding of a context through representation in a model. Observers should focus on comprehending the context by interpreting the model proposed.

Figure 2. Perspectives of Norman's Action Theory.



Source: Adapted from Norman (1986).

Norman (1986) calls attention to points of divergence between an individual's understanding of a given context and the model used to represent it. Such a gap can lead to problems both in the creation and interpretation of the models. These discrepancies are classified based on two communication gaps, namely:

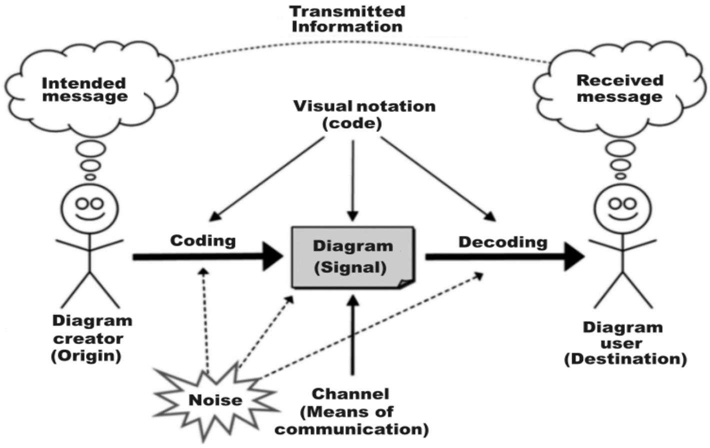
1. An *execution gap* arises from differences in the context conception from the model creator's point of view with what it should actually represent. In other words, there is a non-conformity between what one intends to model and what is actually modelled. These disparities can come from: (*i*) the modelling language lacking semantic elements to express the context; (*ii*) the creator's inability; or (*iii*) the creator misinterpreting the context;
2. An *assessment gap* arises from the divergence between the interpretation of the model in relation to its context. Mainly, the observer does not adequately understand the model. In this case, the main reasons for the discrepancy are: (*i*) lack of experience with the modelling language, leading to misinterpreting the model; (*ii*) observer's confusion, resulting in a different understanding of the context represented; or (*iii*) the existence of ambiguities in the representation.

To be able to increase communication effectiveness through graphic languages, it is necessary to understand how graphic languages communicate. Moody (2009) proposed the theory of communication through graphic languages, based on the mathematical theory of communication by Shannon and Weaver (1971). Moody (2009) and Norman (1986) agree that two individuals should be involved for communication to occur using a graphic language.

As illustrated in Figure 3, there is a *diagram creator* (*i.e.*: sender) who encodes information (message) in the form of a *diagram* (*i.e.*: signal), and the *diagram user* (i.*e.*:

receiver) who decodes this signal. The diagram is coded using a *visual notation* (*i.e.*: code), which defines a set of conventions that both the sender and receiver understand. Therefore, when there is no such mutual understanding, there is a comprehension problem causing communication gaps. The *channel* (*i.e.*: means of communication) is the physical form in which the diagram is presented, for example: paper, whiteboard, or device screen. And *noise* represents a random variation in the signal that can interfere with communication (*i.e.*: gaps). The effectiveness of communication is measured by the correspondence between the intended message and the received message (*i.e.*: *transmitted information*). Therefore, communication consists of two complementary processes: *encoding* (*i.e.*: expressing) and *decoding* (*i.e.*: interpreting).

Figure 3. Graphic Modelling languages' Communication Theory.



Source: Adapted from Moody (2009).

The coding process, carried out by the diagram's creator, explores the available alternatives for coding information through graphic languages (MOODY, 2009). Whilst decoding explores how graphic languages are processed by the human mind. According to Avison and Fitzgerald (2003), graphic languages play a particularly critical role in communication between stakeholders, as they convey information more effectively to non-technical people than text. Visual representations are effective because they exploit the powerful human visual system capabilities; human beings can receive and efficiently process visual information (KOSSLYN, 1985). For physiological reason, about a quarter of the human brains is devoted to vision, more than all other senses together. In addition, models can convey information more concisely (DE MARCO, 1978) and more accurately than common language (BERTIN; 1983, LARKIN; SIMON, 1987).

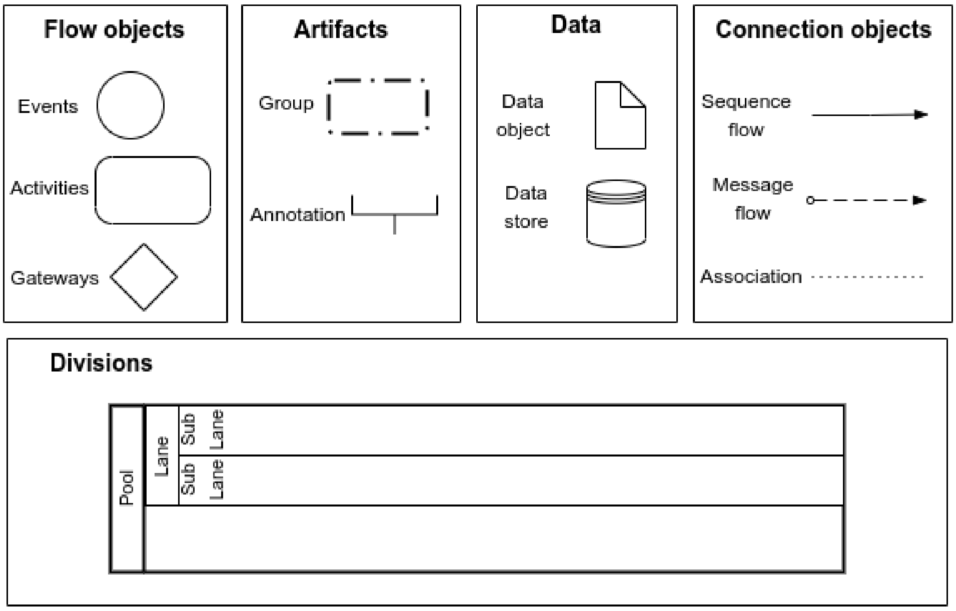
2.1.4 Business Process Modelling Notation

Correia (2014) recalls that the elements used in modelling notations must preserve their intended levels of abstraction. Hence, elements in a certain semantic domain must match the abstraction level of their equivalent modelling concepts, so exact and valuable semantics are paramount. This means that for modelling notations to be comprehensible for all stakeholders the meanings should be linked to well-formed syntactic structures. The same author emphasizes that, although there are standards which can be consulted for the usage of each element, such as rules on how to connect them to each other, there are no explicit instructions on how to use the notation to create meaningful BPMN models.

BPMN (OMG-BPMN, 2014) mainly aims at business users and software developers to collaboratively design, deploy, and monitor business processes. In its version 2.0, as well as its previous versions, it focuses on presenting a notation that is understandable for all stakeholders (WHITE; DEREK, 2008). This broad coverage of stakeholders (analysts, designers, developers, and managers) results in a greater need for understanding (MENDOZA *et al*., 2018). Thus, the main objective of the BPMN language is to produce understandable documentation of BPMs, allowing business designers to develop graphical representations of business processes that can be interpreted by different stakeholders (OMG-BPMN, 2014).

Created by the Business Process Management Initiative (BPMI), incorporated and maintained by the Object Management Group (OMG), BPMN has been adopted as an ISO standard (ISO 19510, 2013). It also meets the requirement of using a notation that guarantees a certain level of sustainability. Even though it offers a wide range of modelling elements, BPMN defines a basic set of core elements that simplify modelling and understanding complex business processes. According to Kossak *et al.* (2014), this language in what concerns symbology is rich in notation, turning it into an expressly complex grammar. Its artifacts can be mainly divided into five groups, demonstrated in Figure 4, with the graphical representation of the main artifacts in each group (OMG-BPMN, 2014).

Figure 4. Core elements of BPMN.



Source: adapted from zur Mühlen and Recker (2008).

Description of each group according to the OMG (OMG-BPMN, 2014) is, following, presented:

- Flow Objects are the most basic elements that define the actions to be taken by the process flow. These elements fall into three categories: `events`, `activities`, and `gateways`;
- Artifacts are the elements used to provide additional information to processes. These elements fall into two categories: `group` and `text annotation`;
- Data are the elements that represent both the physical items and the information related to the execution of the processes. These elements fall into six categories: `data object`, `data store`, `data input`, `data output`, `input set`, and `output set`;
- Connecting Objects are the elements responsible for making the connections between the elements arranged in the workflow. Connection objects fall into four categories: `sequence flow`, `message flow`, `association` and `data association`;

- Swimlanes are the elements that help to group and organize elements into separate categories for different functional responsibilities. They can be catalogued in two categories: `pools` and `lanes`.

Within the categories, additional information can be included without radically changing the visual identity of these elements. BPMN is, therefore, an expressive and broad language, possessing almost 100 different modelling constructs, including, but not limited to, 5 `subprocesses`, 9 `tasks`, 6 `gateways`, 5 `data`, 3 `sequence flows`, besides 3 `activity` markers, and 51 `event` types (OMG-BPMN, 2014). However, studies point out that most designers often resort to only a limited subset of 14 graphical elements (KUNZE *et al.*, 2011; CHINOSI; TROMBETTA, 2012; zur MÜHLEN; RECKER, 2008).

The next sections will bring a discussion on the elements specifically used in this research's *quasi*-experiment.

2.1.5 Flow Objects

As `Flow objects` are the main graphical elements that define the behaviour of a business process, they are divided into three subcategories so that designers and/or readers of BPMN models do not have to learn and/or recognize many different elements: `Event`, `Gateway`, and `Task`.

2.1.5.1 Events

`Events` are used to highlight an interaction with the environment external to the process, but they can also describe internal interactions and extraordinary situations that require some kind of treatment (KOSSAK *et al.*, 2014). They are graphically represented by circles, whose interior is normally used to indicate their semantics. They can be triggered by internal or external factors, and when waiting for a trigger to happen, it is of the `Catch Event` type. When they signal the trigger for an event to happen outside or inside the process, it is of the `Throw Event` type (OMG-BPMN, 2014).

Triggers represent what happens at a certain moment of the process' control flow and have information associated with that `event`. For instance, senders and receivers, error codes, messages, or data sent when `events` are triggered (KOSSAK *et al*., 2014). There are three types of `events` (OMG-BPMN, 2014), as shown in Figure 5:

i. `Start Event` indicates the beginning of the process;

ii. Intermediate Event occurs during the process and may be of the Intermediate Catch Event (capture) or Intermediate Throw Event (release) types;

iii. End Event indicates the end of the process.

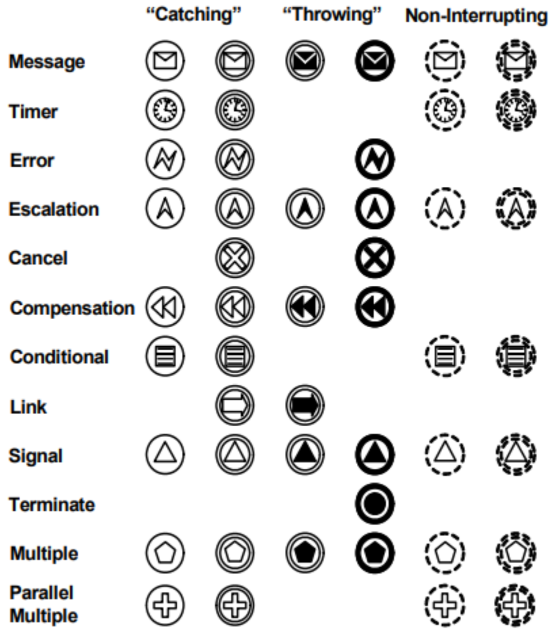
Figure 5. Graphical representation for event types.

Source: Adapted from OMG-BPMN (2014).

In general, intermediate events are connected to Tasks (activities) through Sequence Flow connectors, presenting events that occur between activities. However, an intermediate event can also be defined to occur during a specific activity; when that happens, the intermediate event is attached to the activity's border and is named a Boundary Event.

Every event should have a definition that describes, among other things, the behaviour of these events. For example, a message event must have a definition (Message Event Definition) that specifies to whom the message is sent or by whom it is received. The definition for an error event (Error Event Definition) should describe the possible reasons for the occurrence of errors during the process. The definition of time event (Timer Event Definition) must specify the period or exact instant of time for its occurrence. Similarly, the definition of a conditional event (Conditional Event Definition) must describe the condition(s), possibly a business rule(s), which must always be tested as true (OMG-BPMN, 2014). Figure 6 illustrates all the graphical representations for the types of events and their respective variations according to definitions.

Figure 6. Graphic representation for BPMN 2.0 events.

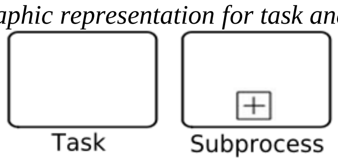


Source: OMG-BPMN (2014).

2.1.5.2 Activities

The `activity` is a generic element that represents actions performed during a process. These actions can be performed by a human, a machine or a system (OMG-BPMN, 2014). `Activities` can be specialized in `Tasks`, that are represented in atomic activities or as `Subprocesses`. `Subprocesses`, in turn, represent activities composed of other BPMN elements, visualized in their contracted or extended form. Following, there is the graphical representation for `task` and `subprocess` (Figure 7).

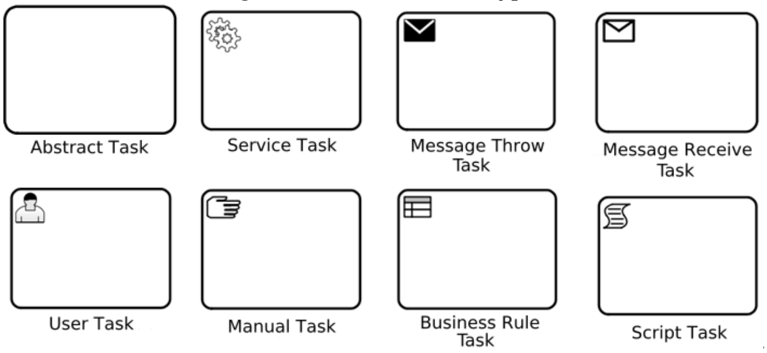
Figure 7. Graphic representation for task and subprocess.



Source: Adapted from OMG-BPMN (2014).

According to OMG-BPMN (2014), there are different types of tasks, each represented by a stereotype located in the upper left corner of the task. These stereotypes represent the possible behaviours that a task can have. Figure 8 presents the graphical representation for the stereotypes available in BPMN 2.0.

Figure 8. Activities stereotype.



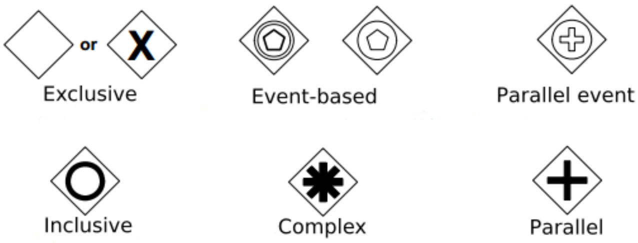
Source: Adapted from OMG-BPMN (2014).

A `task` that does not have a specified type is called an `Abstract Task`, commonly seen in BPMN designs. A `Service Task` is an activity that uses some type of service, such as a Web service or an application. The `Send Task` represents the action of sending a message to a participant external to the process, and once the message is sent, the task is completed. The `Receive Task` represents the action of waiting for a message that arrives from a participant external to the process, and once the message is received, the task is completed. A `Manual Task` represents an action performed without the aid of any execution mechanism or application. A `User Task` stands for an action performed by a human with the aid of a software. A `Business Rule Task` represents an action involving a specific business rule for the domain. Finally, a `Script Task` represents the action of executing a script.

2.1.5.3 Gateways

In the OMG-BPMN reference manual (2014), `Gateways` are mentioned as controllers of the process paths. They control separation (forking) and joining of the process paths, represented visually by a diamond (Figure 9). Similar to `Events`, `Gateways` have internal markers that indicate the behaviour of the flow control (WHITE; DEREK, 2008). `Gateways`, like `Tasks`, have the capability of consuming input `tokens` and/or generating output `tokens`, thus defining the execution semantics of a process (OMG-BPMN, 2014).

Figure 9. Graphical representation for types of gateways.



Source: adapted from OMG-BPMN (2014).

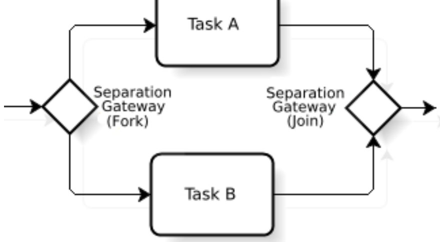
Other business process modelling languages use different elements for forking and joining paths, such as YAWL (VAN DER; HOFSTEDE, 2005). However, BPMN has the same element for both separation and joining of paths.

2.1.5.4 Exclusive Gateway

The `Exclusive Gateway` forking element denotes a question that is asked at a specific point in the process (OMG-BPMN, 2014). This question must have a finite set of alternatives, each alternative having an associated *boolean* expression that must be exclusive to others to indicate, if true, the `sequence flow` for the process to continue its execution. That is, the `exclusive gateway` has the semantics to allow following only one of the valid paths. Therefore, the joining element of this type of `gateway` indicates the point where paths are unified, receiving only the `token` from the path assigned as true.

In other words, the `gateway` element indicates the execution sequence of a process through the `token` stream. It's important to note that a `token` is a theoretical concept used to assist in defining the behaviour of a running process, determining the execution sequence of its elements. For didactic purposes, in this work, the token(s) are represented as circles coloured in red to visually indicate the path taken in a business process. The graphical representation of the types of gateways existing in BPMN is shown below.

Figure 10 Visual representation for split (fork) and join (join) gateway.



Using exclusive gateways can generate a deadlock, preventing the process from continuing. This possibility occurs when all the expressions are considered impediments (tested as false). In that case a default path can optionally be defined to allow the process to continue. The graphical representation for the Default Path consists of a line (cut) over the sequence flow that originates the path. The conditions are mutually exclusive so that the process follows only one path, and if none of the conditions are met, the process follows the path with a line in the sequence flow, indicating that it is the default path.

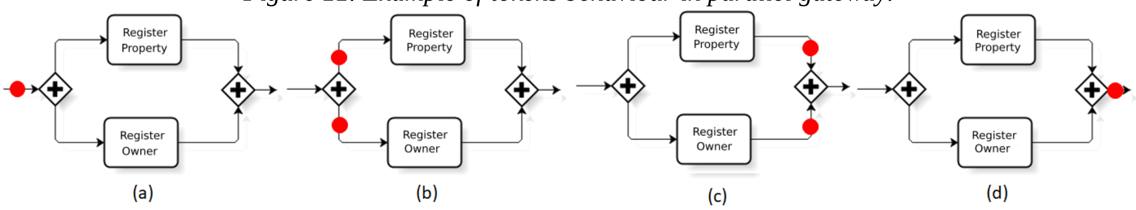
Although there are different possible paths to be followed when this gateway is used, the flow can only pursue a single path. Therefore, from the fork gateway a single token is generated, and it follows the sequence flow that has its condition met (expression tested as true), otherwise it should follow the flow led by the default path (the one with the line). Finally, the join gateway merges the possible paths.

2.1.5.5 Parallel Gateway

The Parallel Gateway denotes situations where activities are performed in parallel. In other words, each path coming from this parallel gateway receives a different token. This gateway's junction element must wait for all the tokens before continuing to execute the rest of the process. As shown in Figure 11, the sequence flow (i.e.: the arrow) preceding the separation parallel gateway has a single token. When the token reaches the parallel separation gateway, it is consumed, and two output tokens are generated. Each path receives one token, and they are separated into two tasks. Subsequently, the token is consumed by the join parallel gateway.

It is important to mention that a parallel gateway may have as many parallel flows as the designer deems necessary, with a minimum of two paths. However, for the process to continue, all of the tokens must reach the join parallel gateway. In other words, if even a single task is not performed when there is a parallel gateway, it will result in a deadlock state.

Figure 11. Example of tokens behaviour in parallel gateway.

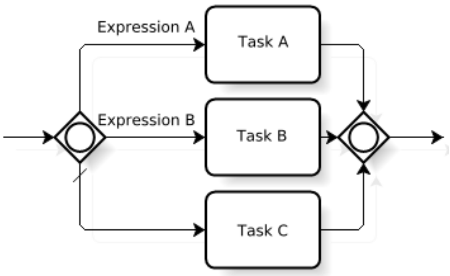


Issues with synchronism are frequently encountered when `parallel gateways` are involved, and modelers should take this into consideration. In the example shown in Figure 11d, it is apparent that only one `token` should exit the join `parallel gateway`, indicating the end of parallel paths.

2.1.5.6 Inclusive Gateway

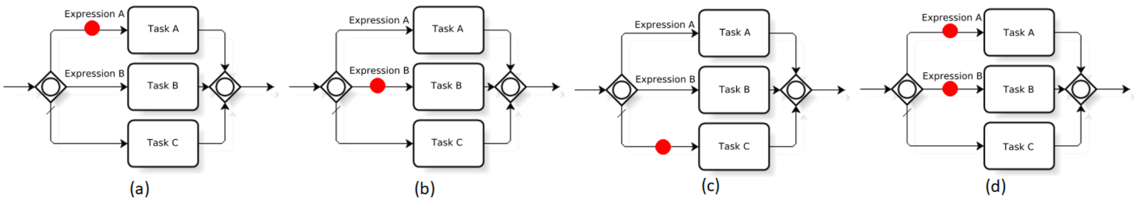
Similar to the `Exclusive Gateway`, an `Inclusive Gateway` denotes a question and also presents both join and split elements. The main difference is that there may be more than one true answer at the same time for an `inclusive gateway`. In other words, this `gateway`, depending on the situation, may be used to express exclusive and/or parallel paths. Hence, for each expression met, a `token` should be assigned to the corresponding path executed. Besides the mentioned similarities, it is also a good practice to ensure a `default path` that should be followed in case no valid expression exists.

Figure 12. Example of an Inclusive Gateway.



This `gateway` also includes a convergence element to join all paths, in other words, it represents the wait for the execution of all paths previously separated. It is important to note that `inclusive join gateways` must wait for all `tokens` to be checked before the execution of the process can continue. Checking the `tokens` means that only expressions considered true will be included in the flow. In this case, the number of `tokens` running at the same time depends on the number of true expressions.

Figure 13. Example of possible flows with the Inclusive Gateway.



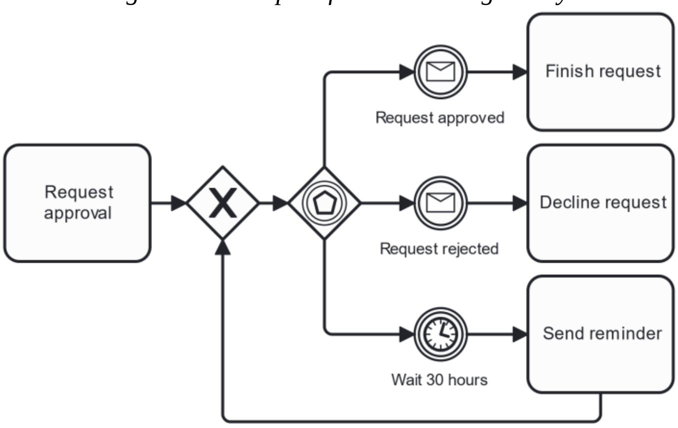
In the example (Figure 13), there are four possible scenarios for how the `inclusive gateway` interferes with the `token`'s path. First, Figure 13(a) indicates the exclusive path, where *Expression A* is true, and *Expression B* is false. Once an expression is met, the default condition does not have a `token`. Second, Figure 13(b) indicates another exclusive path, where *Expression B* is true, and *Expression A* is false. Since an expression has been satisfied, the `default path` is not executed. Third, Figure 13(c) indicates the possible path where both *Expression A* and *Expression B* conditions are false at the same time, so the default path is executed. Finally, Figure 13(d) indicates the possibility where both *Expression A* and *Expression B* conditions are true, thus being executed in parallel. As mentioned, when an expression is met, the `default path` is not executed.

2.1.5.7 Event-based Gateway

The `Event-Based Gateway` denotes the performance of distinct flows that depend on some external response to the process. In other words, this `gateway` represents a point of divergence where the paths are associated with an event rather than a condition. So, only when this event from outside is received, the path to be followed is determined.

There are two types of `Exclusive Event-Based Gateways` that depend on the received event to decide which path the process is going to follow: `gateway based on exclusive initial event` and `gateway based on exclusive intermediate events`. Their names are already an indicative of the type of `event` they depend on. The one based on initial events allow different process beginnings according to different events arrivals. This is demonstrated from the example in Figure 14, where the process may continue after the request is approved, the request is rejected, or after waiting 30 hours without a reply. For each of these `events`, different actions may be performed as `tasks` later; hence, the `token` will follow different paths.

Figure 14 Example of Event-based gateway.

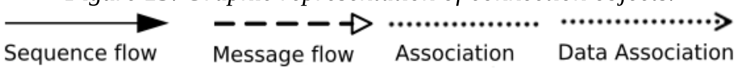


As it can be seen, incoming events are explicitly treated as intermediate events. Therefore, when the first event occurs, the path indicated by it must be followed and all remaining paths are no longer valid. Consequently, the path chosen is the one with the event triggered first. On the other hand, gateways with parallel events are also characterized by event occurrence. However, in this case, when the first event is triggered, the other events are not disabled. Instead, the other paths wait for events before the process can be completely finished.

2.1.6 Connection Objects

Connection objects are used to connect elements in a process (WHITE; DEREK, 2008). As previously commented, there are four types: Sequence Flow, Message Flow, Association and Data Association. Their graphical representations are following presented (Figure 15).

Figure 15. Graphic representation of connection objects.



Source: Adapted from OMG-BPMN (2014).

2.1.6.1 Sequence Flow

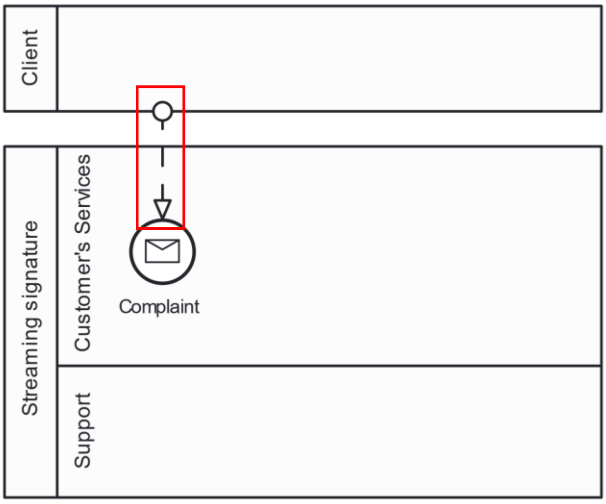
Sequence flows are used to represent the execution order of flow objects in the process, always having a flow object *(i.e.*, Events, Activities, and Gateways) as source and another target object (OMG-BPMN, 2014). It is important to emphasize that the control for the execution of the process is achieved by transferring tokens through this type of flow. A sequence flow can optionally have an expression which, if true, allows the process to continue to the target flow object associated with the Sequence Flow (WHITE; DEREK, 2008).

2.1.6.2 Message Flow

The Message Flow represents the communication between two participants that are able to exchange information. It is often used to indicate communication between pools or between a pool and a Task or Event. Pools can represent processes or participants external to the process (OMG-BPMN, 2014). For instance, in Figure 16, a

`Message Flow` indicates the exchange of communication between a client and the customer's services of a streaming company.

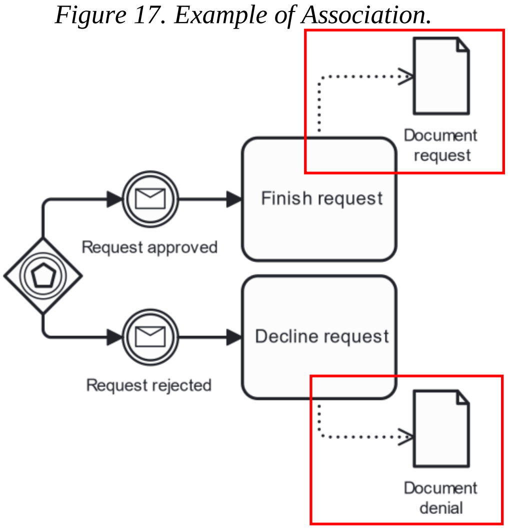
Figure 16. Example of message flow.



2.1.6.3 Association and Data Association

`Association` is used to represent a relationship between artifacts and `Flow Objects`. `Associations` can, for example, be used to link a `text annotation` to flow elements (WHITE; DEREK, 2008). Additionally, there is the `data association`, which represents the exchange of data between `Flow Objects`, indicating, for example, the `input` and/or `output data` of an `activity`. Figure 17 exemplifies a `data association`, used to indicate input or output, in other words, the production or consumption of a `Data Object`.

Figure 17. Example of Association.



2.1.7 Swimlanes

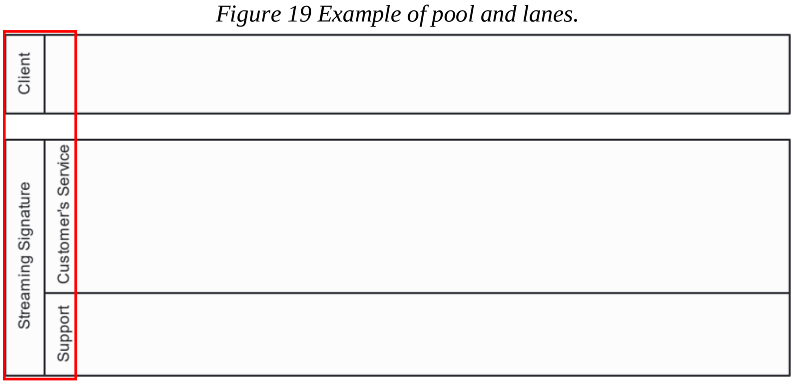
`Swimlanes` help to group and organize BPMN elements, they consist of two division elements: `Pools` and `Lanes` (Figure 18). A `Pool` is the graphical representation of a process or a participant external to the process. It can be subdivided into `Lanes`, where each `lane` represents an internal participant in the process. `Lanes` contain a set of BPMN elements.

Figure 18. Graphical representation of pools and lanes.

Source: Adapted from OMG-BPMN (2014).

In the following example (Figure 19), it is possible to see two `pools` representing the *Client* and the *Streaming Signature* process. The `pool` representing the *Client* is outside the process, and is represented without any internal BPMN elements, making it an empty pool. This indicates that the behaviour of an external participant cannot be predicted or modelled within a process.

Figure 19 Example of pool and lanes.



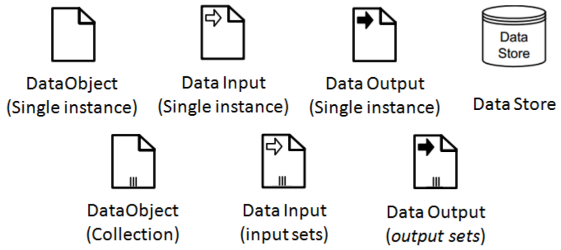
Sequentially, the process' `pool` is subdivided into 2 `lanes`, which graphically represent 2 internal participants in the process, namely: *Support* and *Customer's Services*. Within each lane there should be flows and activities, thus indicating the fragments of the model assigned to each internal participant.

2.1.8 Data

As already mentioned, a process has activities that require and/or produce some data/information in its processing (GONÇALVES, 2000). According to OMG-BPMN (2014), an essential requirement for BPMs is the ability to model items, both physical and information, that are created, manipulated and used during the process performance. BPMN fulfils this requirement through various graphical elements.

The elements that represent data in a BPMN process are: `Data Object`, `Data Store`, `Data Input`, `Data Output`, `Input Set`, and `Output Set`. All of them are graphically illustrated in Figure 20.

Figure 20. Graphical representation of Data.



Source: Adapted from OMG-BPMN (2014).

2.1.8.1 Data Object

The main element for data modelling is the `Data Object`. The lifecycle of a `data object` is directly linked to the lifecycle of the process or its `subprocess`. Thus, when the process or subprocess are instantiated, all `data objects` contained therein may also be instantiated depending on their contexts. Likewise, when the `process` or `subprocess` is terminated, all `Data Objects` are also terminated.

The same `Data Object` might appear several times in the same process. But, each of these appearances only references a single instance of that element. In other words, several occurrences of the same `Data Object` in a process diagram are allowed to simplify its connections. The `data object` reference is a way to reuse the same item multiple times in the same model; and it is often used to specify different states of the same `Data Object` at different points in the model.

2.2 Semiotics

Understanding semiotics can be a bit challenging. When trying to define it, there is a chance to make the mistake of limiting it to the study of signs (road signs, star signs, *etc*.). However, in reality, it is broader because it includes not only visual signs but also drawings, paintings, photographs, words and body language. There's no doubt it is a diverse phenomenon, and according to Chandler (2007), even semioticians diverge on its definition. The author goes on by saying that semiotics not only involves signs from everyday speech, but anything that represents something else. To put it in other words, take the example of the famous words from the *Le Petit Prince* (The Little Prince), children's book by Antoine de Saint-Exupéry:

> "J'ai montré mon chef d'œuvre aux grandes personnes et je leur ai demandé si mon dessin leur faisait peur.
> Elles m'ont répondu: 'Pourquoi un chapeau ferait-il peur?'
> Mon dessin ne représentait pas un chapeau. Il représentait un serpent boa qui digérait un éléphant. J'ai alors dessiné l'intérieur du serpent boa, afin que les grandes personnes puissent comprendre. Elles ont toujours besoin d'explications."[3] (SAINT-EXUPÉRY, 2007)

As the little prince interacts with the grown-ups, showing them what he designed to be a scary picture, he is surprised by their interpretation that the drawing is a hat. This is an example of noise in communication between the design's creator and its user/observer (MOODY, 2009; NORMAN, 1986). He tries to provide a detailed explanation and convey his message by redesigning the code to make sure the end users (grown-ups) understand that it does indeed relate to a boa constrictor digesting an elephant and not a hat. This simple example taken from a book written for children can relate directly to the studies of business process models and semiotics. As previously mentioned, modelling languages should consist of syntax, semantics, and the notation (DUMAS *et al*., 2018), whereas semiotics studies how the signs are a part of semiotic sign-systems (syntax), as a medium or genre, studying both how meanings are made and reality represented (semantics) (CHANDLER;2007).

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[3] I showed the grown-ups my masterpiece and asked them if my drawing scared them. They answered: "*Why would a hat be scary*?" My drawing did not represent a hat. It represented a boa constrictor digesting an elephant. I drew, then, the inside of the boa constrictor, so the grown-ups could understand me better. They always need detailed explanations. (Our translation)

There is evidence of references to semiotics as a branch of philosophy dating back to the seventeenth century; however, the two main streams studied are those of Saussure and Peirce (CHANDLER, 2007; PRIOR, 2014). Both worked independently but are considered co-founders of the umbrella concept known as semiotics. So, it is important to highlight that the general concept of semiotics and Peirce's studies, even though carrying the same name, do have some differences. While Saussure's semiology is a science that studies signs as part of social life, Peirce's semiotic is the doctrine of signs closely related to logic (CHANDLER, 2007; PRIOR, 2014).

Languages and signs are not a new area of study, of course. There have been records that date back to Greek times, but its concern as a science of signs, signifying and culture begins in the twentieth century, then named semiotics (SANTAELLA, 2018). Semiotics is, therefore, a plural field that aids analysing signs in different areas such as cinema, marketing, language arts. Its aim is to understand the world around us, reflect about our surroundings and ourselves to help make it better. Santaella (2018), for instance, brings a plethora of examples of applied semiotics, one of those being what semiotic factors are capable of maintaining the brands *Coca-Cola Zero* and *Coca-Cola light* in the mind of consumers throughout the years. Mostly, what the analysed campaign semiotically expresses in terms of typology, colours and publicity material, because these are semiotic aspects (SANTAELLA, 2018).

Other differences between the co-founders' strands are that saussurean semiology is in search of organizing the meanings the mind produces, even though essentially meaningless, following mostly a structuralist, modern philosophy (CHANDLER, 2007; PRIOR, 2014). Therefore, it is concerned with understanding its own laws and hidden mechanisms, signs are formed by a signifier, its material part and acoustic image, and by a signified, its conceptual, and mental sphere. He also bases his studies on dichotomies, while Peirce preferred to explain his logic through triads (DEELY, 1990). Not basing its principal focus mainly on human language and speech, Peirce's semiotics intends to see semiosis much more as a broader and fundamental process, involving the physical universe in human semiosis to make it part of nature's semiosis (CHANDLER, 2007; PRIOR, 2014; DEELY, 1990; NOVAK; BRANDT, 2017). Intentionally trying to coin such general sign concepts that any science could be based on this semiotics (DEELY, 1990; NOVAK; BRANDT, 2017).

Peirce's strand was the selected one for the study here performed for being the semiotics which aims to be applied in different study fields. But mostly for its work on the representation of objects into their abstraction in the form of symbols, indexes, and icons.

2.2.1 Peirce's Semiotics

Peircean semiotics (PEIRCE, 2017) is not an especial or specialized science with empirical tools to be applied in research (as biology, physics, or economy). It isn`t also special as linguistics and other semiotic streams that come from it. Instead, it is part of a bigger philosophical structure, grounded in phenomenology, encompassing disciplines characterized by their generality and abstraction, alongside aesthetics and ethics. Even though some might believe that it is solely about signs and their meanings, it is actually about developing logic as a general, formal, and abstract investigation methods used in many sciences (SANTAELLA, 2018).

As previously mentioned, Charles Peirce (2017) explains that semiotics can also be understood as the study of logic in the doctrine of signs. Through abstraction, one apprehends what should be the characters of signs used by a scientific intelligence. This apprehension is done via experience; thus, the abstraction is primarily an observation exercise, making this process similar to mathematical reasoning. To answer a given question, it is necessary to analyse its interior (abstractive observation) and within imagination, make considerations, examinations, analysis, summaries, and sketches. Somehow, making hypothetical modifications to complete the information.

A sign (or *representamen*[4]) is that which represents something to someone, creating in people's minds an equivalent or even more developed sign. The sign thus created is, therefore, called the interpretant of the first one, and the object is what is represented (PEIRCE, 2017). It is important to understand that signs do not necessarily represent objects themselves, but their ideas. The sign is connected to three elements: the foundation, the object, and the interpretant (PEIRCE, 2017). This leads the science of semiotics to a division into three branches:

- <u>Speculative Grammar,</u> also known as pure grammar, serves to determine what must be true regarding the *representamen* used in order to incorporate any meaning;

[4] The term "*representamen*" is a key concept in Charles S. Peirce's semiotics and refers to the element or object that represents or refers to something. It is the physical or perceptible form of a sign, such as a word, an image, or an object, that is interpreted as representing something for an interpreter.

- Logic is the science that tries to make *representamen* true in relation to any object. Meaning, this is the formal science of the representations' truth conditions;
- Pure rhetoric aims at determining the generalizations by which a sign originates another, especially when one thought entails another.

It should be noted that these are the basis of semiotic studies. It is not possible to separate speculative grammar from logic, for instance, because they will always be connected in creating meaning. However, in this dissertation, the focus is on logic, trying to understand whether a representamen does represent its object or not in the context of BPMN.

A sign is a perceptible or barely imaginable object, or even unimaginable in a given sense (PEIRCE, 2017). For instance, "*star*" is an unimaginable sign because it is not the actual word that can be transposed on paper or pronounced, but only one of its aspects. It is impossible to actually represent the form of a star into paper. Also, this same sign can have different meanings: the mass of astronomical material or an extremely famous person. Hence, the relationship between a sign and its object is complex to the point that a sign can be part of another sign, or a sign can have more than one object. The key is to understand that when a sign is different from its object, there must be some explanation in the thought, context, or argument that shows how, according to what system or for what reason the sign represents such an object or set of objects. Therefore, every sign must have, real or virtual, a precept of explanation (PEIRCE, 2017).

As for the objects, they can be a singular element, or a set, existing and known, or believed to have existed or expected to come into existence. Objects can also be a quality, relation, or known facts that do not prevent the denial of an act to come to existence (PEIRCE, 2017). Representing is to be in place of, meaning to be in a relationship with another who, for certain purposes, is considered by some to be that other.

2.2.2 Triadic Relations

The triadic division is used to explain Peirce's theory (PEIRCE, 2017) and how it fits into the study of phenomenology. The first triad mentioned is as follows:

- Comparison triadic relations are part of logical possibilities nature;
- Performance triadic relations are part of real facts nature;

- Thought triadic relations are part of the nature of laws;

This triadic division helps to understand the nature of the signs facilitating their interpretation and deepening their scientific analysis. Another triad presented in the theory is the concept of the correlate, that is somehow similar to the mathematical truth table that aims to logically understand propositions, they are, according to Peirce (2017):

- First correlate is of a simpler nature, possible when one of the three elements is possible, and it is law only when all three are a law;
- Second correlate is of medium complexity; if any two elements are of the same nature, then the second correlate is of the same nature. If all are of different natures, this correlate is a real existence;
- Third correlate is considered the most complex, being law when any element is law, and a possibility when all are also possible.

These triadic relationships are further divided into three modes and ten classes (PEIRCE, 2017), which, in turn, will have their own divisions. A *representamen* in the first correlate of a triadic relation, can be the object in the second correlate, and the interpretant in the third correlate. It is determined that, by a triadic relation, the interpretant can be the first correlate of the same triadic relation concerning the same object and for a possible interpretant. A sign, in turn, is a *representamen* of which some interpretant is the cognition of a spirit, and this being the *representamen* has been most studied.

These are all extracts of meaning that are needed to understand the relationship of a sign to itself, to the object or to the interpretant. As previously mentioned, triplicates are core to Peirce's (2007) semiotic studies, to understand how formal and abstract logic is developed for the signs in general.

2.2.3 Signs Trichotomy

As presented in Table 1, signs can be divided into three trichotomies according to their relation to the sign, the object and the interpretant.

Table 1 Signs Trichotomy.

Signs Trichotomy			
	First (Signs)	Second (Object)	Third (Interpretant)
Perceptual quality or feeling.	Qualisign	Icon	Rheme
Involves reaction, response.	Sinsign	Index	Decisign
It's a representation.	Legisign	Symbol	Argument

Source: adapted from Peirce (2017) and Prior (2014).

The first trichotomy analyses the relation to the sign to itself as a mere quality, a concrete existence, or a generalization. As seen and emphasized by Peirce (2017), it is separated into:

i. *Qualisign* is a quality that is a sign and cannot really act as a sign until it is embodied. Embodiment that does not mischaracterize its fact of being a sign. For instance, the perception of colours.
ii. *Sinsign* is an existing and real thing or event that is a sign. It can only be through its qualities, which involve several (embodied) *qualisigns*. For instance, any concrete event or object seen.
iii. *Legisign* is a law that is a sign, commonly established by humans. Every conventional sign is a *legisign*, but the opposite is not always true. It is not a single object, but a general one that within agreements is significant. They have meaning through their application, replica, in which all their occurrences are the same *legisign*, each single occurrence is a replica, and they are *sinsigns*. Therefore, *legisigns* need particular *sinsigns* since there is a law to make them significant. For instance, traffic lights.

The second trichotomy studies the relation of the sign to its object. As highlighted in green in the table and mentioned previously, this trichotomy is the main focus in the study here presented. It consists in the fact that the sign has some character in itself or stands in some existential relation to that object or in its relation to an Interpretant, which, according to Peirce (2017), is divided in:

i. *Icon* is a sign which refers to the object it denotes only by virtue of its proper characters, whether the object exists or not. Anything (quality, individual existence, or law) can be an icon for anything, being one similar to the other. For instance, the drawing of a car;
ii. *Index* is a sign which refers to the object it denotes by being really affected by that object. Therefore, it cannot be a *qualisign* since the qualities are what they are regardless of anything. In being affected by the object, the index has some quality in common with it, and that is how it refers to the object. Thus, it involves a special icon. For instance, smoke indicating a fire;
iii. *Symbol* is a sign referring to the object which it denotes by virtue of a law, usually an association of general ideas, which causes the symbol to

be interpreted as referring to that object. Therefore, in essence, a general law or type, a *legisign*, which operates through replica. The object to which it refers is also of a general nature, having its being in the cases it determines. Therefore, there must be existing instances of what the symbol denotes, even if in the imaginary realm. Through an association or by another law, the symbol will be affected by these cases causing it to involve an Index. For instance, the cross for Christianity.

As for the third trichotomy, it concerns the relation of the sign to its interpretant. The Interpretant represents as a sign of possibility, a sign of fact, or one of reason. This triad, according to Peirce (2017), is separated into:

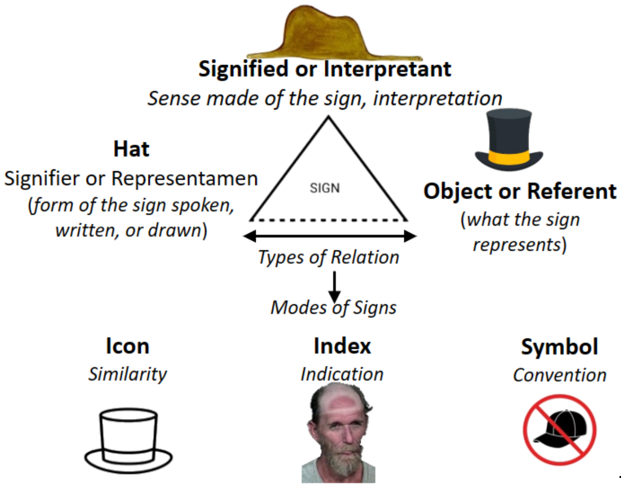
i. *Rheme* for its Interpretant, it is a sign of qualitative possibility, which will perhaps provide information, but it is not interpreted in that sense. For instance, words that don't carry meaning by themselves;

ii. *Dicisign* or *Dicent* is a sign of real existence for its interpretant. It involves a special rheme as part of it. For instance, existential features of signifying an object. "*Thor is a cat*", "*Rafael is happy*", "*Thor loves Rafael*", "*Rafael feeds Thor*";

iii. *Argument* is a sign of law, which is understood to represent its object in its character as a sign. It must be a symbol or sign whose object is a general law. For instance, mathematical laws.

These trichotomies, as mentioned above, are related to each other and do share characteristics. The Results and Discussions presented here focus on the second trichotomy because it pertains the representativeness of BPMN signs (graphical elements) in order to understand whether they relate to their object in the form of icons, indexes, or symbols.

Figure 21. Signs' Types of Relation.



Source: adapted from KUHAR and POLANCIC (2021).

In summary, as seen in Figure 21, there should always be an interpretation made out of a sign (Interpretant), its represented form (Representamen), and what is represented (Object). Studying how these graphical elements (Representamen) are represented and how they represent their actual objects (Object). Also, understanding the types of relation present to understand if the signs relate to their object by a direct similarity (icon), an indication (index) or by convention (symbol).

2.2.4 Visual Support

According to Santaella (2018), communication is of utmost importance for a culture to prevail, and there is no communication without signs. Ergo, anything used to communicate, *e.g.* written, spoken, or even body language, can also be considered a significant part of communication. Figl *et al.* (2009) recognize the value of the visual support process models give to analyse and improve complex organizational processes. The study they have developed compares elements from four different modelling languages (UML, YAWL, BPMN, and EPCs) to identify weaknesses and strengths from a user experience point of view. They do so by identifying criteria to support a quality analysis of the use of those elements, aiming at comparing the cognitive effectiveness in each modelling language.

This is an example of how signs have been analysed in the modelling languages field, and it has become clear that little has been studied on the actual representativeness of each sign for specific modelling languages. Therefore, this presents itself as a great opportunity to study the perception of stakeholders who are often affected by communication failures or misinterpretation of poorly represented process models (NORMAN, 1986).

Furthermore, research in the field of modelling quality has drawn inspiration from semiotics, incorporating its principles to analyse visual languages. For example, the study conducted by Figl and Derntl (2011) utilized concepts such as semantic transparency and semiotic clarity to investigate how users perceive the quality of a conceptual modelling language from a cognitive perspective. The first concept refers to how easy it is to associate a sign with its corresponding concept, while the second connects to a straightforward connection between the concepts and their visual representation. The authors emphasize sign redundancy, overload, excess, and deficit as patterns that should be avoided in modelling languages since they cause ambiguity and needless cognitive effort for the user.

Such studies do not necessarily bring the actual concept of semiotics, apply its concepts, or theory within their analyses, but it is possible to notice the essence of the theory being applied even if not mentioned. When discussing language elements, their representation, abstraction, visual expressiveness, signs, and their application, in essence, it is also a conversation about the semiosis of those signs and what they communicate.

Santos (2016) is another one that even mentions a concept brought by Peirce, specifically his concept of an icon. Her study is related to the comprehension of signs in a graphic language, and the author emphasizes that icons are signs visually similar to the concepts they represent. This author explains further those diagrams, which are the case of models, presenting cognitive benefits over text representations due to their potential to transfer pressure from cognitive processes to perceptual ones. In other words, reading a text explaining the processes from a company could be much more burdensome than looking at a diagram representing it. Even though, she does not explicitly mention semiotic theories, but only works with principles that have dealt with in the theory, the author makes use of iconic signs to explain the whole idea behind her studies.

This author also makes use of Figure 3 to explain the process of transmitting information, thereby transforming text into an image. By doing so, they are explained, within an image, that there are two parties involved in this process: the one who wishes to transmit the information, being the one that creates the diagram; and the one who picks up the information by interpreting the diagram, in the figure of the diagram user. While the diagram's author codes the information (message) in the form of a diagram it is the work of the diagram user to decode the message. To be able to properly decipher the diagram, it must be coded into a graphic language (code) defined into a set of conventions, generalizations, that must be understood by both agents. As the means of communication in any physical form the diagram is presented, it can even cause noise affecting the communication (SANTOS, 2016). So, an efficient diagram for communication would be the one that does not have variations from the message intended to the message received. Santos (2016) goes even further, adding that using recognizable signs increases diagram comprehension, and she argues that those should suggest their meaning, that is, signs are supposed to have a correspondence between their visual properties and the semantic properties of the objects they represent.

All in all, the importance of understanding meaning has been proven useful for many years now, except that studies on the area of business process modelling tend to intrinsically study semiotic aspects without even noticing they are doing so. Therefore, it is important to dive into this theory a bit deeper to understand the signs used in BPMN and their representation, both for business and IT professionals, who are often affected by the use of these diagrams (DUMAS *et al.*, 2018; MENDLING *et. al.*, 2018; SCHALLES, 2012). Additionally, semiotics is going to help understand the impact of using new signs suggested by these professionals.

3. Related Works

This section presents some works related to the topic addressed in the current research, observing factors that may impact on the signs' representativeness of modelling languages. The approaches assess or are concerned with the comprehension of business process models and diagrams, mainly focusing on the visual representations of the varied notations they assessed.

3.1 Mendling and Strembeck (2008)

These authors explore the same field of study as the work presented here, business and information systems. They focus on the issues regarding quality measures that have arisen from the increasing use of BPMs, mainly targeting understandability. Similarly, they also separate participants into two groups, but decided to use models with abstract and illustrative labels. Their premise is that understandability is a quality aspect and wanted to analyse its connection to personal, model, and content-related factors.

Both models used in the study presented by these authors were EPC models, differently, the current study aims at observing BPMN models. Even though two out of their six research questions mention semantically equivalent models and visual layout strategies those are not the main aim of their research. Besides that, they propose an online survey. Another aspect that diverges from this research to the one presented here is that they chose to adopt a *Boolean* approach to their variable "`correctanswer`" when assessing whether a participant answered questions correctly or not. The study here presented considered a different approach, as it was considered that there should be different levels of comprehension of model's elements. Hence, participants were given the chance to describe their understanding in text, and during analysis, this was assessed within a scale that assesses whether participants completely, partially or did not match the description of functions for the used BPMN graphical elements. This information is to be detailed in section 5, in which the *quasi*-experiment is explained.

3.2 KUHAR and POLANCIC (2021)

In their work, the authors present a systematic literature review on semantic transparency. Their aim is to clarify this principle since it is one of the elements that influences cognitive effectiveness of notations. Being cognitive effective means that notations will be easily planned, documented, and communicated. They state that one of the problems with this principle is that it is not well-defined, therefore challenges arise for applying and assessing semantic transparency in business process models. They then conduct a systematic review to understand how this concept is defined, operationalized, and evaluated in current notations, as well as the application in new notations. To do so, they delve into the theory of semiotics, as the principle comes from this source.

The study presented here shares the theoretical background with the aforementioned research, considering semiotics as the study of signs. However, here it is used to analyse the signs used in BPMN while Kuhar and Polancic (2021) aim to understand how concepts are utilized in notations in general. Besides that, there is no applied analyses effectively shown in their study. The descriptive semiotic analysis used in the current research is presented in section 6.

3.3 Santos *et al* (2018)

In their work, the authors discuss challenges faced by stakeholders without formal training in requirements modelling languages, particularly KAOS, to understand specifications. They mention that the lack of semantic transparency in the model's syntax acted as a barrier between stakeholders and requirements engineers. This research makes use of design ideas proposed by participants and evaluates them, as done in the study presented here.

Differently from the previously mentioned study, the current research focuses on BPMN, focusing on understanding the essence of representations from both the notation and the signs alternatives proposed by participants. Mainly making clear the difference between the concept of different sign modes (icon, index and symbol) and what part they play in this notation.

3.4 Roelens *et al* (2023)

Theses authors chose to take a look at Domain-Specific Modeling Languages (DSMLs), they also mention that an intuitive understandable notation is important to facilitate communication with users. So, they proposed a technique to compose an initial DSML notation by reusing icons, in the context of Process-Goal Alignment (PGA) business modeling technique. They empirically assessed the proposed technique by applying an experiment with 85 business users comparing the intuitiveness of newly developed and existing PGA notations. Their results showed that the semantic transparency of the newly developed notation was significantly higher than the PGA notations already existing.

In comparison, the research presented here selected BPMN as its object of study. Besides that, it takes a look at signs in general understanding what role they play in this notation, be it of icons, indexes or symbols. Most importantly, the sample of participants is constituted of users from business and IT areas, as they are stakeholders frequently involved in the use and communication of BPMs.

3.5 Distinction to this Research

As seen from the examples above, it was possible to observe that even though works in the BPM field might make use of ideas from semiotic studies, they may not be explicitly named as such in semiotic theory. Alternatively, there might be a conceptual divergence between the concept used with its actual meaning; in other words, ideas might be properly used but words and/or definitions might be misplaced.

Through a descriptive semiotic analysis focusing exclusively on the relation of a sign and its object, the study presented here intends to clarify the distinction between the levels of representativeness of signs (icons, indexes, symbols). Making clear that how graphical elements are presented in the BPMN might affect the comprehension of models.

4. Methodological Procedures

This chapter describes the methodological procedures planned to perform the research. The following sections will contemplate the methodological choices and principles that guide the development of this research. It will highlight the epistemological positioning, the nature of the research, the method performed, and, finally, the research design.

4.1 Prologue

Scientific research aims at understanding a particular issue that a certain level of formality, and to achieve its goal, it makes use of certain methods (FONSECA, 2002). This requires detailed planning of the stages to be observed, including the selection of the research topic, defining the problem to be investigated, the data collection process, analysis, and data treatment, as well as presenting results (MARCONI; LAKATOS, 2000).

Scientific knowledge differs from others due to its support on theoretical foundations, techniques and methodologies. It is acquired through systematic procedures that aim to discover, explain, and understand the facts that are part of a certain reality (FONSECA, 2002; PRODANOV; FREITAS, 2013). Hence, it is essential to present the methodological procedures that enabled acquisition of knowledge considered scientific (GIL, 2008). This ensures the level of scientificity in research and the methodological accuracy (COOPER; SCHINDLER, 2003), making it easier to understand and replicate results.

As previously mentioned, the aim of this dissertation is to check the representativeness of the main BPMN graphic elements for business and IT professionals. Additionally, it seeks to understand the potential impact on the comprehension of these signs. Therefore, it is necessary to define an appropriate methodological procedure aligned with the objective, encompassing epistemological positioning, nature, research approach, research methods, data collection, and analysis techniques.

4.2 Epistemological Positioning

Methodological research procedures are intrinsically linked to the epistemological stance and underlying a network of ontological human nature assumptions that should define researchers' point of view (RICHARDSON, 1999). Hence, it was opted for the conventional position, notable for being the basis of logical positivism (DUTRA, 2010). This perspective asserts the importance of observing facts through the senses and formulating generalizations that govern the observed phenomena.

Reality, for positivism, is formed by isolated parts (RUSSEL, 2005), which establishes relationships between explanatory facts (MARTINS, 1994). The objective of positivism is to discover the existing relationships between these facts. In this context, two principles must be respected in scientific research of this nature: objectivity and neutrality (COMTE, 1978). Objectivity reflects the proximity with the truth, while neutrality implies that objectivity in science can overcome the inherent subjectivity of the researcher. Myers (2005) points out that positivists assume that reality is objective data (objectivity) and can be described by measurable properties that are independent of the observer (neutrality). Therefore, methodological rigor in this approach must translate accuracy, universality, and researcher independence.

As Guba and Lincoln (1994) explain, the post-positivist approach represents an evolution of positivism, rejecting a naive realist posture, which believes in the possibility of direct access to reality itself. Even preserving the idea of an objective world existence, governed by natural laws, it is accepted that it is impossible for human beings to perceive reality with their sensory and intellectual mechanisms. Therefore, post-positivism embraces a critical objectivist epistemology, in the sense of taking objectivity as a regulatory ideal, by admitting that it is only approximately possible to achieve it (DENZIN, LINCOLN, 2006).

Given that this research deals with an objective reality formed by BPMN models, as well as another subjective reality involving stakeholders (participants of this study) interested in the process models, according to their informational needs, this research positions itself epistemologically in a post-positivist perspective.

4.3 Research Nature

According to its objectives, the research's nature can be classified as exploratory, descriptive, or explanatory (CHURCHILL JR., 2012). Exploratory research deals with deepening preliminary concepts, often unpublished, in a view in which researchers do not have a clear and precise idea of the phenomenon under investigation (COOPER; SCHINDLER, 2003). Richardson (1999) suggests that this type of research aims at bringing the researcher closer to the phenomenon, allowing the identification of specific characteristics and themes to be explored. Vergara (2003) mentions that exploratory research is carried out in areas in which there is little accumulated and systematized knowledge. Hair Jr. *et al.* (2007) advise that exploratory research is useful when research questions are vague or when there is little theory available to guide predictions.

In contrast to exploratory studies, descriptive research is usually structured in a format where hypotheses or clearly stated investigative questions are frequent (COOPER; SCHINDLER, 2003). In a descriptive study, the researcher's focus is on describing or defining a subject, examining the distribution and exploring its meaning. The aim is not to explain the differences but to describe them and associate certain results with groups of respondents (RICHARDSON, 1999).

On the other hand, explanatory research aims to test theories and their causal relationships. It is characterized by attempting to make the studied object intelligible (VERGARA, 2003) and to justify the reasons that make a certain phenomenon appear or happen, clarifying its causes as well as its consequences from a planned and strict control of the variables. Explanatory research focuses on identifying the factors that determine or contribute to the occurrence of phenomena, seeking to point out their causes and answer "*why*" and "*how*" they occur (RICHARDSON, 1999; COOPER; SCHINDLER, 2003). When performed in the natural sciences, it requires the use of the experimental method; in the social sciences, however, it requires the use of the observational method (VERGARA, 2003).

Regarding its nature, the present research is classified as exploratory and descriptive, as it aims to seek to deepen the conceptual knowledge related to the topic in question (CHURCHILL JR, 2012), originally seeking to develop the study through the performance of a *quasi*-experiment to obtain empirical validation. Furthermore, the study involves the description of the characteristics of this phenomenon from a given population (GIL, 2008), seeking to establish relationships between variables (VERGARA, 2004), and for this reason it can be described as descriptive.

4.4 Research Strategy

The selection of a research strategy must align with the research question and objectives, as these are the characteristics that define the researcher's performance in the empirical field. In this particular research, the *quasi*-experiment's strategy is discussed, where participants were asked comprehension questions on the representativeness of the signs (graphical elements). Additionally, participants were encouraged to suggest some signs that may be more representative for these artifacts. Thus, as already highlighted, this study's aim is to verify whether the signs used in BPMN are representative for the given population. More specifically, the objective is to observe whether these graphical elements indeed express what the signs mean to users of this process model.

Subsequently, for this methodological research to reach its objective of contributing to the scientific instrument, it is necessary to present how the operationalization took place, with the next steps being the presentation of its research design.

4.5 Research Method

A research method aims at establishing standards to be used in the various study's stages, defined as a set of appropriate techniques to understand the phenomena studied (CRESWELL, 2010). So, it is through the scientific method that the researcher defines the procedures employed throughout the research in an orderly, explicit, and systematic manner to reach an objective. Thus, the distinctive feature of the method is its capacity to facilitate understanding, not only of the results of scientific investigation but also of the very process that guides the research. In this sense, scientific methods can be classified into two main strands, namely: qualitative and quantitative. The qualitative method is concerned with a level of reality that cannot be quantified, working with a universe of meanings such as motivations, aspirations, beliefs, values, and attitudes (MINAYO; SANCHES, 1993). This method uses various data collection and analysis techniques, including interviews, observation, content analysis, *etc*.

On the other hand, quantitative research, according to Richardson (1999), imposes a predetermined structure on the respondent, reducing the heterogeneity of data collection and offering greater reliability to the results. Also, according to the aforementioned author, quantitative methods work with larger samples, providing more precise data, and are indicated when more information is available about the problem to be studied. This method primarily aims to ensure the results' precision, minimizing analysis and interpretation distortions, thus allowing a safety margin regarding inferences.

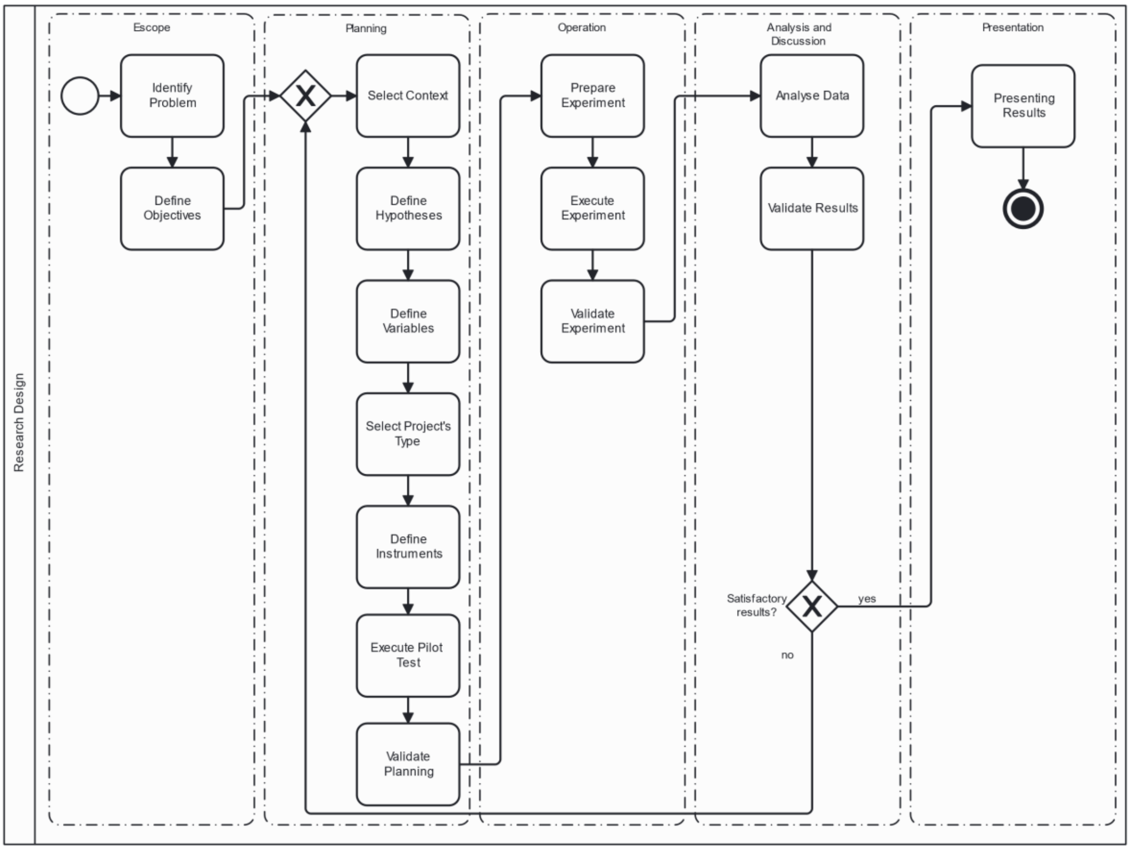
In line with these perceptions, this research chose to adopt a qualitative strategy, aiming to examine the representativeness of the main signs used in BPMN, taking into account the perspective of business and IT users. Understanding how the use of different signs may impact the levels of representativeness of BPMN, implementing signs suggested by users of the notation from the proposed population during the *quasi*-

experiment. By adopting this approach, this research aims to broaden its understanding of this phenomenon in a more comprehensive and in-depth manner.

4.6 Research Design

The research design represents the logical order layout to be followed during an investigation (MARCONI; LAKATOS, 2000). Schematically, it illustrates the activities carried out during the development of the research, defined as descriptive and exploratory, structured in a *quasi*-experiment. The research design used in this study is depicted in Figure 22, as follows:

Figure 22. Research Design.



Each phase of the *quasi*-experiment and their corresponding activities are described in the following chapter.

5. *Quasi*-Experiment

Carrying out a *quasi*-experiment involves five distinct stages, namely: (*i*) scope, which includes the experiment`s motive; (*ii*) planning, which describes the experiment`s conduction; (*iii*) operation, which presents the experiment`s execution; (*iv*) analysis and interpretation, which presents and discusses the results obtained; and, finally, (*v*) results presentation, which disseminates the results obtained in the experiment (WOHLIN *et al*., 2012).

5.1 Scope

Scoping a study is concerned with defining its goals and ensuring that essential features of an experiment are outlined before the stages of planning and execution are performed (WOHLIN *et al*., 2012). This stage focuses on analysing the object of study to find the purpose of the research, within a perspective and a given context.

As already highlighted, the objective of this study was to verify whether the signs currently used by BPMN are representative for users of the business and IT fields. Particularly, this study aimed to observe whether changing the graphical elements used in process model diagrams would influence their comprehension when compared to the same diagram with different signs. At this point, it is essential to note that this study, developed from the researcher's perspective, involved 104 participants, including professionals, graduate, and undergraduate students in the areas of business and information technology. Also, two models were used: one using BPMN graphical elements and the other employing elements suggested by participants themselves in the first phase of the study.

Hence, the scope of the current research was to apply a semiotic analysis to understand the type of relation of BPMN graphical elements' representation to their objects, aiming at observing whether BPMN signs affect models' comprehension. The study compared models with BPMN graphical elements and another with participant created graphical elements, considering the perspective of professionals, graduate and undergraduate students in the fields of business and information technology while interpreting the respective models.

5.2 Planning

To make sure that essential features of an experiment are outlined before the stages of planning and execution are performed (WOHLIN *et al.*, 2012). This stage focuses on analysing the object of study to find the purpose of the research within a specific perspective and context. The scope of the present research was to analyse which BPMN graphical elements are more or less representative for participants and ask for suggestions for more representative signs for the less representative elements; collect and categorize this information to understand which new signs are more representative in the context of these participants. The scope is better explained in the following sections.

5.2.1 Context Selection

This study consists of visualizing a process model in BPMN specifically prepared in laboratory, simulating a real state property appraisal process that could be used in real organizations. It was decided to model this process in a lab to avoid presenting published models that could have already been seen by any of the participants.

The research was performed in controlled settings, such as college classrooms and company meeting rooms, both in public and private spheres. Which consisted of a constraint for the sample of the data collection, to be able to accompany all the stages of the execution of this study, researchers had to physically be available to participants during the application of questionnaires. Additionally, in the first phase of the execution, drawings were collected as suggestions for less representative graphical elements. Conducting this research online could have further reduced the number of participants and increased the risk of them copying elements available through search tools. Therefore, the intention was to minimize any influence that could affect their abstraction.

In order to analyse responses from educational and professional environments, the target participants of this research were selected from professionals, undergraduate, and graduate students in both IT and Business areas.

5.2.2 Hypothesis Formulation

According to the attributions highlighted by Wohlin *et al.* (2012), the basis for the statistical analysis of an experiment is hypothesis testing. As such, hypotheses must first be formulated when planning the experiment, so that they can be tested with the results obtained afterwards. Two hypotheses have to be formulated, the null hypothesis (H_0) and the alternative hypothesis (H_1).

Therefore, within this context, the hypotheses presented here are related to the representativeness of BPMN signs, as follows:

- Null hypothesis (H_0) states that there is no difference in representativeness for signs between phases 1 and 2. This is the hypothesis that the experimenter wants to reject with as high significance as possible.
- Alternative hypothesis (H_1) is the hypothesis in favour of rejecting the null hypothesis, expressing that there is a difference in the representativeness of the signs between phase 1 and phase 2. Therefore, if the null hypothesis cannot be rejected, the alternative cannot be accepted as well.

5.2.3 Variables Selection

When selecting appropriate variables, it is important to follow a goal-oriented approach, as highlighted by Wohlin *et al*. (2012), to avoid collecting data that is irrelevant to the research. Within this approach there are two types of variables to be defined: independent and dependent. The independent variables are those that control and change in the experiment. For example, the modelling notation used or the signs of the model itself. These variables must have some effect on the dependent variables and must be controlled. The dependent variables measure the effect of the independent variables. When using signs representativeness, the dependent variable is related to the level of representativeness of signs that one wants to measure. When choosing the dependent variable, the measurement scale and the range of the variables must also be determined.

5.2.4 Selection of Subjects

Population's sample or sampling is used to refer to experiments which involve human beings (WOHLIN *et al.*, 2012), which is the case presented here. Thus, sampling a population can be either a probabilistic or non-probabilistic sample. Even though there are several sampling techniques, according to Daniel (2011), in empirical research such as the current one, it is more common to sample the closest people for convenience.

On the other hand, when generalizing, the sample size can also impact the results. The larger the sample, the smaller the error should be when generalizing the results. Therefore, when planning the experiment, the researcher must also determine its size to ensure an adequate level of results reliability (KITCHENHAM *et al.*, 2019). Thus, this study is going to follow the recommendations already consolidated in the literature (MONTGOMERY *et al*., 2000), with a sample size greater than 30 individuals to have statistical relevance.

Therefore, to understand whether stakeholders are affected by the use of specific signs, participants from the fields of business and IT were selected. They were conveniently selected due to their proximity, be it geographical or availability times and participants ranged from different levels of expertise. Most importantly, participants were purposely selected and divided into two groups: those with prior knowledge of BPMN (*phase* 1) and those who had no knowledge of BPMN (*phase* 2). They were presented to models and asked to rate the representativeness of signs. The first phase evaluated graphical BPMN elements, while the second phase analysed elements proposed in the first phase, intentionally avoiding comparative bias[5] (ZANG; ALICKE, 2020) in relation to the suggested signs.

This convenience sampling of participants is possible, according to Wohlin *et al*. (2012). Also, contact with subjects was made via electronic mail messages (email) and *WhatsApp*, when time and location for the *quasi*-experiment's execution was properly scheduled.

5.2.5 *Quasi*-Experiment Design

Experiment designs are connected to thoroughly planned and designed series of tests to ensure the experiment prospers. There are three general design principles: randomization, blocking, and balance (WOHLIN *et al*., 2012).

Even though participants were chosen by convenience and specifically directed to different phases of the operation, this selection was purely based on whether they had had contact with BPMN before or not. After data collection, participants were given an ID in our database, for instance [0a] for participants in *phase* 1 and [0b] for the ones in *phase* 2, so their identities could be preserved, and data randomly analysed.

There was no necessity to make use of the blocking factor to eliminate unwanted effect due to the qualitative and abstract perspective of this research. It was considered that points made by participants should be taken into account even when they were novice, for example.

[5] Comparative bias is when you see one side more favourably than the other (ZANG and ALICKE, 2020).

Another factor used in software experimentation is balancing. It concerns having an equal number of subjects on the phases, which is desirable because it simplifies and strengthens the statistical analysis of the data. Although ideal, this factor is not necessary, so it wasn't applied to its core, but numbers of participants from the first and second phases were similar, 54 and 50, respectively.

5.2.6 Instrumentation

For Wohlin *et al.* (2012), experiment instruments are of three types: (*i*) objects, (*ii*) guidelines, and (*iii*) measurement instruments. They are chosen during planning and developed during execution. Regarding guidelines of the present research, they consisted of oral instructions before the application of questionnaires, occasionally interacting with participants who raised questions, with direct questions printed in the questionnaires themselves. Making use of verbs in the imperative to clearly state that an action was needed from participants, for instance. The objects used, and reasoning for their selection, are described as follows:

(i) Business Process Model developed in laboratory in BPMN representing the process of a "*Property Appraisal*" (Figure 23). It was modelled to illustrate the scenario of a real estate company and to provide participants with context to visualize the graphical elements proposed.

(ii) Questionnaire 1 (Annex B) aimed to evaluate how those who have experience with BPMN assess the representativeness of its graphical elements. Besides collecting suggestions (drawings) for graphical elements (signs) these participants believe could be more expressive.

(iii) A model for the second phase (Figure 24), consisting of the same process of the property appraisal, but this time with signs suggested by participants during phase 1.

(iv) Questionnaire 2 (Annex C) aimed at evaluating how participants who hadn't had any experience with this notation perceived the model with the proposed signs. It was planned this way to avoid showing preference to a specific element from the already existing notation simply because they had been instructed in it before. Therefore, avoiding any kind of comparative bias (ZANG; ALICKE, 2020).

Figure 23 Property appraisal: BPMN model from quasi-experiment's Phase 1.

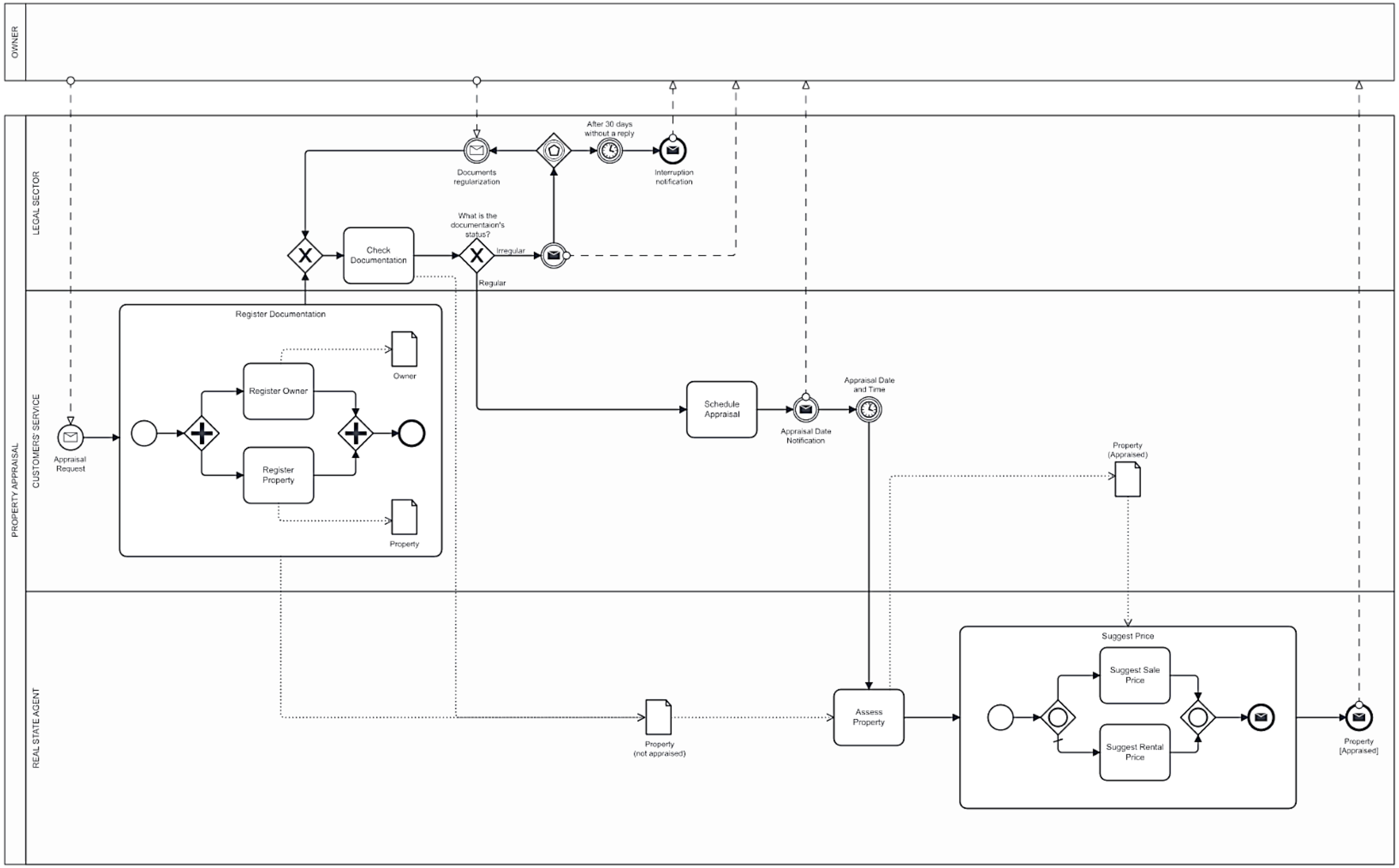
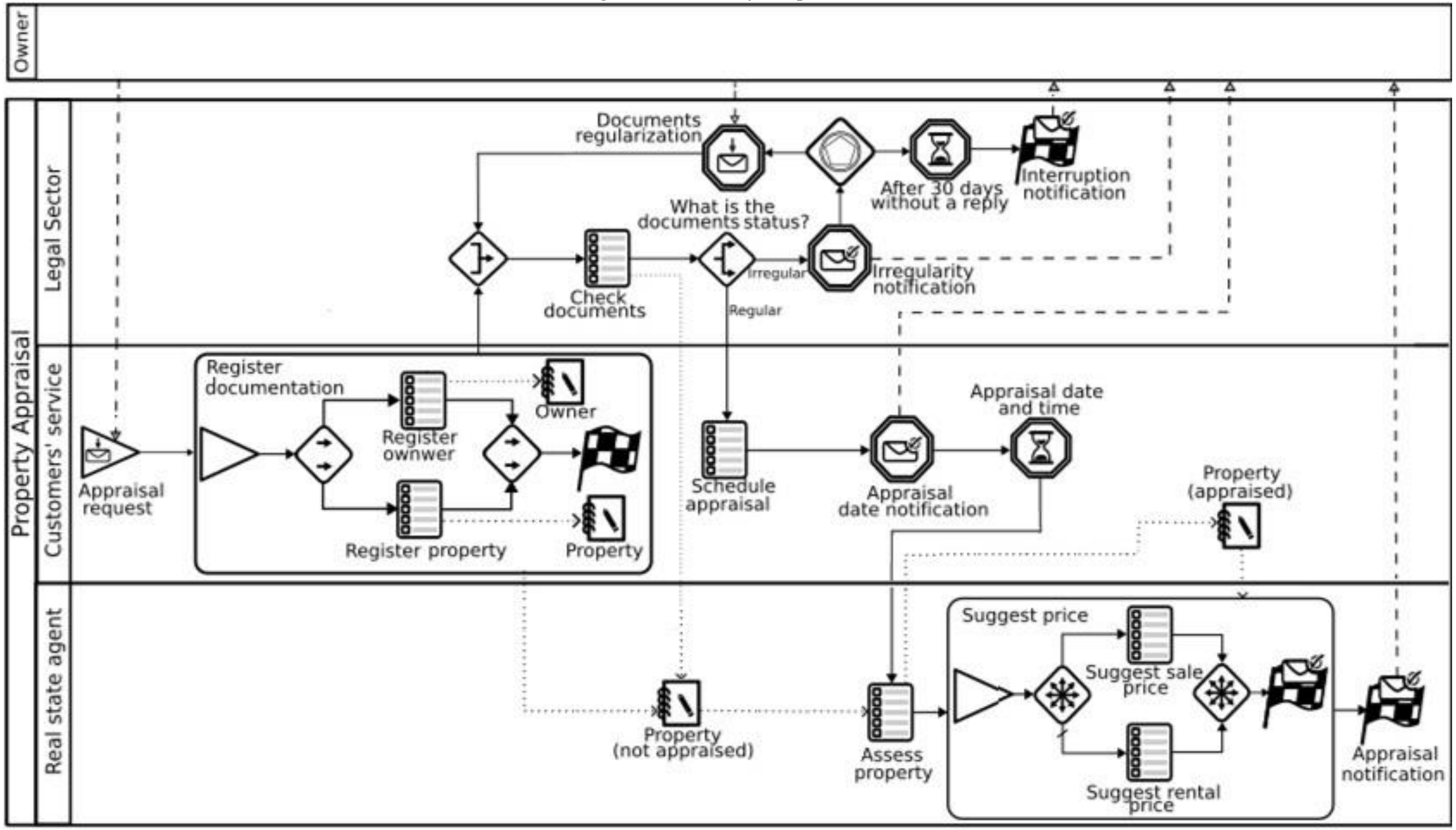


Figure 24. Model from phase 2.



To be able to measure the data collected on both questionnaires, two important questions on the background of the participants were added. The first was on the amount of time, in years, participants had been in touch with BPMN, ranging from 0 to more than 5 years. This allowed visualizing who among them were novices and who were experts in process modelling notation, thus potentially having different levels of signs recognition.

In the second question, participants were asked to rate from 0 to 10 how familiarized they felt with the signs from the notation. The intention was to be able to delineate the number of people who actually felt they could easily recognize its graphical elements.

Although before the pilot test, and even after that, a third question on the participants' gender was kept, it was decided that it should be only part of the descriptive analysis, considering this variable should not affect the goal in hand. However, it is worth mentioning that it could be an opening for a future work for peers who do have a broader background on gender studies.

5.2.7 Validity Evaluation

The present study does involve interactions with the researcher through the application of instruments. As based in Wohlin *et al.* (2012), it is important to make sure the results are trustworthy and that they do not reflect bias, which could be the researchers' subjective point of view of data analysis. Therefore, the four aspects of validity (construct, internal, external, and reliability) are paramount during all phases of the study.

- *Construct validity* is concerned with the extent to which the operational measures studied represent what researchers have in mind and what is investigated according to research questions. Both researchers and participants must have the same interpretation of the questionnaire questions, for example, not to threat the construct validity.
- *Internal validity* is a concern when investigating casual relationships. It happens when a third factor, for example, that the researchers were not aware of or did not understand, affects the factors they were primarily analysing. For instance, the choice made to exclude gender analysis from scope could potentially be a threat to internal validity, since its impact cannot be confirmed or denied.

- *External validity* is concerned with the extent to which findings can be generalized. It also involves assessing how relevant findings are for other people and cases. The first stages of this dissertation were published as a paper titled "*A Semiotic Analysis of the Representativeness of* BPMN*'s Graphic Elements*" being part of the 13th International Symposium on Business Modelling and Software Design, a conference with over 10 years of renown in the area (see Appendix D). The paper was indexed in Springer, a major international database, and received great feedback from reviewers, whose suggestions have been taken into consideration to improve the work also presented here. Moreover, it is worth noting that this study also benefitted from insights derived from another article entitled "*Evaluating the Semantic Transparency of* BPMN *Through a Semiotic Analysis*". This article has been accepted for publication at the 49th Latin American Conference on Informatics, where it will be indexed in the prestigious IEEE Xplore digital library (see Appendix E).
- *Reliability* concerns the extent to which data and analysis are independent from researchers. To decrease the threats to reliability, the attempt was to clearly state the research design, decision-making, and analysis criteria throughout all stages of the research.

5.3 Operation

This stage's main concern is ensuring that the experiment takes place as planned (WOHLIN *et al.,* 2012). According to the author, the operationalization of the experiment includes three stages: (*i*) **preparation**, selection of participants and preparation of questionnaires; (*ii*) **execution**, carrying out the experiment itself, which should occur with the maximum number of students who agree to sign the consent letter (see Appendix A), read moments before the execution of the experiment; and (*iii*) **validation**, which verifies the integrity and readability of the responses delivered to the researcher.

The execution stage was divided in two phases. The first phase focused on understanding the signs currently in use in BPMN language, as well as collecting different signs suggested by participants. The second phase focused on assessing the representativeness of these new signs.

5.3.1 Preparation

The more prepared the experiment is the easier the execution will be (WOHLIN *et al,* 2012). This step is mainly divided into selecting and informing participants, followed by preparing the necessary materials. Once the willing participants were contacted, and a suitable time and space were allocated for the experiment, they were given an oral explanation of the research's objective. The content of a consent letter (see Appendix A) was read out loud for them, assuring them that their identities would be kept confidential for the presentation of results in this dissertation and any resulting papers. They were also informed that they were free to withdraw from the experiment or leave any of the questions unanswered.

Throughout the execution, some motivation was needed, particularly because some participants expressed concerns about their drawing skills. Researchers always reassured them that their abilities would not be tested, and they should express themselves however they could. There was no kind of inducement whatsoever in the execution of this research; people who chose to participate did so out of their own interest in science.

To preserve their identities, the only sensitive information collected was the names of the participants, which were transformed into numerical IDs. Other than that, the results will be fully disclosed, as pertinent.

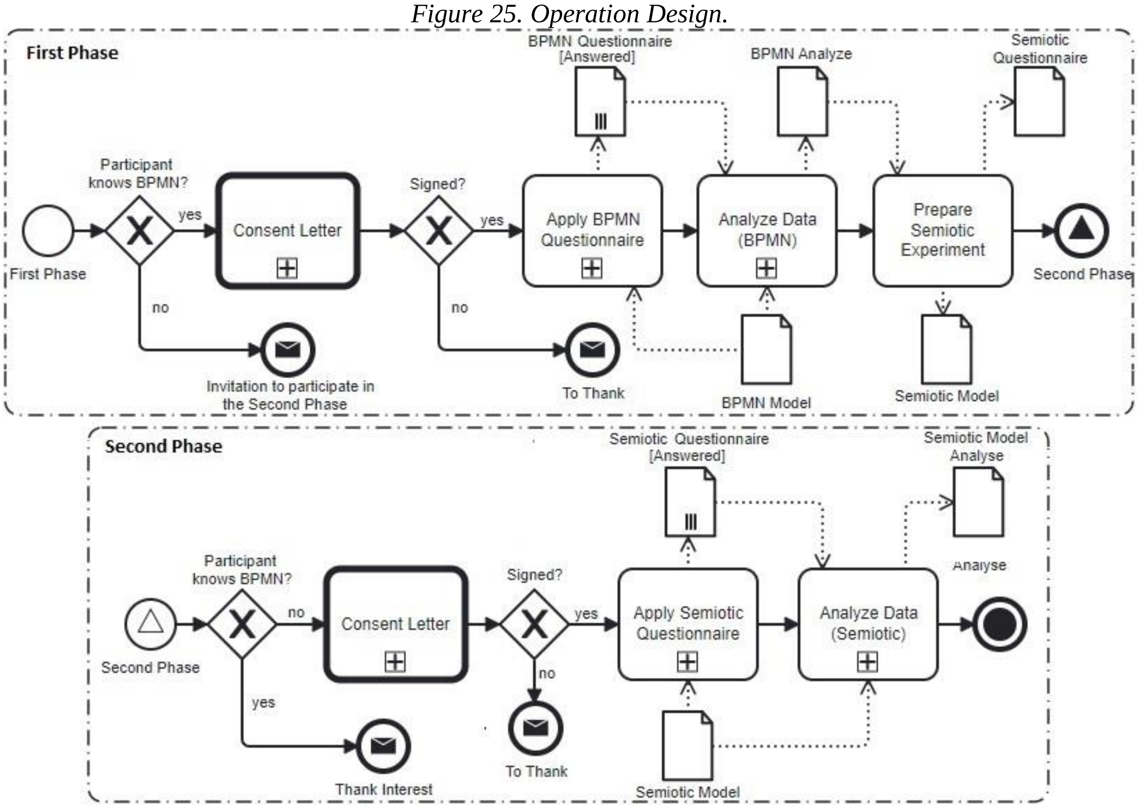
Another aspect of the preparation was to separate sets of pencils and erasers hand in with the questionnaires sets. The prediction was that many participants would not carry such tools with them. Some explained that they use computers and smartphones more frequently than writing by hand nowadays, so it was essential for researchers to be ready for this scenario.

5.3.2 Execution

Due to geographical and scheduling constraints, it was not possible to execute the *quasi*-experiment in one location and time slot. Consequently, it was performed through meetings with small groups, with a few participants grouped at different times. This might have affected internal validity, as one participant could have potentially commented to another about what they had seen in the questionnaires before the second executed it. To mitigate this situation, researchers asked participants not to discuss the elements presented or the models with anyone else. Besides that, groups of people who had higher likelihood of knowing each other were allocated together.

To understand how participants perceive the representativeness of BPMN signs, as mentioned, the execution was divided into two phases: the first phase (Figure 25) aimed to understand how participants perceive the representativeness of BPMN signs and to collect different signs proposed by them; and the second phase (Figure 25) aimed to test whether different graphical representations can influence representativeness.

Figure 25. Operation Design.



5.3.3 Validation

After data collection it is essential to verify its validity and ensure that it has been properly collected. This involves checking that the forms have been filled out properly and, if not, removing them before data analysis. For the present study, participants were definitely free not to answer any questions they did not feel like answering. During data analysis, these unanswered questions were categorized as "*did not reply*" and this data was included in the descriptive analysis.

The decision made to keep such questionnaires with unanswered questions was because even those might convey meaning during the analysis. For instance, a certain sign might have had high scores on unanswered functions of signs. Therefore, researchers deemed it beneficial to keep this data for further consideration in the analysis.

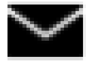
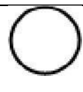
5.4 Analysis and Interpretation

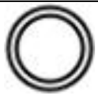
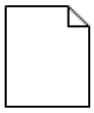
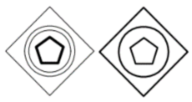
This stage's main objective is to analyse the data collected during the operation of the *quasi*-experiment (WOHLIN *et al*., 2012). Data presented as a result will be analysed and interpreted to determine whether the hypotheses were rejected or not, enabling decision-making regarding the use of the investigation's results. The aim is to determine, through the responses arising from the questionnaire's application, whether the signs used as BPMN graphical elements influence the understanding of models.

Data analysis began with descriptive statistics on professional's background, amount of time they have known BPMN, and their self-assessed level of familiarity with the notation. As for the assessment of representativeness of the graphical elements, a combination of descriptive statistics and an editing approach (WOHLIN *et al.*, 2012) was employed. Participants were asked to rate the representativeness of each graphical element, both in the first and second phases, on a scale from 0 to 10. This allowed for a statistical assessment of the ratings, the results are presented in graphs and described for each of the questions posed in both questionnaires.

For the other part of the analysis, Figl and Laue's (2011) principle was taken into account, which states that there is understanding of a BPD when readers are able to explain the behaviour of a structure within a context. Hence, for each graphical element provided the responses for functions were confronted by the description present in the literature (Table 2).

Table 2. BPMN graphical elements used.

Element	Description	Graphic Representation
Sequence Flow	Connects two object flows, showing the order they are performed in a process.	
Task	Generic term for work an organization performs in a process. The types of tasks that are a part of a process model are: sub-process and activity.	
End Event	Indicates where a process ends.	
Message End	"Trigger" that defines the cause for the event, defines the "throw" of a message in an end event. Consequence of a sequence flow path ending.	
Start Event	Indicates where a particular process starts.	

Message Start	Represents the beginning of the process and only reacts "catches" a message from one of the external participants to the process. For those events, triggers that catch, markers are not populated.	
Exclusive Gateway	This decision represents a branching point where alternatives are based on conditional expressions contained within the outgoing Sequence Flows. Only one of the alternatives will be chosen.	
Parallel Gateway	This decision uses the term "fork" to refer to the dividing of a path into two or more parallel paths (also known as an AND-Split). It is a place in the process where activities are performed concurrently, rather than sequentially.	
Inclusive Gateway	Also known as an OR-Split, represents a branching point where alternatives are based on conditional expressions contained within the outgoing sequence flows. Since each path is independent, all combinations of the paths may or may not be taken.	
Intermediate Event	Represents an event during the process.	
Timer	Represents the occurrence of a time period during a process.	
Message Flow	Used to show the flow of messages between two participants that are prepared to send and receive them. That is, it indicates the communication between pools.	
Data Object	Provides information about what activities require to be performed and/or what they produce, it can represent a singular object or a collection of objects. Data input and data output provide the same information for processes.	
Event-based Gateway	Start a new instance of a process triggered by an event.	

Association	Links information to graphical elements, when appropriate has the indication of direction.	....>

Source: OMG-BPMN (2014) and RECKER (2010).

According to Recker (2010), BPM designers often rely on a subset of graphical elements when modelling processes, even though there are many others available, as already mentioned. Although, Association and Event-based Gateway do not belong to this group, they were used in the models for this research to ensure the accuracy of the notation's syntax. They were also included in the questionnaires, which were later assessed, as they were necessary in that specific context.

Besides that, all signs presented into both phases of the execution (BPMN and suggested elements) were thoroughly analysed. They were evaluated and graded into the following scale: totally corresponds, partially corresponds, does not correspond, and did not reply. An explanation for each of these codes is provided in Table 3.

Table 3. Qualitative Analysis Code.

Code	Model Comprehension	Signs	Example
Totally Corresponds	Used when participants were able to describe the models in detail.	Used when both name and function, or when only the function was properly replied.	[1a] *“Indicates the initial state of a flow or sub-flow.”*
Partially Corresponds	Used when participants were only vaguely able to describe the models.	Applied when answers consisted of only the name of the graphical element, or name was provided with an incorrect function.	[6a] *“Start event.”*
Does not Correspond	Applied when there was incorrect information or when participants evaded the question answering something other than explaining the model.	Used when neither the name nor the function corresponded to the graphical element presented.	[44a] *“Beginning of an activity.”*
Did not reply	Used when questions where left empty or when participants stated they did not know.	Applied when questions where left empty, or participants stated not knowing the answer.	[54a] No answer.

After assessing each element separately, the numbers were then analysed descriptively and statistically, to be presented in the following sections.

5.4.1 Hypothesis Testing

To compare the responses from the groups in *phase* 1 and 2 the *Chi-Square* test of independence was applied. According to Agresti (2007) and Magalhães (2010) this test is calculated from the construction of a contingency table, which is a cross table between two variables or attributes. It is used to discover the existence or absence of an association between the row variable and the column variable in that table. The test is built from the calculation of the Q statistic, that must be compared with the tabulated value. Large values of the Q statistic are significant as they indicate differences between the observed and expected values in the data. In other words, the null hypothesis is rejected, indicating the non-independence of the data and suggesting differences between the classes given a second variable. Another option is to evaluate the test by comparing the extracted *p-value* with a previously defined significance level, with values of $\alpha = 0.01$, 0.05 or 0.10 being adopted more frequently. If the *p-value* is lower than the established α value, the null hypothesis is rejected (AGRESTI, 2007; MAGALHÃES, 2010).

5.4.2 Drawing Conclusions

Although the statistical results of the *quasi*-experiment may seem of low statistical significance, the lessons learned from it are definitely valuable, as reminded by Wohlin *et al* (2012). The present research can be reference for future works on BPMN signs, given its methodological procedures and results.

5.5 Presenting Results

During this stage, the knowledge acquired from the results obtained in this study will be presented. Besides the present dissertation, which will be made available for the academic community, as previously mentioned, there is already one paper published in an international conference (see Appendix D) and another one has also been accepted for publication in an international congress (see Appendix E). The intention is to gather the rest of information collected here and apply for other conferences and journals in order to reach as many people as possible. Also, when the results for the presentation of the dissertation are available, a research report will be handed to Fundação do Amparo a Ciência e Tecnologia do Estado de Pernambuco (FACEPE), the financier of this research.

6. Results and Discussions

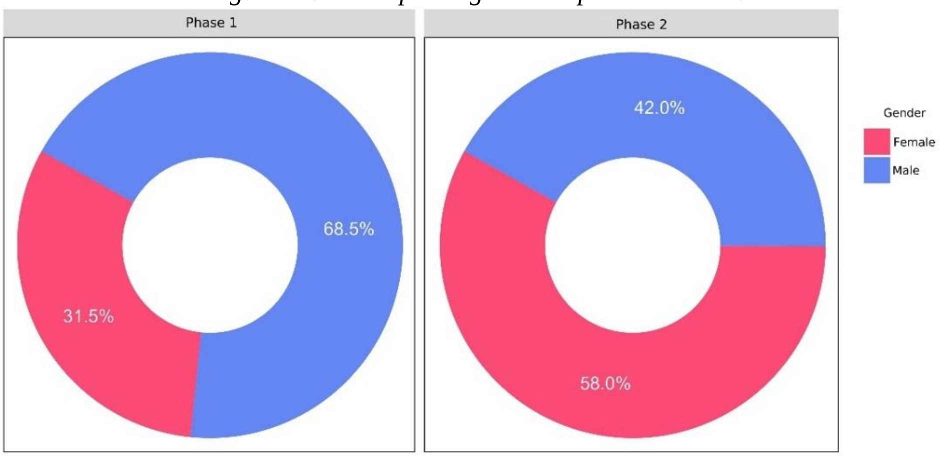
This chapter presents results and discusses the interpretation of various perspectives that influenced the understanding of the data collected during the execution stage of the *quasi*-experiment. It is important to remember that the theme of this research revolves around determining whether different signs influence the representativeness of BPMN models for IT and Business professionals. To achieve this, a descriptive analysis is performed on the graphical elements used in the notation, along with a descriptive statistical analysis and a *Chi-Square* test.

The following sections provide detailed information regarding the evaluation of the representativeness of BPMN signs, based on the questionnaires administered during the investigation. The first part presents sociocultural data, including participants' familiarity with BPMN. Subsequently, an analysis of the graphical elements is presented.

6.1 Gender

To gain further insights into the participants, they were asked about their gender on both phases (male, female or other). Since there were no participants who identified themselves differently from male or female, the numbers are presented only for these two categories. Interestingly, a different behaviour was observed between the two phases of the study concerning gender.

Figure 26. Participants' gender in phases 1 and 2.



In phase 1, there was a greater number of male participants, representing more than twice the number of females in that phase. In phase 2, a higher number of females was observed, however there was a greater balance between the number of males and females compared to the first phase. Nonetheless, for the scope of this research, this difference should not interfere with the numbers and the analysis of the representativeness of the signs.

6.2 How long have you been in contact with BPMN?

Regarding the amount of time each participant experienced BPMN, Table 4 shows that the vast majority of participants have little to no experience. This is true in both phases 1 and 2, where 80% of participants in phase 1 declared having less than 1 year of experience. It is worth noting that in phase 2, all participants were purposefully selected for not having prior experience with BPMN to avoid any kind of comparative bias (ZANG; ALICKE, 2020).

Table 4. Period of contact with BPMN between the study's phases.

Phases	0 to 1 year	1 to 3 years	3 to 5 years	More than 5 years
Phase 1	43	6	1	4
Phase 2	50	-	-	-

These numbers provide valuable insights into the background of individuals engaged with this notation. As already mentioned, participants were selected from graduate programs in business and information technology, as well as employees of a software company involved in the development of information systems. However, it became evident that although some participants having some exposure with the notation, the vast majority could still be categorized as novice users. Nearly 89% of participants selected for phase 1 indicated having less than 3 years of experience with BPMN. This connection with the notation was noticed during the analysis of self-rated familiarity with BPMN and when participants identified the functions of the graphical elements, as described in the upcoming sections.

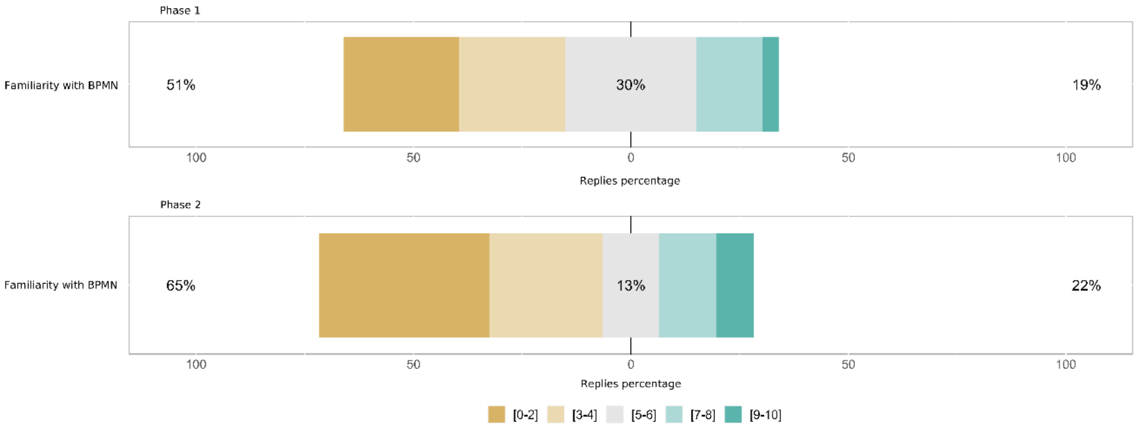
Besides that, it was a challenge to find participants who had been in contact with the notation for many years. Even though having more representatives with over 5 years of experience in this study may not significantly change the qualitative analysis here presented, there remains a slight possibility of it affecting the quantitative results. It is important to consider that these participants would need to go through the first phase of the research, in which they need to suggest drawings for the graphical elements, imposing constraints on reaching a larger number of volunteers. The hope is that by sharing these results with the academic community, it will help develop the necessary network to reach individuals with more years of BPMN experience.

6.3 How familiar do you feel with BPMN elements?

Participants were then asked to rate their familiarity to BPMN, considering that even if someone had been in contact with the notation for a long period, they might not feel entirely comfortable with it. This question aimed to confirm whether number of years in contact with the notation correlated with a higher level of familiarity.

As already mentioned in the previous chapter, participants were asked to rate their familiarity with this notation in a scale from 0 to 10. As shown in Figure 27, the behaviour between the two phases is quite similar.

Figure 27. Level of familiarity with BPMN in the different phases of the study.



There was a higher concentration of participants in scores indicating lower levels of contact with BPMN. During application of the first model, 49% of participants declared a familiarity level of 6 to 10, 46% declared 0 to 5, and 2% did not respond. In the second phase, the same 2% did not respond, while only 4% of participants declared having a familiarity from 6 to 10. This indicates that 94% of participants indeed declared a familiarity range of 0 to 5.

To emphasize these results, the following Table 5 and Table 6 distribute the number of participants for each period of experience with BPMN and their self-rated familiarity with the notation.

*Table 5. **Phase 1:** Familiarity rates versus experience years.*

Rate	Participants		Years				
			0 to 1	1 to 3	3 to 5	More than 5	Did not reply
0	3	6%	3	0	0	0	0
1	3	6%	3	0	0	0	0
2	8	15%	8	0	0	0	0
3	5	9%	5	0	0	0	0
4	8	15%	7	0	0	1	0

5	10	19%	8		1		1		0		0
6	6	11%	4		2		0		0		0
7	5	9%	4		1		0		0		0
8	3	6%	0		2		0		1		0
9	0	0%	0		0		0		0		0
10	2	4%	0		0		0		2		0
Did not reply	1	2%	1		0		0		0		0
	54	100%	43	80%	6	11%	1	2%	4	7%	0%

It's evident that in both phases, those who did not respond to the familiarity level declared having from 0 to 1 year of experience, with exactly one participant for each phase.

In phase 1, the two participants who declared themselves with 10 points familiar with BPMN also indicated that they had been in contact with the notation for more than 5 years. They are identified as IDs [3a] and [4a], and they will be mentioned again during the analysis of graphic elements. In the second phase, no one declared themselves with 10 points. Similarly, in both phases, no participants responded with 9 for rate.

In phase 1, three participants rated themselves with 8 points. Among them, two had been in contact with the notation from 1 to 3 years, and one for more than 5 years. In phase 2, no participants declared this rating.

*Table 6. **Phase 2:** Familiarity rates versus experience years.*

Rate	**Participants**		**Years**					
			0 to 1		1 to 3	3 to 5	More than 5	Did not reply
0	25	49%	25		0	0	0	0
1	9	17%	9		0	0	0	0
2	6	12%	6		0	0	0	0
3	3	6%	3		0	0	0	0
4	3	6%	3		0	0	0	0
5	2	4%	2		0	0	0	0
6	1	2%	1		0	0	0	0
7	1	2%	1		0	0	0	0
8	0	0%	0		0	0	0	0
9	0	0%	0		0	0	0	0
10	0	0%	0		0	0	0	0
Did not reply	1	2%	1		0	0	0	0
	51	100%	51	100%	0%	0%	0%	0%

Regarding rate 7, in phase 1, there were five participants who identified themselves in this category, with four of them declaring 0 to 1 year of experience and only one person indicating 1 to 3 years of experience. In contrast, in phase 2, only one participant rated themselves in this category and had 0 to 1 year of experience.

For rating 6 in phase 1, four participants declared 0 to 1 year of experience with BPMN, while two had 1 to 3 years. On the other hand, only one person indicated this rating, and they had 0 to 1 year of experience.

In phase 1, ten participants rated themselves as 5. Among them, eight declared having 0 to 1 year of experience, while two others had 1 to 3, and 3 to 5 years of experience, respectively. In phase 2, two participants rated themselves as 5 and had 0 to 1 year of experience.

Eight participants rated themselves as 4 in phase 1, with seven of them having 0 to 1 year experience and one participant indicating more than 5 years of experience. In phase 2, three participants rated themselves with 0 to 1 year of experience.

Within the range of 0 to 1 year of experience, participants rated themselves as 3, 2, 1, and 0. In phase 1, five participants rated themselves as 3, while in phase 2, three participants declared this rating. For rating 2, there were eight participants in phase 1 and six participants in phase 2. In phase 1, three participants rated themselves as 1, while phase 2 had nine participants in this rating. Finally, in phase 1, three participants rated themselves as 0, while in phase 2, there were twenty-five participants with this rating.

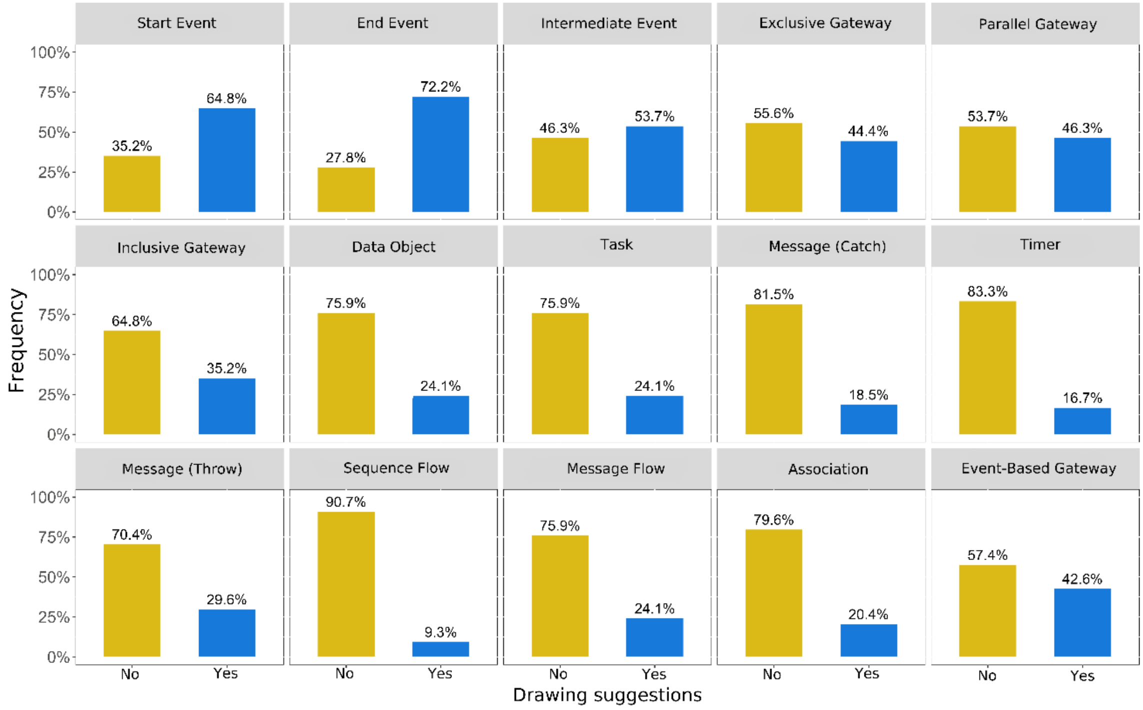
It was possible to see that participants with less experience tended to rate their familiarity with the notation lower than 5 marks. However, it is still evident that even participants with some experience, such as the one who rated their familiarity as 4 in phase 1 and had more than 5 years of experience (ID [2a]), might still feel unfamiliar with the notation. Thus, number of years of connection to the notation might not be definite to how familiar someone is going to feel with it.

To gain a deeper understanding of these numbers and their implications, the semiotic analysis also considers how each participant perceives the function of BPMN artifacts.

6.4 Semiotic Analysis of BPMN's Signs

When presenting participants with the BPMN model, phase 1, as described on page 66, they were given the opportunity to suggest different graphical elements than the ones currently used by the notation. It was observed (Figure 28) that more than half of the elements had a low proportion of participants who actually proposed new signs.

Figure 28. Suggestion of graphical elements per artifact for phase 1.



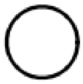
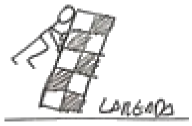
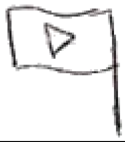
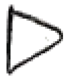
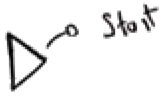
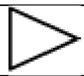
It is worth mentioning that the `Start` and `End Events` were the elements with the highest percentage of suggestions, while the `Sequence Flow` had the lowest percentage of suggestions. In the following sections, the graphical elements proposed as described in the methodology undergo a descriptive semiotics analysis, and the numbers seen above will be better interpreted.

6.4.1 Start Event

Regarding the `Start Event`, out of the fifty-four participants, seventeen (35.2% – as shown in Figure 28) did not suggest a drawing. However, there were thirty-five drawing suggestions (64.8%), among which one participant proposed using a countdown gif[6] as a more representative option. While BPMN follows a symbolic sign approach, associating the graphical element with general ideas and establishing a convention within the community that such a circle with a line denotes the beginning of a process, some participants offered alternative representations. Examples of these suggested representations can be seen in Table 7.

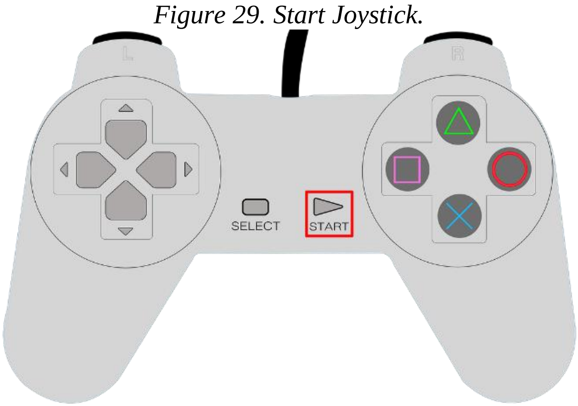
[6] According to Cambridge dictionary (2023), gif is the abbreviation for Graphic Interchange Format, which contains a static or moving image computer file.

Table 7. Start Event suggestions.

Start Event			
BPMN			
Suggestions			
	[3a]	[8a]	[21a]
			
	[42a]	[43a]	[48a]
			
	[52a]		
Phase 2			

Twenty six percent (26%) of the suggestions were related to the gaming domain, specifically depicting the start button of a joystick (Figure 29). It is noteworthy that participants' suggestions aim to transform the BPMN symbol into an icon by associating it with an existing element of a real object. The triangular shape of the start button seems to be more representative of a beginning for the current generation, contrasting than with the generalization of event as a circle.

Figure 29. Start Joystick.



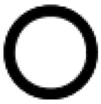
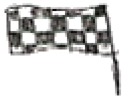
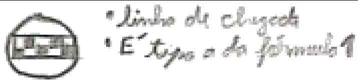
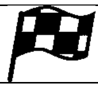
Source: Sberveglieri (2020)

6.4.2 End Event

For the `End Event`, 27.8% (eleven participants) chose not to propose any drawing. Among the remaining 72.2% (thirty-nine participants), various suggestions were made. One participant suggested using the colour green to represent success and red for fails, while another proposed a gif with a waving hand. Additionally, one participant expressed that there was no need to propose a different graphical element.

Similar to the `Start Event`, the `End Event` can also be observed as a symbol, where its meaning is arbitrarily chosen and conventionally established. As a result, the circle with thick borders used in BPMN underwent significant change in the hands of participants.

Table 8. End Event suggestions.

<table>
<tr><th colspan="4">End Event</th></tr>
<tr><td>BPMN</td><td colspan="3"></td></tr>
<tr><td rowspan="6">Suggestions</td><td></td><td></td><td></td></tr>
<tr><td>[3a]</td><td>[6a]</td><td>[8a]</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>[10a]</td><td>[21a]</td><td>[48a]</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">[42a]</td></tr>
<tr><td>Phase 2</td><td colspan="3"></td></tr>
</table>

As shown in Table 8, the majority of the suggestions involved depicting racing flags, which are traditionally used in motorsports to represent the completion of a race (Figure 30).

Figure 30. Racing Flag.

Source: Spamforpic (2016)

This is the point where icons, indexes, and symbols might start being confusing. Participants decided to draw an icon that directly recalls the image of the checkered finish line flag, which, in turn, is a symbol for the end of a race. Hence the drawings showed much resemblance with the real object, indicating that participants chose a more iconic approach representation compared to the symbolic one chosen by the notation.

6.4.3 Intermediate Event

For the `Intermediate Event`, 46.3% opted not to suggest any drawings. Among the remaining 53.7% who did suggest different graphical elements, once again, one participant expressed that there was no need to suggest anything.

The `Intermediate Event` is represented by two parallel circles, one inside the other, indicating occurrence of an `event` in the middle of the process. This characteristic likely explains why 24.1% of the suggested drawings shared similarities with traffic signs, particularly the "*Stop Sign*".

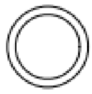
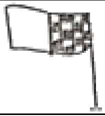
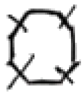
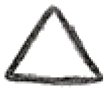
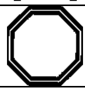
Road signs are implemented to alert drivers so they can drive with caution and avoid accidents. The "*Stop Sign*" (Figure 31), is one that is internationally used to represent a full stop is needed at an approaching intersection. It is represented by an octagonal sign across different countries, with variations in the language used to indicate "*stop*" (FREEPIK, 2023).

Figure 31. Stop sign.

Source: Freepik (2023)

As seen in Table 9, participants had the tendency to draw symbols that did not directly resemble their actual objects. Even when their drawings recalled traffic signs, they did not represent the object as they really are. Instead, participants focused on just taking some of their characteristics to make suggestions.

Table 9. Intermediate Event suggestions.

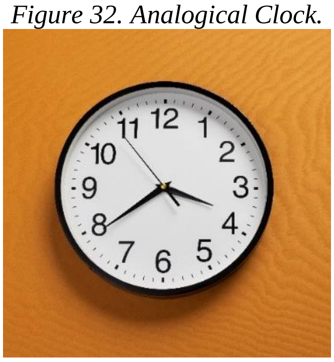
Intermediate Event			
BPMN			
Suggestions			
	[8a]	[22a]	[23a]
			
	[33a]	[34a]	[39a]
			
	[48a]		
Phase 2			

Among, the participants, there were those who chose a more iconic approach, such as [8a] and [48a], who respectively drew a half-checked racing flag and a stop button from a joystick to represent an `event` in the middle of a process. However, as already mentioned, the majority of suggested drawings did hint at the “*stop sign*” symbol. Therefore, it was the chosen one to be represented in phase 2.

6.4.4 Timer

Only 16.7% of participants suggested a different graphical element for this marker. The `Timer`, represented by the icon of an analogical clock (Figure 32), placed inside the representation of the `Intermediate Event`, received only nine drawing suggestions. However, despite a limited number of suggestions it was decided to proceeded with this element’s analysis on phase 2 due to the striking similarity observed among what had been suggested.

Figure 32. Analogical Clock.



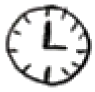
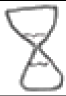
Source: Freepik (2023)

Figure 33 Hourglass.

Source: Pixabay (2016)

Therefore, specifically with this element, the aim between one phase to the other was to test whether changing an icon that already posed positive levels of representation for another equally iconic would have different results. Forty-four percent (44.4%) of participants proposed representing hourglasses (Figure 33) instead of analogical clocks (Table 10), which persists its status as an icon since both share immediate resemblance to their actual objects.

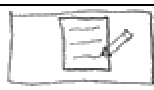
Table 10. Time Event suggestions.

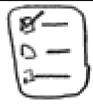
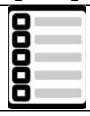
Timer			
BPMN			
Suggestions			
	[23a]	[24a]	[25a]
			
	[27a]	[29a]	[34a]
			
	[43a]		
Phase 2			

6.4.5 Activities

As previously mentioned, `Activities` are a generic element used to represent actions operated during a process, their unity represented by `Tasks`. They are visually represented by a shape that resembles a rectangle with round edges. There is no indication in this shape that resembles a real activity or the action of performing a `Task`. Therefore, when BPMN chose this graphical element, it made a decision based on reinforcing an idea or generalization that such symbol would represent a certain meaning within the given context.

Table 11. Task suggestions.

Task			
BPMN			
Suggestions			

	[14a]	[22a]	[32a]
			
	[36a]	[37a]	[51a]
			
	[48a]		
Phase 2			

Seventy-five-point nine percent (75.9%) of participants decided not to suggest other representations. However, the twelve participants (24.1%) who suggested different graphical elements demonstrated a preference for an indication within the element of what it is about. As seen in Table 11, some of them made use of working tools such as hammers to represent activities, but the majority (25%) agreed on representing lists of activities or checklists. Even though the drawings do resemble their real object they cannot be considered icons, because making a checklist does not necessarily infer the meaning of performing an `Activity`. Therefore, here it was considered that both representations from the notation and the suggested one are symbols.

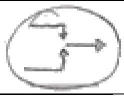
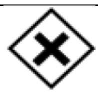
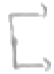
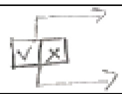
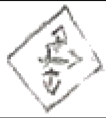
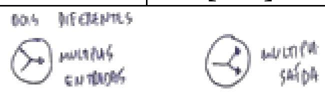
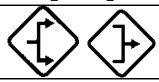
6.4.6 Exclusive Gateway

Within the diamond shape, the `Exclusive Gateway` can be represented either without any marker inside or with two intersecting lines forming an "×" shape. As it gives no direct indication to its actual meaning, users of this graphical element must interpret it either from context or have prior knowledge, recognizing its stated generalization. Therefore, this form functions as a symbol.

Fifty-five-point six percent (55.6%) of participants did not suggest any drawings for this element, and there were twenty-four who at least commented on this matter. One participant suggested there is no need for a different element, while another participant reinforced that removing the perpendicular lines would imply the same meaning.

From the signs suggested, approximately 33.3% drew arrows instead of lines on the intention to represent possible paths (Table 12). This idea of following paths was also implied in the suggestion of participant [3a], who made use of train tracks to represent the possible stream to follow, indicating that decisions should be made one at a time.

Table 12. Exclusive Gateway suggestions.

<table>
<tr><td colspan="4"></td></tr>
<tr><td>BPMN</td><td colspan="3"></td></tr>
<tr><td rowspan="6">Suggestions</td><td></td><td></td><td></td></tr>
<tr><td>[3a]</td><td>[12a]</td><td>[22a]</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>[27a]</td><td>[32a]</td><td>[43a]</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">[52a]</td></tr>
<tr><td>Phase 2</td><td colspan="3"></td></tr>
</table>

Most importantly, it was suggested to create two different signs to represent "*multiple entries*" and "*multiple exits*", hence the single `Exclusive Gateway` transformed into `Exclusive Gateway Split` and `Join` (Table 12) for the model in phase 2. Although BPMN has a premise to minimize the number of graphical elements to lessen the burden to learn the language (MENDLING, REIJERS and AALST, 2010; GRUHN and LAUE, 2009; MENDLING *et al*, 2012), participants showed paired elements that complement each other's meanings to facilitate the understanding of the process.

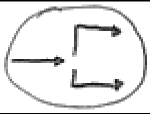
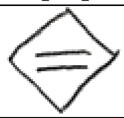
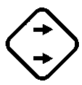
Despite the attempt to represent the possible paths to be followed by indicating them with arrows, it is still not possible to classify these two signs as icons. They do not share straight resemblance to their real object to be categorized that way. Therefore, both of them are still considered symbols, albeit with iconic indication.

6.4.7 Parallel Gateway

`Parallel Gateways` are represented by a diamond shape marked by two perpendicular lines forming a cross (+) in the middle of the graphical element. Since they are used to indicate paths that can be followed at the same time, there is no direct indication of that meaning within that representation, leaving its understanding to context and/or previous instruction. Thus, BPMN's `Parallel Gateways` can be considered symbols.

Participants demonstrated to prefer modifying the already used signs just a bit, by changing the perpendicular lines to parallel ones, indicating that streams could be followed at the same time (Table 13). In total, 53.7% of participants chose not to indicate a different representation, while twenty-five participants chose to fill the field for suggestions. One participant stated there was no need to change the element in use, and 33.3% of the ones who presented a suggestion implied the change of the perpendicular lines for parallel ones. So, the sign presented in the model for phase 2 was an attempt to merge such suggestions.

Table 13. Parallel Gateway suggestions.

Parallel Gateway			
BPMN			
Suggestions			
	[3a]	[6a]	[10a]
			
	[32a]	[39a]	[45a]
			
	[51a]		
Phase 2			

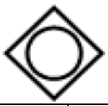
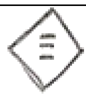
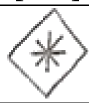
Although this sign graphically indicates the idea of parallels, it is still considered that if taken out of the context, participants wouldn’t be able to identify its meaning. Therefore, it still keeps its essence as a symbol.

6.4.8 Inclusive Gateway

The `Inclusive Gateway` is represented by a diamond shape with a circle (○) inside. Its purpose is to indicate that any combination with at least one of the paths is possible. In essence, there is need for instruction on its meaning to be able to understand it. In other words, it follows the pattern of symbols, that have their meaning reinforced by generalizations created by man.

There were 35.2% of participants who decided to suggest a different graphical element for this function, representing twenty subjects. Out of those, approximately 45% made use of lines or arrows to represent the possibility of following many directions (Table 14). The graphical element selected to be represented in the second process model appeared almost drawn the same twice by two different participants, while others drew very similar versions.

Table 14. Inclusive Gateway suggestions.

		Inclusive Gateway	
BPMN			
Suggestions			
	[3a]	[27a]	[29a]
			
	[36a]	[39a]	[44a]
			
	[49a]		
Phase 2			

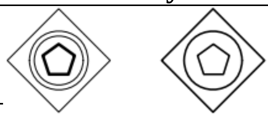
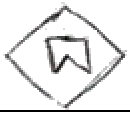
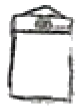
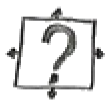
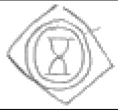
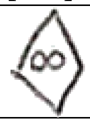
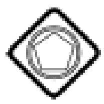
It is worth noting that BPMN already uses this element as the `Complex Gateway` to express splitting or merging of complicated process flow scenarios. However, in the models presented in this research, `Complex Gateways` were not included. Instead, it was decided to use the participants' suggestions to understand if they would actually consist of better representation.

Although participants' suggestions exhibit more iconic characteristics compared to BPMN's representation, as they try to indicate different paths to follow, it is still not possible to consider the sign suggested by participants as an icon. Rather, it remains a symbol since it would demand context and/or previous knowledge to interpret its meaning.

6.4.9 Event-based Gateway

As the other `Gateways`, `Event-Based Gateways` are branching and joining points. These `Gateways` indicate decisions for paths that can be followed after an `Event` occurs in that point in the process. It is represented by the diamond shape, with an `Intermediate` or `Start Event` in the middle, a pentagon and markers such as `message` and `timer` can be used inside. This sign is a construct of different elements and its meaning reinforced by the users of the notation; thus, classifying it as a symbol.

Table 15. Event-based Gateway suggestions.

Event-based Gateway			
BPMN	+ 		
Suggestions			
	[8a]	[22a]	[24a]
			
	[27a]	[33a]	[37a]
			
	[53a]		
Phase 2			

From the fifty-four participants, 57.4% opted not to suggest different graphical elements, leaving the other 42.6% who did opt for any kind of suggestion on this element. One of these participants decided to dissect the sign already used by BPMN, separating each different graphical element and explain the logic of the gateway presented by the notation, not suggesting a different element. Other 2 participants wrote that they couldn't suggest a different element from the one in the notation. As for the other suggestions, even though there was a good number of participants who actually drew graphical elements, they were mostly either too similar to the one already used by the notation or too different from each other (Table 15). These points made it extremely difficult to suggest an element other than the one already in use to be analysed in phase 2. Hence, this element was preserved as the same symbol used in BPMN.

6.4.10 Message Catch

Communication between `Pools` are necessary for obtaining information or actions from agents external to the process. For example, these communications were used in phase 1's model (Figure 23) when agents inside the process, *Legal Sector*, *Customer Services*, or *Real Estate Agent*, needed to communicate with the *Owner*. The `message` marker can happen in `Start`, `Intermediate` and `End Events`, each with its own distinct characteristics.

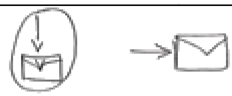
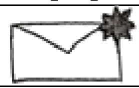
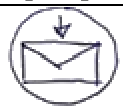
`Start Events` are only able to react to catch triggers, as it is not possible to initiate a process by sending a message to an external agent. On the other hand, `Intermediate Events` can react to both catch and throw triggers, allowing communication to be received and sent during a process. The `catch-type event message` is visually represented by an unfilled letter envelope (Figure 34). Even though there is clear resemblance with its real object, both the sign and object indicating communication, there is an important semantic factor that this representation by itself does not clearly state: the message is being received. For depending on other elements to fully express its message, this sign is here considered a symbol.

Figure 34. Letter envelope.

Source: Akyurt (2022)

There was a striking low number of suggestions for this element, reaching only 18.5%, compared to the 81.5% of participants who opted not to suggest a different graphical element. From the ones who provided some info (ten participants), one expressed there was no need to propose a different graphical element, and another mentioned that the current representation from the notation was already ideal for its function. However, one specific participant, identified as [3a], further commented on the difficulty in discerning whether a message was being received or sent. (S)he mentioned that the differentiation of graphical elements through colour or filling of the letters is not intuitive enough for conveying this distinction.

Table 16. Message Catch suggestions.

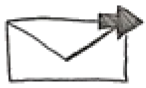
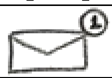
Message Catch			
BPMN			
Suggestions			
	[7a]	[22a]	[29a]
			
	[39a]	[49a]	[51a]
			
	[52a]		
Phase 2			

Among those who suggested different graphical elements, the unfilled letter envelope was the unanimous choice (Table 16). However, 22.2% of participants used arrows to indicate the direction the communication should be flowing within the process. The sign utilized in the second model (Figure 24) consisted of two parts: an icon representing a letter envelope and a general representation of arrows to indicate directions, making it a symbolic representation. Thus, for its attempt to indicate the direction the message is flowing within the sign itself, it should be considered an icon.

6.4.11 Message Throw

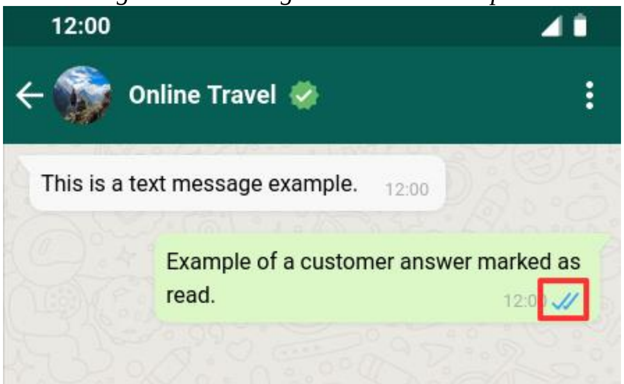
`End Events` can only generate throw-type triggers as results, while, as already mentioned, `Intermediate Events` can trigger both catch and throw. This distinction arises because, when finishing a process, it is not possible to receive communication from external agents, you can only send them. For example, in the case of a `message throw event`, triggers of this type are represented by filled markers (Table 17). Even though the visual representation of a letter envelope is the same as that of the `message catch` `event`, there is no explicit actual indication or direct resemblance to their object in reality. It is indeed possible to infer, through the image and context, that communication is somehow related to it. However, BPMN made use of a generalization to instate that filled letter envelopes are an indicator that messages are being sent from the process to other agents. Therefore, this sign should be considered a symbol, even though it does have iconic hints.

Table 17. Message Throw suggestions.

<table>
<tr><th colspan="4">Message Throw</th></tr>
<tr><td>BPMN</td><td colspan="3"></td></tr>
<tr><td rowspan="6">Suggestions</td><td>
</td><td></td><td>
</td></tr>
<tr><td>[3a]</td><td>[23a]</td><td>[29a]</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>[30a]</td><td>[32a]</td><td>[39a]</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">[51a]</td></tr>
<tr><td>Phase 2</td><td colspan="3"></td></tr>
</table>

If compared to the `message catch event`, `Message Throw` had only a slight bigger percentage of suggestions, 29.6%, as 70.4% of participants preferred not to indicate or comment. As it happened for the previous element, one participant expressed there was no need to change the graphical element already in use and another mentioned finding it ideal for its function. Another participant suggested the use of colours green or red, but did not provide further details on how this could be implemented. In total, there were sixteen drawing suggestions, from which 18.7% included checkmarks (Figure 35) to indicate a message is being sent (Table 17).

Figure 35. Message checkmark example.



Source: Meta for Developers (2023)

Symbols from social networks have become so routinary in the lives of this generation that it may explain why so many connected the idea of checkmarks with sending messages. In the second model, the chosen sign uses an unfilled letter envelope icon since filling it could be confusing for some and the checkmark characteristic to messaging in social media. Therefore, this was considered as an effort to transform a symbol into an icon.

6.4.12 Sequence Flow

`Sequence Flows` are used to represent the sequential order in which `activities` are performed within a process. `Tokens` traverse these flows to illustrate the progression towards the target object. In BPMN, `Sequence Flows` are represented by continuous line with a filled arrowhead. It could be considered that arrows are a concept reinforced by humankind's generalizations, since it is unknown when this international representation for directions was conventionalized, therefore overall, they are considered symbols. However, `Sequence Flows` as graphical elements are used to visually represent directions/paths to be taken, and they do share straight resemblance to their objects used in real life situations, for instance "traffic signs" (Figure 36). In the context of BPMN, `Sequence Flows` were here considered icons.

Figure 36. Traffic sign arrow use.

Source: Komarov (2022).

Among the fifty-four participants from phase 1, there was a striking amount of 90.7% of participants who opted not to suggest a different graphical element for this element. Other three participants expressed satisfaction with the current representation describing it as “*ok*”, “*good*” or “*ideal*”. One participant said that there was no need for suggesting a different one. Additionally, there were only five drawing suggestions, 9.3% (Table 18).

Table 18. Sequence Flow suggestions.

Sequence Flow			
BPMN			
Suggestions			
	[3a]	[25a]	[29a]
			
	[35a]	[51a]	
Phase 2			

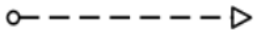
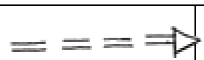
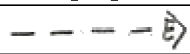
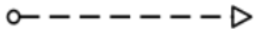
As observed, the suggested drawings have a striking similarity to the one already employed by BPMN. The suggestions that could enhance comprehension were related to using `tokens` to make possible paths to be followed clearer. However, given that the research presented the models in 2D versions printed in A4 papers, it was determined that incorporating this concept would be more confusing than helpful. Nonetheless, this topic has been acknowledged and proposed as potential future work.

Following this further, due to the low number of suggestions and their similarity to the existing graphical element, it was decided that BPMN’s icon should be reproduced in the second model.

6.4.13 Message Flow

Message Flows are used to indicate the exchange of information between participants, either to receive or to send them. Similar to Sequence Flow, Message Flows are represented using lines and arrows, the difference is that they utilize a dashed line with an unfilled arrowhead. There is no indication, from how this element is designed, that its meaning is connected to the exchange of communication. Although it indicates direction as the sequence flow, the way it is represented was definitely defined upon an agreement among those who created the notation. For those reasons, message flow should be considered a symbol.

Table 19. Message Flow suggestions.

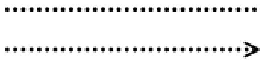
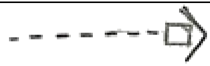
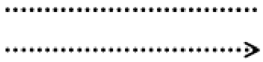
Message Flow			
BPMN			
Suggestions			
	[3a]	[5a]	[22a]
			
	[25a]	[29a]	[37a]
			
	[51a]		
Phase 2			

Among participants from phase 1, 75.9% opted not to suggest a different graphical element. From the other 24.1%, one mentioned no need to change the notation, while two other participants stated the current representation is "*good*" and "*ideal*" for its intended function. There were thirteen drawing contributions, and one of them reiterated that it is difficult to differentiate between the representation for Message Flows and Data Objects. As shown in Table 19, the suggested drawings either diverged a lot from each other or were similar to the one already in use. Consequently, the decision made was to keep the element used in BPMN for phase 2.

6.4.14 Association

Associations, used to link information (e.g., Data Objects) to graphical elements within a process flow, are represented by dotted lines and an arrowhead that indicates the direction of the flow. Once again, this is a case of a symbol, where the concept that such dotted lines represent the association of certain information (`Data Objects`).

Table 20. Association suggestions.

Association			
BPMN			
Suggestions			
	[3a]	[25a]	[29a]
			
	[47a]	[49a]	[51a]
Phase 2			

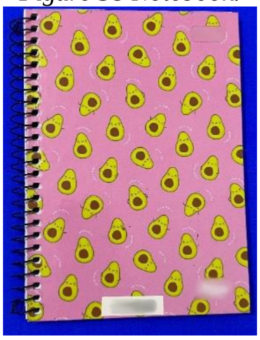
Seventy-nine point six percent (79.6%) of participants opted not to fill in suggestions or comments. There were only 20.4% who did so, in which one stated there was no need for a different representation and another expressed satisfaction with the existing one. As observed in Table 20, the suggestions for `association` either varied greatly from one another or were too similar to the one already employed by the notation. Consequently, it was not possible to propose a different sign for the modal in phase 2.

6.4.15 Data Object

`Data Object` represents physical items and information generated during the execution of the process. This representation provides information about the requirements of `Tasks` or the outcomes they produce. It is represented by an A4 sheet of paper with its top right corner slightly bent (Figure 37).

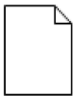
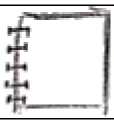
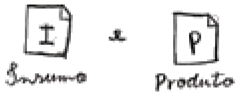
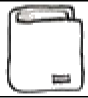
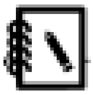
Figure 37. A4 paper with tilted corner.

Figure 38 Notebook.



Although this sign does have a straight resemblance to an existing object it does not share enough similarities in meaning to its element, in other words, if not in the context of this notation it becomes difficult to relate the image of this paper to the product of an `Activity`. Therefore, it should be considered a symbol.

Table 21. Data Object suggestions.

Data Object			
BPMN			
Suggestions			
	[5a]	[29a]	[34a]
			
	[36a]	[37a]	[39a]
			
	[51a]		
Phase 2			

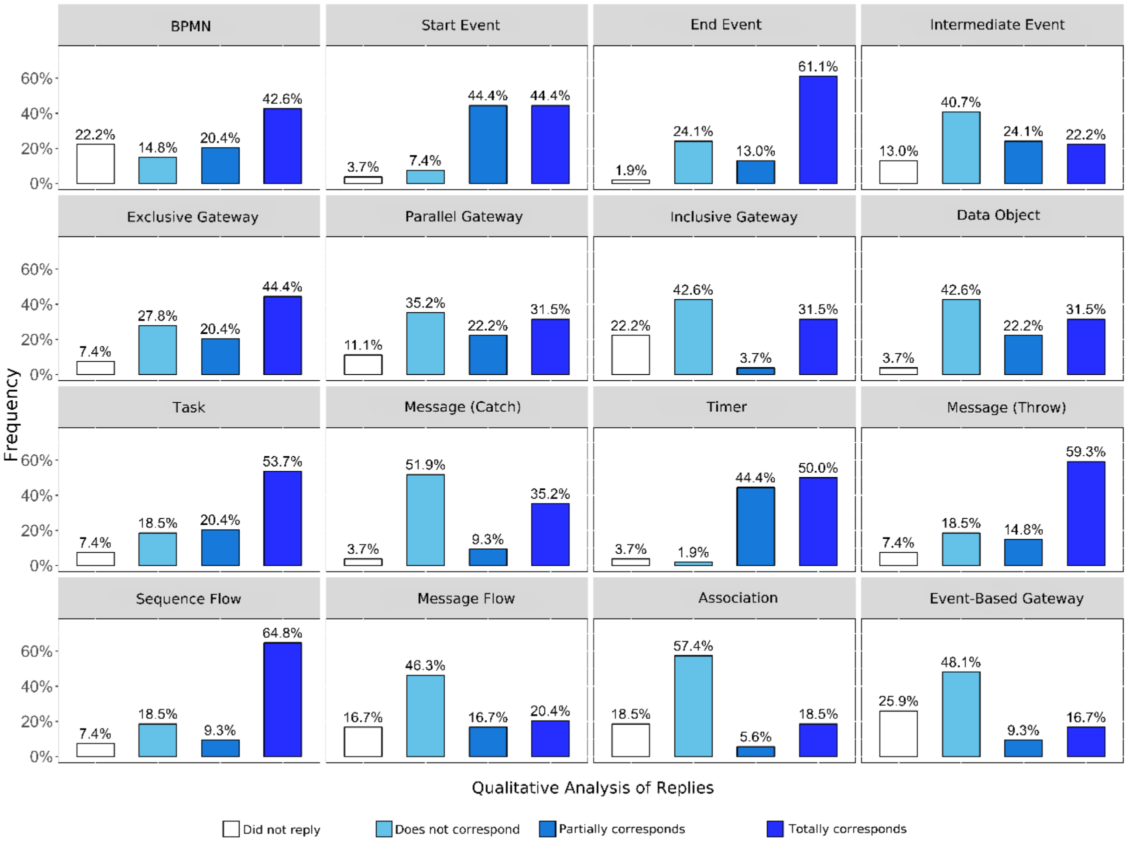
From the fifty-four participants, 75.9% opted not to suggest any different elements, and 24.1% did suggest. A total of fourteen drawing suggestions were received, where two participants drew the exact same graphical element from BPMN. Another one expressed that changing the notation was not necessary. Among those fourteen suggestions, 23% recalled images of notebooks or notepads (Table 21). As the symbol of a sheet of paper to represent data, notebooks and notepads (Figure 38) also does not share a direct resemblance to its object and meaning to be categorised as an icon, the sign used in phase 2 for `Data Object` was also categorized as a symbol.

6.5 Comprehension of Sign's function

As mentioned during the research design, participants were also asked to describe the function they understood each presented sign performed in the models. Analysing the phases individually, for each graphic element, participants were free to express themselves however they wanted using words. These answers were then categorized into one of the following four concepts: did not reply, does not match the concept, partially matches the concept, and totally matches the concept.

This approach allowed to understand, in numbers, how many participants actually understood and could match the functions of the graphical elements to the concepts presented by BPMN. Based on Figure 39, for phase 1, it is possible to observe that some signs' functions were better described than others. The elements `Intermediate Event`, `Inclusive Gateway`, `Data Object`, `Message Catch`, `Message Flow`, `Association` and `Event-Based Gateway` were those that presented a higher concentration of replies that did not correspond with the true function presented. It is also worth mentioning that for the last two elements, the number of answers that did not correspond is almost twice as many as the answers that partially or totally correspond.

Figure 39. Qualitative analysis of replies by signs for Phase 1.

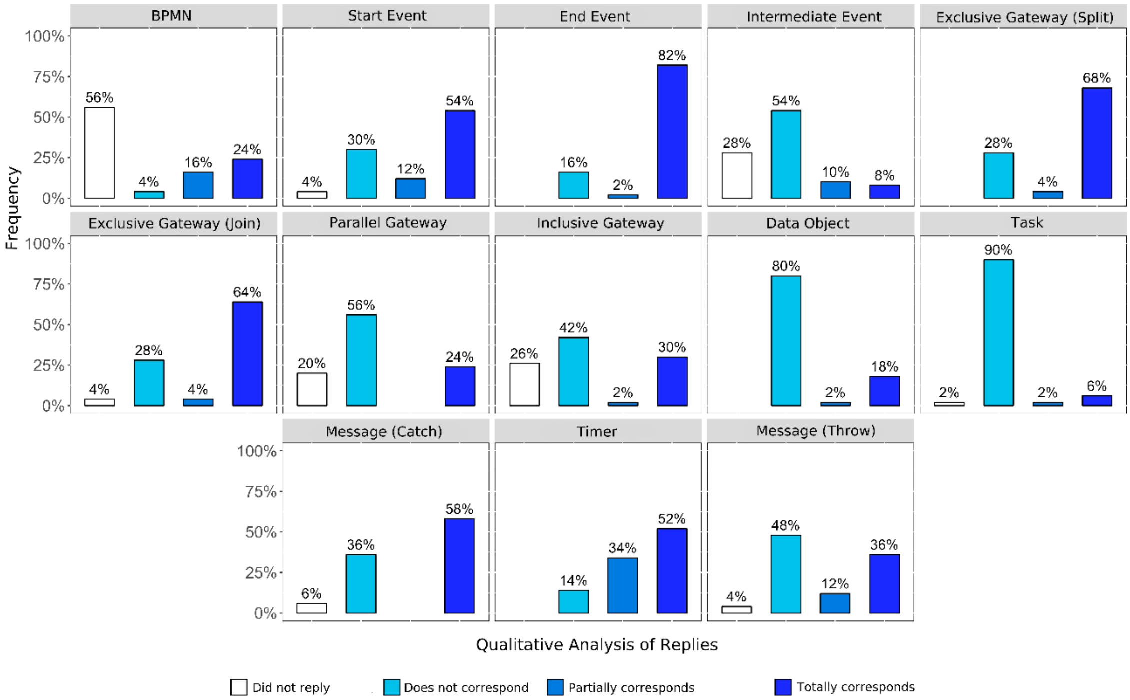


Highlighting that for all these elements, the percentage of replies that partially or totally corresponded with the concept presented is quite high, representing, in many cases, twice as many as those that did not. Finally, there is also the `Parallel Gateway`, where greater balance was observed throughout the responses.

On the other hand, for phase 2, there is a greater distinction between the description of the signs presented (Figure 40). There was a smaller number of replies that corresponded partially. In this phase, when asked to described the model there was a high number of non-responses, surpassing half of the total of participants. For the signs representing `Inclusive Gateway` and `Message Throw`, it is possible to see balance in the replies, showing better distribution among the three classes (does not correspond, partially corresponds, and totally corresponds).

There was a greater concentration of replies that totally corresponded to the function presented for the `Start Event`, `End Event`, `Exclusive Split Gateway`, `Exclusive Join Gateway`, `Message (Catch)` and `Time Event`. Finally, there was a higher concentration of replies that did not correspond to their function for `Intermediate Event`, `Parallel Gateway`, `Data Object` and `Task`.

Figure 40. Qualitative analysis of replies by sign for phase 2.



In general, the high concentration of replies that correspond to the function presented for `Start Event`, `Time Event` and `End Event` in both phases of this study may indicate that such signs are easier to be understood. On the other hand, the high concentration of replies that do not correspond to the function for the `Intermediate Event` and `Data Object`, also in both phases, it may indicate that such signs are more difficult to be understood.

In addition, it is worth highlighting `Message (Catch)` and `Task`, which showed different behaviours in each of the phases. During *phase* 1, `Message (Catch)` was categorized a symbol, while in the second *phase*, it was considered an icon. The percentage of replies that did not correspond went from 51.9% to 36%, and the percentage of replies that totally corresponds increased from 35.2% to 58%. As for `Task`, it was observed that though both signs were categorized as symbols in both *phases*, there are still variants to be taken into account, as the 53.7% of totally corresponds in *phase* 1 turned into the striking amount of 90% of does not correspond in *phase* 2.

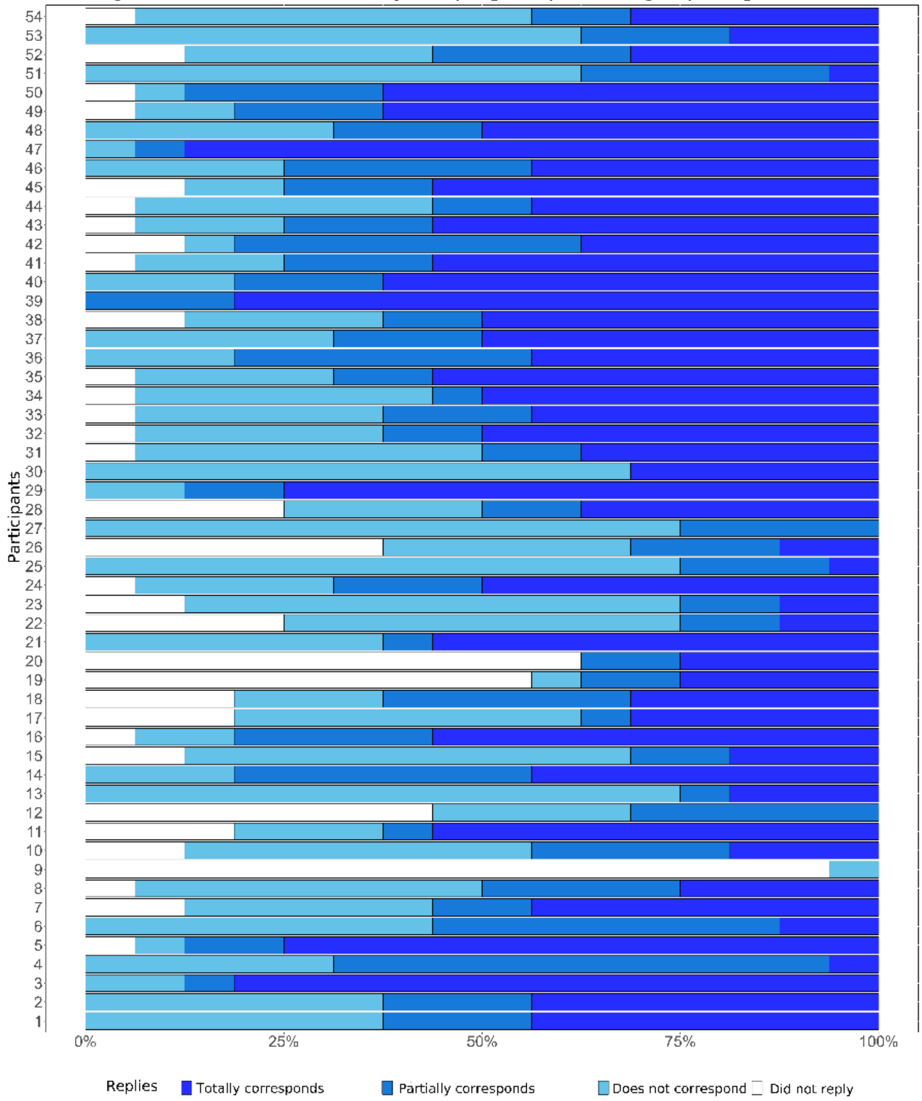
This can lead to the interpretation that the signs with more iconic indications tend to have better results in comprehension, while those based on symbols show lower results. However, even among symbolic representations, there are those to which users are able to relate more than others.

6.6 Individual analysis of participants' performance

In order to analyse the behaviour of each participant individually, their replies on the functions of graphical elements were also graded within the same system as previously mentioned. Here there is a short description of their performance starting from *phase* 1.

As shown in Figure 41, many participants opted not to reply to questions describing the functions for several different elements. This could be attributed to less experience of many participants, with participant [9a] standing out as (s)he did not respond to more than 90% of the questions.

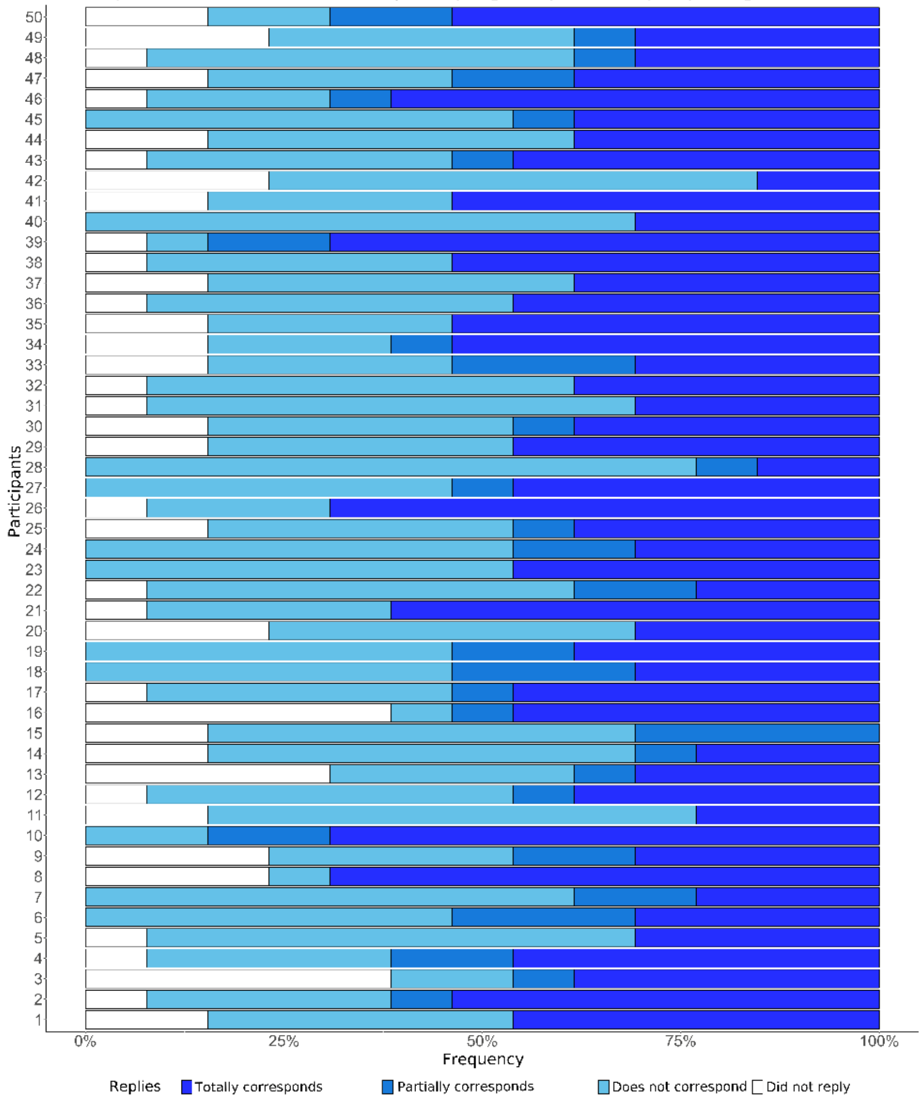
Figure 41. Quantitative analysis of replies for the signs from phase 1.



Even among those who did respond to the questions about the functions, a high percentage of replies did not correspond to the intended function. Nonetheless, it is worth noting that less than 30% of participants managed to have their answers classified as "*totally correspond*" to the actual function in at least 50% of the assessed graphical elements from BPMN. It is important to highlight five participants who reached this response in 75% of the assessed elements: [3a], [5a], [29a], [39a] and [47a].

When analysing *phase* 2 (Figure 42), a smaller number of "*did not reply*" was observed, as well as a more consolidated division between those whose responses did not correspond to the actual function and those whose responses "*totally corresponded*", as seen in Figure 40. However, similar to the first *phase*, there was a lower number of participants who exceeded 50% of signs where their answers "*totally correspond*" to the actual function. It is worth highlighting participant [15b], who had no replies classified as "*totally corresponds*".

Figure 42. Quantitative analysis of replies for the signs from phase 2.



6.7 Validating Hypotheses

Although the main aim of this study focuses on a qualitative analysis, a *Chi-Square* test of independence was proposed to validate and compare results between the two phases. This test allows us to assess the relationship between both *phases* and two variables: *representativeness* of signs presented and the *qualitative analysis* of sign's function descriptions.

First, regarding the representativeness of signs, it was tested the null hypothesis in which there is no difference in representativeness of signs between the two *phases* against the alternative hypothesis that there is difference in the representativeness of signs when changing phases. Table 22 shows the results of the test for the different signs.

Table 22. Independence Chi-Square Test for the sign's representativeness in phases 1 and 2.

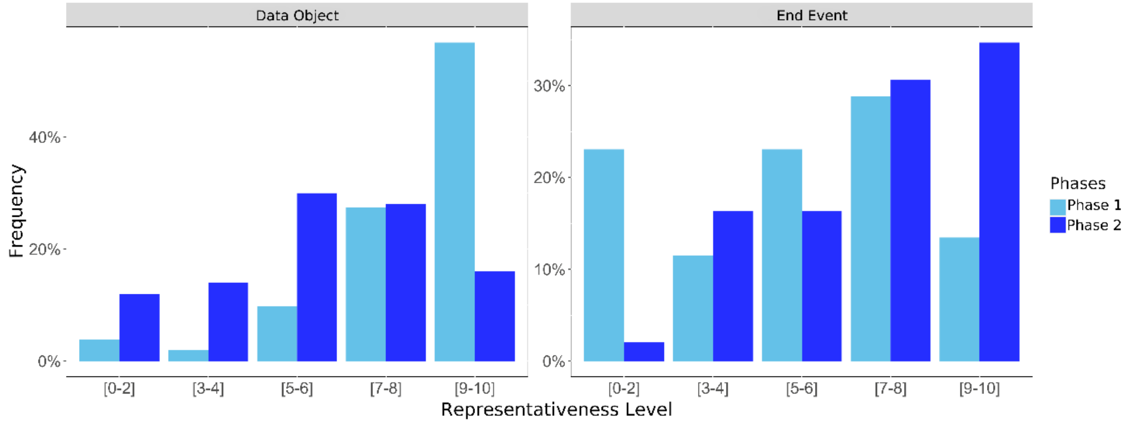
Sign	Q	*p-value*
Start Event	0.239	0.9934
End Event	**14.484**	**0.0059**
Intermediate Event	4.845	0.3036
Parallel Gateway	7.448	0.1140
Inclusive Gateway	7.905	0.0951
Data Object	**23.411**	**0.0001**
Task	4.904	0.2973
Message (Throw)	4.534	0.3385

During the descriptive analysis, fifteen graphical elements were presented, but four of them (`Sequence Flow`, `Message Flow`, `Association` and `Event-Based Gateway`) were eliminated after phase 1. While their descriptive semiotic analysis remains relevant for the context of this study, they did not provide statistical significance to be considered in the subsequent stages.

Then, ten elements were modified and represented by different signs in the second *phase*, with their functions being part of both *phases*. However, for `Time Event` and `Message (Catch)`, the *Chi-Square* test could not be used due to the high concentration of responses in only a few classes, making it unsuitable for analysis. Among the remaining eight graphic elements, at a significance level of 5%, evidence was found to reject the null hypothesis for `End event` and `Data object`. This means that there is a difference in the representativeness of these signs between the two phases.

Figure 43 provides a detailed illustration of this behaviour. For `Data Object`, there are higher levels of representativeness in phase 1, while in *phase* 2 there is a greater balance with lower ratings. In contrast, for the `End Event`, this behaviour is inverted, as participants from *phase* 1 rated this element lower in representativeness, while those form *phase* 2 graded the proposed sign with higher ratings. For the other graphic elements, no statistically significant differences were found between the two *phases* regarding the representativeness of the signs.

Figure 43. Level of representativeness of Data Object and End Event between both phases.



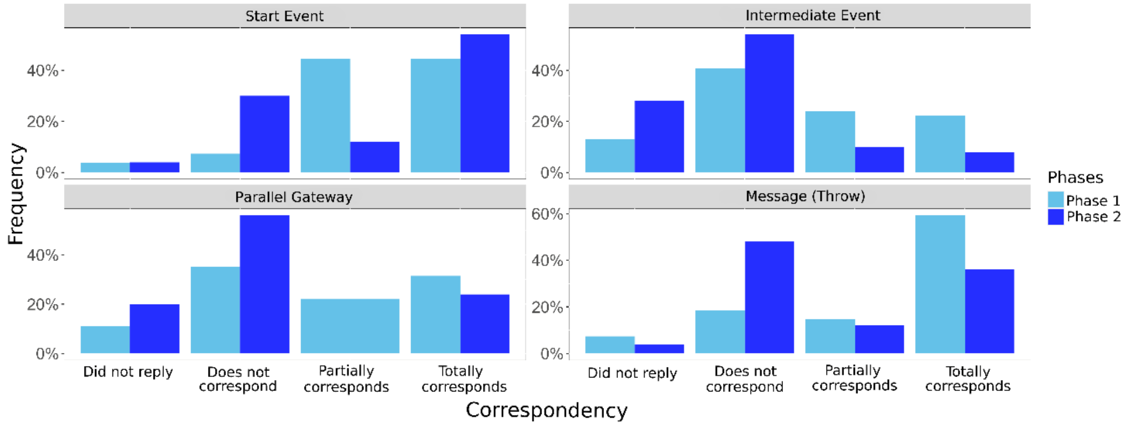
Continuing with the analysis, the qualitative descriptions of the signs' functions were assessed. The null hypothesis assumed that the level of correspondence in the sign's function description is the same for the participants of both *phases*, while the alternative hypothesis suggested that there would be a difference in the correspondence of the function description between the two *phases*. The results of this analysis are presented in Table 23 according to the *Chi-Square* test of independence.

Table 23. Independence Chi-Square Test for matching sign's function description between phases 1 and 2.

Sign	Q	*p-value*
Start Event	**17.217**	**0.0006**
End Event	7.413	0.0599
Intermediate Event	**10.26**	**0.0165**
Parallel Gateway	**15.454**	**0.0015**
Inclusive Gateway	0.4360	0.9327
Message (Throw)	**10.499**	**0.0148**

Similarly, to the assessment on the representativeness of signs, the evaluation of functions' descriptions included ten signs used in both *phases*. Once again, due to the high concentration of responses in only a few classes, four elements (`Data Object`, `Task`, `Message Catch` and `Time Event`) were not suitable for the *Chi-Square* test. However, for the remaining six signs, at a significance level of 5%, there was evidence to reject the null hypothesis, indicating a difference in correspondence of descriptions between *phases* 1 and 2. Specifically, the signs that showed a difference in the level of correspondence in their descriptions were: `Start Event`, `Intermediate Event`, `Parallel Gateway` and `Message (Throw)`. A more detailed illustration of this behaviour can be observed in Figure 44.

Figure 44. Correspondence level of sign's function descriptions for Start Event, Intermediate Event, Parallel Gateway and Message (Throw) in both phases.



Regarding the `Start Event`, although there is a close proximity in the "*totally corresponds*" category, a noticeable difference between *phases* 1 and 2 can be observed in the "*does not correspond*" and "*partially corresponds*" categories. Participants from *phase* 1 show a greater correspondence in these categories compared to participants from *phase* 2. The same pattern is observable for the other three signs, where there are statistically significant differences between the *phases* (`Intermediate Event`, `Parallel Gateway` and `Message Throw`), with a particular emphasis on `Message (Throw)`. As for the other elements/signs, no statistically significant differences were found between the two phases regarding their level of correspondence.

6.8 Conclusions

From observations made, it can be concluded that BPMN primarily uses signs that relate to their objects based on rules reinforced by humans, making them mostly symbols. This includes `events` (`start`, `end` and `intermediate`), `gateways` (`exclusive`, `parallel`, `inclusive` and `event-based`), `messages` (`catch` and `throw`), `message flow`, `association` and `data object`. The only element that directly resembles its actual object, `timer`, as it can frequently represent the passing of time, closely related to its function.

During the analysis, there were no indications of indexes, as the signs used were not directly affected by their object, such as the example of a man with a sunburn in the shape of a hat indicating previous hat usage.

Participants, especially those with less than 3 years of experience with the notation, tend to prefer seeing the processes designed with the use of icons, possibly because they share a direct resemblance to their objects.

BPMN pays attention to the syntax of language, making elements within the same semantic field similar so they can be connected. However, during the analysis, participants tended to focus on each sign separately, and few were able to connect elements with similar functions. This level of abstraction can be reached, but inexperience with the notation may contribute to lower levels of abstraction, as most participants in the study had contact with BPMN for less than three years.

Interestingly, some experienced users still rated their familiarity with the notation lower than 5 on a scale from 0 to 10, indicating that the number of years a person is exposed to the notation does not necessarily define how familiar they feel with it.

Although the intention was to let participants free to suggest signs as they saw fit, there was a certain resistance to suggest different graphical elements, even for elements that received low ratings in terms of representativeness. `Start Event` and `End Event` received the most suggestions, but they were not the lowest in this rank.

Besides, it was expected that participants from *phase* 1, who had prior experience with BPMN, would have achieved higher results in the qualitative assessment of the descriptions of elements' functions. However, only five participants managed to totally correspond the description of functions in 75% of the signs studied.

In conclusion, the majority of graphical elements used in BPMN are symbolic signs, requiring training in notation to recognize their intended meanings. Participants in this study showed a preference for iconic signs, indicating that they can easily remember the meaning of an object simply by looking at its representation. This suggests that signs with more iconic indications tend to have better comprehension results, while those based on symbols show lower results. However, among symbolic representations some may be more easily relatable to users than others.

Yet, it is essential to focus on the signs' meanings to improve the quality of communication among stakeholders. It is advisable to explore the semiotics of signs used in new modelling languages, as it can aid in designing iconic models that facilitate better comprehension. Ultimately, an effective diagram for communication is one that conveys its intended message accurately to the receiver.

7. Final Considerations

The main objective of this research was to assess the representativeness of the signs used in BPMN for IT and business professionals. Additionally, the impact of using signs suggested by these professionals on the comprehension of the notation was observed. Through a *quasi*-experiment and semiotic analysis, this dissertation aimed at contributing to professionals who use process models by promoting appropriate communication techniques, systematizing abstract thoughts, and bridging the gap between specific language used by business and IT professionals. The use of business process models is intended to facilitate communication between stakeholders, but the different backgrounds of IT and business professionals often cause comprehension difficulties and miscommunication

To address this situation, this dissertation presented a *quasi*-experiment with semiotic analysis, utilizing a BPMN model with signs proposed by participants to enhance process models comprehension and reduce the communication gap between IT and business professionals. The process model resulting from this approach merged the most representative signs from BPMN with participants' ideas

The objective of examining whether specific signs influence the understanding of process models was achieved through the *quasi*-experiment involving participants who assessed the representativeness of signs used as BPMN graphical elements and signs suggested during *phase* 1 of the research. The main contributions of this paper include: (*i*) improving process models comprehension for better communication between stakeholders; (*ii*) emphasizing the importance of focusing on the meaning of specific signs for comprehending the context of process models; (*iii*) encouraging the use of semiotic analysis before creating new modelling languages to reduce discrepancies between the intended message and the message received.

It is important to note that this research did not aim to propose new graphical elements but rather to understand whether the elements used in BPMN are representative according to their semantics, which has been successfully achieved. The study highlighted that there is still much to explore in the realm of processes modelling and semiotic studies.

7.1 Research Limitations

It is crucial to acknowledge the limitations of any study to ensure the validity of research and demonstrate that the researchers are aware of the phenomenon being studied. With that in mind, the following limitations have been identified and presented:

- Geographic and time constraints: due to the need for the presence of a researcher during the application of questionnaires, the amount of data collected wasn't as big as intended. To address this limitation, future research could establish connections with various communities to conduct the study in different areas with a larger sample.
- Difficulty in finding experienced specialists in BPMN: it was challenging to find participants with more than five years of experience in BPMN, which might have affected quantitative results. However, it did not impact the qualitative analysis of the study.
- Use of print questionnaires: the use of print questionnaires limited the presentation of interactive models to demonstrate concepts such as Token in the notation, as suggested by one of the participants, or the use of gifs, as mentioned by others. Utilizing digital formats in future studies could overcome this limitation and offer interactive options.
- Lack of a comparative stage: although avoiding comparative bias aligned with research objectives, having a stage where signs from BPMN and the ones suggested could be compared would have been beneficial. Participants could then choose the visual option they found most suitable for specific functions.

These limitations may have had impact on the development of the research presented here. Nevertheless, identifying and addressing these limitations reinforces science's commitment to transparency and honesty, providing valuable insights for future research. Accordingly, it is recommended that these limitations be viewed as opportunities for improvement, enabling future studies to overcome these challenges and deepen the phenomenon's understanding. The following subsection presents some proposed areas of exploration for the future scientific community.

7.2 Future Work

It is important to emphasize that based on the results of the study presented here and potential developments of this *quasi*-experiment, there are some opportunities for future research in the fields of process modelling, particularly concerning semiotics. Some promising options for future studies are highlighted below:

- Invest in virtual reality environments to provide interaction with the concept of `tokens`, to analyse whether this enhances the comprehension of other signs.
- Explore the context of stakeholders to determine statistically whether there are more male users of BPMN than female users, the age range of individuals who utilize the notation, and other factors. Identify gaps that could widen the usage of the notation to a broader range of users, regardless of gender and age.
- Consider including a third *phase*, *Phase* 3, in the research design described in this methodology. This phase would analyse whether participants who took part in *Phase* 1 and 2 would prefer the model with BPMN graphical elements or the proposed signs, and explore the reasons for their choice. Additionally, conduct a Semantic Transparency analysis on all signs presented in both models to further investigate their representativeness.

Business process modelling still requires significant efforts to comprehend the signs used in its modelling languages. Improving the significance of business process diagrams can be achieved through studies on how they are represented and the meaning attributed to them. Conducting these studies could strengthen the evidence gathered, pointing towards ways to enhance the approach indicated in the present study, which aims to assist all involved stakeholders.

References

ABPMP – Association of Business Process Management Professionals. BPM CBOK V3.0: guia para o gerenciamento de processos de negócio (3ª ed). ABPMP Brasil, 2015

AGRESTI, Alan. An introduction to categorical data analysis. John Wiley & Sons, Inc., Hoboken, New Jersey, 2007.

AKYURT, E. Carta, Background image, Envelope. De utilização gratuita. 2022. 8944x6708. Available at: https://pixabay.com/pt/photos/carta-envelope-mensagem-escrita-7614014/. Accessed: 2 Jun 2023.

ALVES FILHO, B.. Processos organizacionais: simplificação e racionalização. São Paulo: Atlas, 2011.

ALVES, Alexandre *et al*. (Eds). Web Services Business Process Execution Language Version 2.0. OASIS, 2007. Available at: <http://docs.oasis-open.org/wsbpel/2.0/OS/wsbpel-v2.0-OS.html>. Accessed: 15 Feb 2023.

AVISON, D.; FITZGERALD, G. (2003). Information systems development: methodologies, techniques and tools. McGraw-Hill.

BERTIN, Jacques. Semiology of graphics. University of Wisconsin press, 1983.

CAIRE, P., GENON, N., HEYMANS, P., MOODY, D. L. (2013). Visual notation design 2.0: Towards user comprehensible requirements engineering notations. In 2013 21st IEEE International Requirements Engineering Conference (RE) (pp. 115-124). IEEE.

CHANDLER, Daniel. Semiotics: the basics. 2nd edition. New York, Taylor & Francis e-library: 2007.

CHAOS REPORT. Decision Latency Theory: It Is All About the Interval (2018). Available at: https://www.standishgroup.com/store/services/10-chaos-report-decision-latency-theory-2018-package.html>. Accessed: 20 Feb 2023.

CHINOSI, M.; TROMBETTA, A. Bpmn: An introduction to the standard. Computer Standards & Interfaces, Elsevier, v. 34, n. 1, p. 124–134, 2012.

CHURCHILL JR., Gilbert. A. A Paradim for Developing Better Measures of for Constructs. Journal of Marketing Research, v. 16, n. 1, p. 64–73, 2012.

COMTE, A. Curso de filosofia positiva / Discurso sobre o espírito positivo / Discurso preliminar sobre o conjunto do positivismo / Catecismo positivista. São Paulo: Abril Cultural, 1978.

COOPER, Donald R.; SCHINDLER, Pamela S. Métodos de pesquisa em adminitração.7 ed. Porto Alegre: Bookman, 2003.

CORREIA, A. C. e. Quality of Process Modeling Using BPMN: a model-driven approach. Lisboa: 2014. Available at: https://www.researchgate.net/publication/270158524_Quality_of_Process_Modeling_Using_BPMN_A_Model-Driven_Approach. Accessed: 20 Feb 2023.

CRESWELL, John W. Projeto de pesquisa: métodos qualitativo, quantitativo e misto. Porto Alegre: Bookman, 2010.

DANIEL, J. SAMPLING ESSENTIALS: Practical Guidelines for Making Sampling Choices, Sage Publications, 2011. ISBN: 978-1412952217.

DEELY, John. Basics of Semiotics. Indianapolis: Indiana University Press, 1990.

DEMARCO, T. (1978). Structured analysis and system specification. Yourdon. Inc., New York, New York.

DENZIN, N. K.; LINCOLN, Y. S. (2006). O planejamento da pesquisa qualitativa: teorias e abordagens. 2 ed. Porto Alegre: Artmed, p. 15-47.

DUMAS, M.; ROSA, M.; MENDLING, J.; REIJERS, H.A. Fundamentals of Business Process Management, 2nd ed., Springer, Berlin, Heidelberg, 2018. DOI: 10.1007/978-3-662-56509-4.

DUTRA, L. H. A. Introdução à epistemologia. São Paulo: Editora UNESP, 2010.

EVANS, E. J. (2003). Domain-driven design: tackling complexity in the heart of software. Addison-Wesley Professional.

FIGL, K., MENDLING, J., STREMBECK, M. (2009). Towards a usability assessment of process modeling languages. In 8th GI-Workshop Geschäftsprozessmanagement mit Ereignisgesteuerten Prozessketten (EPK), CEUR-WS (Vol. 554, pp. 138-156).

FIGL, K.; DERNTL, M. The Impact of Perceived Cognitive Effectiveness on Perceived Usefulness of Visual Conceptual Modeling Languages. 2011. Conference: Conceptual Modeling - ER 2011, 30th International Conference, ER 2011, Brussels, Belgium, October 31 - November 3, 2011. Proceedings. Available at https://www.researchgate.net/publication/221269870_The_Impact_of_Perceived_Cognitive_Effectiveness_on_Perceived_Usefulness_of_Visual_Conceptual_Modeling_Languages. Accessed: 20 Feb 2023.

FIGL, K.; LAUE, R. Cognitive complexity in business process modeling. In: H. Mouratidis, H; Rolland, C. Eds. Advanced Information Systems Engineering (CAiSE 2011). Springer: Berlin, Heidelberg, 2011, p. 452–466.

FILIPOWSKA, A., KACZMAREK, M., KOWALKIEWICZ, M., ZHOU, X., BORN, M. (2009). Procedure and guidelines for evaluation of BPM methodologies. Business Process Management Journal.

FLEISCHMANN, A. What is S-BPM? In: H. Buchwald, A. et al., Eds. S-BPM ONE – Setting the Stage for Subject-Oriented Business Process Management. Springer: Berlin Heidelberg, 2010.p. 85–106.

FONSECA, J. J. S. Metodologia da pesquisa científica. Universidade Estadual do Ceará, Fortaleza. 2002. Available at: <http://www.ia.ufrrj.br/ppgea/conteudo/conteudo-2012-1/1SF/Sandra/apostilaMetodologia.pdf>. Accessed in: 03 oct. 2021.

FREEPIK. Pare o sinal na cidade. 2023. 1 photo. Available at: https://br.freepik.com/fotos-gratis/pare-o-sinal-na-cidade_24238246.htm#query=road%20stop%20sign&position=9&from_view=search&track=ais. Accessed in 8 May 2023.

FREEPIK. Vista superior do relogio de parede natureza morta. 2023. Available at: https://br.freepik.com/fotos-gratis/vista-superior-do-relogio-de-parede-natureza-morta_42952314.htm#query=rel%C3%B3gio%20analogico&position=14&from_view=search&track=ais. Accessed in 8 May 2023.

GEMINO, A.; WAND, Y. A framework for empirical evaluation of conceptual modeling techniques. Requirements Engineering, Springer, v. 9, n. 4, p. 248–260, 2004.

GIF. In: Cambridge Dictionary. 2023. Cambridge University Press & Assessment 2023. Available at: https://dictionary.cambridge.org/us/dictionary/english/gif. Accessed 14 Jun 2023.

GIL, A. C. Métodos e técnicas de pesquisa social. 6. ed. São Paulo: Atlas, 2008.

GONÇALVES, J. E. L. (2000). As empresas são grandes coleções de processos. Revista de administração de empresas, 40, 6-9.

GRUHN, V.; LAUE, R. Reducing the cognitive complexity of business process models. In: 2009 8th IEEE International Conference on Cognitive Informatics. [S.l.]: IEEE, 2009. p. 339– 345. ISBN 978-1-4244-4642-1.

GUBA, E. G.; LINCOLN, Y.S. Competing paradigms in qualitative research. In: DENZIN, N.K., LINCOLN, Y.S. (eds.). Handbook of Qualitative Research. Thousand Oaks: Sage, 1994.

GUESSI, M.; GRACIANO NETO, V.; NAKAGAWA, E.. Architectural Description of Systems-of-Information. In book: Tópicos em Sistemas de Informação: Minicursos SBSI 2019 (pp.29-52). 2019. Available at: https://www.researchgate.net/publication/337031960_Architectural_Description_of_Systems-of-Information. Accessed: 2 Jun 2023.

GULLA, J. A., BRASETHVIK, T. (2000). On the challenges of business modeling in large-scale reengineering projects. In Proceedings Fourth International Conference on Requirements Engineering. ICRE 2000. (Cat. No. 98TB100219) (pp. 17-26). IEEE.

HAIR JR., J. F.; BABIN, B.; MONEY, A. H.; SAMOUEL, P. Fundamentos de metódos de pesquisa em administração. Porto Alegre: Bookman, 2007.

HARMON, Paul; WOLF, Celia. Business Process Modeling Survey. Tech. rep., Business Process Trends. 2011. Available at: https://www.bptrends.com. Accessed: 15 Oct 2021.

HOFSTEDE, A.; VAN DER AALST, W.; ADAMS, M.; RUSSELL, N. Modern Business Process Automation: YAWL and Its Support Environment, 1st ed. Springer Publishing Company, Incorporated, 2009.

HOLT, J., A Pragmatic Guide to Business Process Modelling. BCS - British Computer Society, Swindon SN2 1FA, UK, 2nd edition, 2009.

INDULSKA, Marta.; ZUR MUEHLEN, Michael; RECKER, Jan. Measuring method complexity: The case of the business process modeling notation. Tech. rep., 2009.

ISO/IEC19510:2013. Information technology — Object Management Group Business Process Model and Notation. 1st. ISO/IEC JTC 1. Available at: https://standards.iso.org/ittf/PubliclyAvailableStandards/index.html. Accessed 15 Feb 2023.

KATHRIN, F.; MENDLING, J.; STREMBECK, M.; RECKER, J.. On the Cognitive Effectiveness of Routing Symbols in Process Modeling Languages. W. Abramowicz and R. Tolksdorf (Eds.): BIS 2010, LNBIP 47, pp. 230–241, 2010.

KITCHENHAM, B., MADEYSKI, L., BRERETON, P.. Problems with Statistical Practice in Human-Centric Software Engineering Experiments. In: Proceedings of the 23rd Evaluation and Assessment on Software Engineering (EASE). ACM, pp. 134–143, 2019. DOI: 10.1145/3319008.3319009.

KO, R.K.L.., A computer scientist's introductory guide to business process management (BPM). Crossroads, 15(4):4, 2009.

KOMAROV, EGOR. Cidade meio urbano luzes se movendo. 2022. 1 photo. 6240 x 4160. Available at: https://www.pexels.com/pt-br/foto/cidade-meio-urbano-luzes-movendo-se-12476870/. Accessed in 8 May 2023

KOSSAK, F.; Illibauer, C.; Geist, V.; Kubovy, J.; Natschläger, C.; Ziebermayr, T.; Kopetzky, T.; Freudenthaler, B.; Schewe, K-D. (2014). A Rigorous Semantics for BPMN 2.0 Process Diagrams. Springer International Publishing. 2014. DOI https://doi.org/10.1007/978-3-319-09931-6.

KOSSLYN, Stephen M. Graphics and human information processing: A review of five books. Journal of the American Statistical Association, v. 80, n. 391, p. 499-512, 1985.

Kuhar, S.; Polancic, G. (2021). Conceptualization, measurement, and application of semantic transparency in visual notations. Software and Systems Modeling, https://doi.org/10.1007/s10270-021-00888-9.

KUNZE, M.; LUEBBE, A.; WEIDLICH, M.; WESKE, M. Towards understanding process modeling–the case of the BPM academic initiative. In: International Workshop on Business Process Modeling Notation, Springer Berlin Heidelberg, pp. 44-58,2011.

LARKIN, J. H., SIMON, H. A. (1987). Why a diagram is (sometimes) worth ten thousand words. Cognitive science, 11(1), 65-100.

LAUDON, Kenneth; LAUDON, Jane. Management information systems: managing the digital firm. 15 ed. São Paulo: Pearson, 2017.

LAUDON, Kenneth. C; LAUDON, Jane P. Management information systems: managing the digital firm. 9th ed. New Jersey: Prentice Hall, 2006

LU, R., SADIQ, S. (2007). A survey of comparative business process modeling approaches. In International conference on business information systems (pp. 82-94). Springer, Berlin, Heidelberg.

MAGALHÃES, Marcos Nascimento; LIMA, A. C. P. Noções de Probabilidade e Estatística. 6a edição revista. São Paulo, EDUSP, 2010.

MARCONI, M.; LAKATOS, E. Metodologia científica: ciência e conhecimento científico; métodos científicos; teoria, hipóteses e variáveis; metodologia jurídica. 3. ed. rev. ampl. São Paulo: Atlas, 2000.

MARTINS, G. A. Metodologias convencionais e não convencionais e a pesquisa em administração. Caderno de pesquisa em administração, v. 0, n. 0, 1994.

MELÃO, Nuno.; PIDD, Michael. A conceptual framework for understanding business processes and business process modelling. Information Systems Journal, 2000.

MENDLING Jan; et al. Blockchains for Business Process Management - Challenges and Opportunities. ACM Transactions on Management Information Systems, v. 9, n. 1, p. 1-16, 2018. https://doi.org/10.1145/3183367. DOI:10.1145/3183367.

MENDLING, J.; SÁNCHEZ-GONZÁLEZ, L.; GARCIA, F.; LA ROSA, M. Thresholds for error probability measures of business process models. Journal of Systems and Software, v. 85, n. 5, p. 1188–1197, 2012. ISSN 01641212.

MENDLING, Jan; REIJERS, H.A.; VAN DER AALST, WIL, M. P. Seven Process Modeling Guidelines (7PMG). Information and Software Technology. v. 52, n. 2, p. 127-136. 2010.

MENDLING, Jan.; STREMBECK, Mark. Influence Factors of Understanding Business Process Models. In: Witold Abramowicz; Dieter Fensel, Eds.Business Information Systems. Springer, Berlin, Heidelberg, p. 142–153, 2008.

MENDOZA, V.; SILVEIRA, D. S; ALBUQUERQUE, M. L.; ARAÚJO, J.. Verifying BPMN Understandability with Novice Business Managers. In Proceedings of the 33rd Annual ACM Symposium on Applied Computing (SAC). Association for Computing Machinery: New York, United States.2018. pp. 94–101.

Meta for developers. Marcar mensagens como lidas. 2023. 1 photo. Available at: https://developers.facebook.com/products/whatsapp/. Accessed: 2 Jun 2023.

MILI, H.; TREMBLAY, G.; JAOUDE, G. B.; LEFEBVRE, E.; ELABED, L.; BOUSSAIDI, G. E. Business process modeling languages: Sorting through the alphabet soup. ACM Comput. Surv. 43, 1, Dec, 2010.

MINAYO, M. C.; SANCHES, O. Quantitativo-qualitativo: oposição ou complementariedade? In: Caderno de Saúde Pública, Rio de Janeiro, p. 239-262, 1993.

MONTGOMERY, D.C., RUNGER, G.C., CALADO, V. Estatística Aplicada E Probabilidade Para Engenheiros. Grupo Gen-LTC, 2000.

MOODY, D. The" physics" of notations: a scientific approach to designing visual notations in software engineering. In: 2010 ACM/IEEE 32nd International Conference on Software Engineering. IEEE, 2009. p. 485-486.

MYERS, M. D. Hermeneutics in Information. Social Theory and Philosophy for Information Systems. 2005 Apr 8:103.

NORMAN, D. A. (1986). Cognitive engineering. User centered system design, 31, 61.

NOVAK, F. I. L.; BRANDT, C. F.. A Semiótica de Peirce e Saussure, contributos e limites para a teoria das representações semióticas de Raymond Duval e a análise da forma e conteúdo em matemática. In: REVEMAT, v.12, n.2, p.1-15. Florianópolis: 2017.

OMG-OBJECT MANAGEMENT GROUP. Business Process Model and Notation (BPMN). Version 2.0.2. Tech. rep., 2014. Available at: <https://www.omg.org/spec/BPMN>. Accessed in: 23 Oct 2022.

OMG-OBJECT MANAGEMENT GROUP. Unified Modeling Language ® (OMG UML®). Version 2.5.1. Tech. rep. 2017. Available at: https://www.omg.org/spec/UML/About-UML/ Accessed in: 23 Oct 2022.

PEIRCE, Charles S.. Semiótica. 4. ed. São Paulo: Perspectiva, 2017.

PETRI, Carl. Adam. Kommunikation mit Automaten. Schriften des Rheinisch-Westfälischen Institutes für Instrumentelle Mathematik an der Universität Bonn Nr.2, 1962.

PIXABAY. Vidro Transparente Com Grão De Areia Vermelha. 2016. 3056 x 2304. Available at: https://www.pexels.com/pt-br/foto/vidro-transparente-com-grao-de-areia-vermelha-39396/. Accessed: 2 Jun 2023.

PRESSMAN, R. S. (2014). Software engineering: a practitioner's approach. Palgrave macmillan.

PRIOR, Paul. Semiotics. In: Constant Leung and Brian Street (Eds.), The Routledge Companion to English Studies (pp. 160-173). London, UK: Routledge. 2014.

PRODANOV, C. C.; FREITAS, E. C. Metodologia do trabalho científico: métodos e técnicas da pesquisa e do trabalho acadêmico. 2ª ed. Novo Hamburgo: Feevale, 2013.

RECKER, Jan. “Opportunities and constraints: the current struggle with BPMN”. Business Process Management Journal, v. 16, n. 1, p. 181-201, 2010.

RICHARDSON, R. J. Pesquisa social. 3. ed. São Paulo: Atlas, 1999.

ROELENS, B.; EBBEN, R.; WETERING, R.. Composing an Initial Domain-Specific Modeling Language Notation by Reusing Icons. In: Business Modelling and Software Design: 13th International Symposium, BMSD 2023, Utrecht, The Netherlands, July 3-5, 2023 Proceedings. p. 245-255. 2023.

ROSEMANN, M. (2006). Potential pitfalls of process modeling: part A. Business Process Management Journal.

RUSSELL, B. Os problemas da filosofia. Florianópolis: Comte: 2005.

SAINT-EXUPÉRY, A.. Le Petit Prince (The little Prince). Folio Junior. 2007.

SANTAELLA, L. Semiótica aplicada. Cengage. 2nd ed. São Paulo. 2018.

SANTOS, M.; GRALHA, C.; GOULÃO, M.; ARAÚJO, J.. Increasing the semantic transparency of the KAOS goal model concrete syntax. In et al., editor, Conceptual Modeling, pages 424–439, Cham, 2018. Springer International Publishing.

SANTOS, Mafalda. Avaliação da Eficácia Cognitiva de Modelos de Requisitos Orientados a Objetivos. Dissertação – Faculdade de Ciências e Tecnologia, Universidade NOVA de Lisboa. Lisboa, p. 251. 2016.

SBERVEGLIERI, M. Controlador de Playstation, Sony. 2020. De utilização gratuita. 3500x1968. Available at: https://pixabay.com/pt/illustrations/controlador-de-playstation-sony-5048156/. Accessed: 2 Jun 2023.

SCHALLES, Christian. Usability Evaluation of Modeling Languages, Wiesbaden, Alemanha: Springer Gabler, 2012. ISBN 978-3-658-00050-9.

SCHEER, A.W. & NÜTTGENS, M. – ARIS Architecture and Reference Models for Business Process Management in Business Process Management. Springer, Berlin, Heidelberg, 2000. p. 376-389.

SHANNON C. E.; WEAVER W. (1971). The Mathematical Theory of Communication. First Edition (US). The University of Illinois Press. isbn: 9780252725487.

SIGN. In: Merriam-webster Dictionary. 2023. Merriam-Webster, Incorporated. Available at: https://www.merriam-webster.com/. Accessed 14 Jun 2023.

SILVEIRA, D. S. (2009). Animare: Um método de Validação dos Processos de Negócio através da Animação (Doctoral dissertation, Universidade Federal do Rio de Janeiro).

SINDRE. G.. An analytical evaluation of BPMN using a semiotic quality framework. Advanced topics in database research, 5:94, 2006.

SOMMERVILLE, I. (2016) Software Engineering, 10ª Edition, Pearson – Addison Wesley.

SPAMFORPIC. Kart, Corrida, Dirigir. De utilização gratuita. 2016. 3888x2592. Available at: https://pixabay.com/pt/photos/kart-corrida-dirigir-esporte-1263686/. Accessed: 2 Jun 2023.

VAN DER AALST, Wil MP; TER HOFSTEDE, Arthur HM. YAWL: yet another workflow language. Information systems, v. 30, n. 4, p. 245-275, 2005.

VERGARA, S. C. Projetos e relatórios de pesquisa em administração. 4 ed. São Paulo: Atlas, 2003.

VERGARA, Sylvia. Constant. Projetos e Relatórios de Pesquisa em Administração. 5. ed. São Paulo: Altas, 2004.

WESKE, Mathias. Business Process Management: Concepts, Languages, Architectures. 2nd edn. Berlin: Springer, 2012.

WHITE, S. A.; DEREK M., BPMN Modeling and Reference Guide: Understanding and Using BPMN. Future strategies, 1.ed, 2008.

WOHLIN C, RUNESON P, HÖST M, OHLSSON MC, REGNELL B, WESSLÉN A. Experimentation in software engineering. Springer, Berlin, 2012.

ZANG, Y.; ALICKE, M.. 2020. My True Self is Better Than Yours: Comparative Bias in True Self Judgments. Personality and Social Psychology Bulletin. Vl. 47. 10.1177/0146167220919213

ZUR MUEHLEN, M., RECKER, J. (2008). How much language is enough? Theoretical and practical use of the business process modeling notation. In Seminal Contributions to Information Systems Engineering (pp. 429-443). Springer, Berlin, Heidelberg.

APPENDIX A – Consent Letter: information to participants

Carta de informação de consentimento

Informações aos participantes

Este trabalho experimental é realizado pelo Núcleo de Estudo e Pesquisa em Sistemas de Informação. O NEPSI é um grupo de pesquisa com professores da Universidade Federal de Pernambuco e da Universidade de Pernambuco. Informamos que todas as informações declaradas como parte deste experimento são confidenciais e serão mantidas como tal. O prof. Denis Silveira é responsável por este experimento e pode ser contatado em: dsilveira@ufpe.br ou no CCSA da UFPE, sala D27.

Ainda sobre o experimento, gostaríamos de enfatizar que:

- sua participação é inteiramente voluntária;
- você é livre para recusar a responder qualquer pergunta;
- você é livre para desistir a qualquer momento;

O experimento será mantido em sigilo absoluto e será disponibilizado apenas aos membros da equipe de pesquisa ou, caso ocorra avaliação externa da qualidade, aos avaliadores nas mesmas condições de confidencialidade. Porém, os dados coletados neste experimento vão fazer parte de um relatório final de pesquisa, mas sob nenhuma circunstância seu nome ou qualquer característica de identificação será incluída no relatório.

Recife, ________ de _________ de 2023

____

Assinatura participante

APPENDIX B – BPMN Questionnaire

Nome:

[____]

Sexo:

☐ Feminino
☐ Masculino

1. **Há quanto tempo você tem contato com a notação BPMN?**

☐ **De 0 até 1 ano.** ☐ **Acima de 1 até 3 anos.** ☐ **Acima de 3 até 5 anos.** ☐ **Acima de 5 anos.**

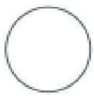
2. **O quanto você se sente familiarizado com os elementos da notação de modelagem de processos de negócios (do inglês, *Business Process Model Notation* ou BPMN)?**

Pouco familiarizado	0	1	2	3	4	5	6	7	8	9	10	Muito familiarizado

3. **Descreva o seu entendimento sobre o modelo apresentado:**

____

4. **Descreva a função que você entende pelo símbolo apresentado a seguir?**



____

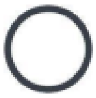
5. **O quanto você acha que esse símbolo é representativo para essa função descrita por você?**

Pouco Representativo	0	1	2	3	4	5	6	7	8	9	10	Muito Representativo

6. **Se possível, proponha (desenhe) um novo símbolo que seja mais representativo para essa função:**

2

7. **Descreva a função que você entende pelo símbolo apresentado a seguir?**

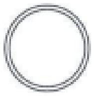


8. **O quanto você acha que esse símbolo é representativo para essa função descrita por você?**

	0	1	2	3	4	5	6	7	8	9	10	
Pouco Representativo												Muito Representativo

9. **Se possível, proponha (desenhe) um novo símbolo que seja mais representativo para essa função:**

10. **Descreva a função que você entende pelo símbolo apresentado a seguir?**

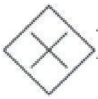


11. **O quanto você acha que esse símbolo é representativo para essa função descrita por você?**

	0	1	2	3	4	5	6	7	8	9	10	
Pouco Representativo												Muito Representativo

12. **Se possível, proponha (desenhe) um novo símbolo que seja mais representativo para essa função:**

13. **Descreva a função que você entende pelo símbolo apresentado a seguir?**

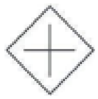


14. O quanto você acha que esse símbolo é representativo para essa função descrita por você?

Pouco Representativo	0	1	2	3	4	5	6	7	8	9	10	Muito Representativo

15. Se possível, proponha (desenhe) um novo símbolo que seja mais representativo para essa função:

16. Descreva a função que você entende pelo símbolo apresentado a seguir?

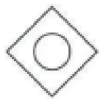


17. O quanto você acha que esse símbolo é representativo para essa função descrita por você?

Pouco Representativo	0	1	2	3	4	5	6	7	8	9	10	Muito Representativo

18. Se possível, proponha (desenhe) um novo símbolo que seja mais representativo para essa função:

19. Descreva a função que você entende pelo símbolo apresentado a seguir?



20. O quanto você acha que esse símbolo é representativo para essa função descrita por você?

Pouco Representativo	0	1	2	3	4	5	6	7	8	9	10	Muito Representativo

21. **Se possível, proponha (desenhe) um novo símbolo que seja mais representativo para essa função:**

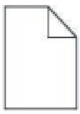
22. **Descreva a função que você entende pelo símbolo apresentado a seguir?**

23. **O quanto você acha que esse símbolo é representativo para essa função descrita por você?**

Pouco Representativo	0	1	2	3	4	5	6	7	8	9	10	Muito Representativo

24. **Se possível, proponha (desenhe) um novo símbolo que seja mais representativo para essa função:**

25. **Descreva a função que você entende pelo símbolo apresentado a seguir?**



26. **O quanto você acha que esse símbolo é representativo para essa função descrita por você?**

Pouco Representativo	0	1	2	3	4	5	6	7	8	9	10	Muito Representativo

27. **Se possível, proponha (desenhe) um novo símbolo que seja mais representativo para essa função:**

28. Descreva a função que você entende pelo símbolo apresentado a seguir?

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29. O quanto você acha que esse símbolo é representativo para essa função descrita por você?

Pouco Representativo	0	1	2	3	4	5	6	7	8	9	10	Muito Representativo

30. Se possível, proponha (desenhe) um novo símbolo que seja mais representativo para essa função:

31. Descreva a função que você entende pelo símbolo a seguir quando ele é usado no modelo apresentado?

____

____

____

____

____

32. O quanto você acha que esse símbolo é representativo para essa função descrita por você?

Pouco Representativo	0	1	2	3	4	5	6	7	8	9	10	Muito Representativo

33. Se possível, proponha (desenhe) um novo símbolo que seja mais representativo para essa função:

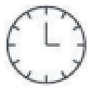
34. Descreva a função que você entende pelo símbolo a seguir quando ele é usado no modelo apresentado?

35. O quanto você acha que esse símbolo é representativo para essa função descrita por você?

Pouco Representativo	0	1	2	3	4	5	6	7	8	9	10	Muito Representativo

36. Se possível, proponha (desenhe) um novo símbolo que seja mais representativo para essa função:

37. Descreva a função que você entende pelo símbolo a seguir quando ele é usado no modelo apresentado?



38. O quanto você acha que esse símbolo é representativo para essa função descrita por você?

Pouco Representativo	0	1	2	3	4	5	6	7	8	9	10	Muito Representativo

39. Se possível, proponha (desenhe) um novo símbolo que seja mais representativo para essa função:

40. **Descreva a função que você entende pelo símbolo a seguir quando ele é usado no modelo apresentado?**

41. **O quanto você acha que esse símbolo é representativo para essa função descrita por você?**

Pouco Representativo	0	1	2	3	4	5	6	7	8	9	10	Muito Representativo

42. **Se possível, proponha (desenhe) um novo símbolo que seja mais representativo para essa função:**

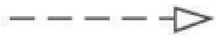
43. **Descreva a função que você entende pelo símbolo a seguir quando ele é usado no modelo apresentado?**

44. **O quanto você acha que esse símbolo é representativo para essa função descrita por você?**

Pouco Representativo	0	1	2	3	4	5	6	7	8	9	10	Muito Representativo

45. **Se possível, proponha (desenhe) um novo símbolo que seja mais representativo para essa função:**

46. Descreva a função que você entende pelo símbolo a seguir quando ele é usado no modelo apresentado?



47. O quanto você acha que esse símbolo é representativo para essa função descrita por você?

Pouco Representativo	0	1	2	3	4	5	6	7	8	9	10	Muito Representativo

48. Se possível, proponha (desenhe) um novo símbolo que seja mais representativo para essa função:

APPENDIX C – Semiotics Questionnaire

Nome:

[____]

Sexo:
☐ Feminino
☐ Masculino

1. **Há quanto tempo você tem contato com a notação BPMN?**

☐ **De 0 até 1 ano.** ☐ **Acima de 1 até 3 anos.** ☐ **Acima de 3 até 5 anos.** ☐ **Acima de 5 anos.**

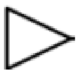
2. **O quanto você se sente familiarizado com os elementos da notação de modelagem de processos de negócios (do inglês, *Business Process Model Notation* ou BPMN)?**

	0	1	2	3	4	5	6	7	8	9	10	
Pouco familiarizado												Muito familiarizado

3. **Descreva o seu entendimento sobre o modelo apresentado:**

____

4. **Descreva a função que você entende pelo símbolo apresentado a seguir?**



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5. **O quanto você acha que esse símbolo é representativo para essa função descrita por você?**

	0	1	2	3	4	5	6	7	8	9	10	
Pouco Representativo												Muito Representativo

6. **Descreva a função que você entende pelo símbolo apresentado a seguir?**

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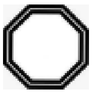
7. O quanto você acha que esse símbolo é representativo para essa função descrita por você?

Pouco Representativo	0	1	2	3	4	5	6	7	8	9	10	Muito Representativo

8. Descreva a função que você entende pelo símbolo apresentado a seguir?



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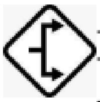
9. O quanto você acha que esse símbolo é representativo para essa função descrita por você?

Pouco Representativo	0	1	2	3	4	5	6	7	8	9	10	Muito Representativo

10. Descreva a função que você entende pelo símbolo apresentado a seguir?



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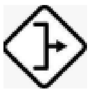
11. O quanto você acha que esse símbolo é representativo para essa função descrita por você?

Pouco Representativo	0	1	2	3	4	5	6	7	8	9	10	Muito Representativo

12. Descreva a função que você entende pelo símbolo apresentado a seguir?



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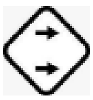
13. O quanto você acha que esse símbolo é representativo para essa função descrita por você?

Pouco Representativo	0	1	2	3	4	5	6	7	8	9	10	Muito Representativo

14. Descreva a função que você entende pelo símbolo apresentado a seguir?



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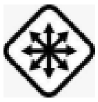
15. O quanto você acha que esse símbolo é representativo para essa função descrita por você?

	0	1	2	3	4	5	6	7	8	9	10	
Pouco Representativo												Muito Representativo

16. Descreva a função que você entende pelo símbolo apresentado a seguir?



17. O quanto você acha que esse símbolo é representativo para essa função descrita por você?

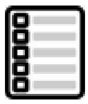
	0	1	2	3	4	5	6	7	8	9	10	
Pouco Representativo												Muito Representativo

18. Descreva a função que você entende pelo símbolo apresentado a seguir?

19. O quanto você acha que esse símbolo é representativo para essa função descrita por você?

	0	1	2	3	4	5	6	7	8	9	10	
Pouco Representativo												Muito Representativo

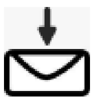
20. Descreva a função que você entende pelo símbolo apresentado a seguir?



21. O quanto você acha que esse símbolo é representativo para essa função descrita por você?

	0	1	2	3	4	5	6	7	8	9	10	
Pouco Representativo												Muito Representativo

22. Descreva a função que você entende pelo símbolo a seguir quando ele é usado no modelo apresentado?



23. **O quanto você acha que esse símbolo é representativo para essa função descrita por você?**

	0	1	2	3	4	5	6	7	8	9	10	
Pouco Representativo												Muito Representativo

24. **Descreva a função que você entende pelo símbolo a seguir quando ele é usado no modelo apresentado?**

25. **O quanto você acha que esse símbolo é representativo para essa função descrita por você?**

	0	1	2	3	4	5	6	7	8	9	10	
Pouco Representativo												Muito Representativo

26. **Descreva a função que você entende pelo símbolo a seguir quando ele é usado no modelo apresentado?**

27. **O quanto você acha que esse símbolo é representativo para essa função descrita por você?**

	0	1	2	3	4	5	6	7	8	9	10	
Pouco Representativo												Muito Representativo

APPENDIX D – Published Paper[7]

A Semiotic Analysis of the Representativeness of BPMN Graphic Elements

Evelyne Batista Duarte[1], Rafael Batista Duarte[2], and Denis Silva da Silveira[1](✉)

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{evelyne.duarte,dsilveira}@ufpe.br
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rbd@ecomp.poli.br

Abstract. Business Process Modeling (BPM) has been under considerable attention from business and information technology (IT) communities. It is an important asset in the quest to decrease the gap in communication between these two groups. To contribute to decreasing this gap, this paper presents the execution of a *quasi*-experiment to verify whether Business Process Modelling Notation's (BPMN) graphical elements are representative according to their semantics. Data collected with 89 participants, so far, through a semiotic analysis has shown that the notations' elements are based on symbolic signs, understood due to shared law, while participants showed preference for iconic signs, that have visual relation to the real object.

Keywords: Business Process Models · BPMN · Semiotics Analysis · *Quasi*-Experiment

1 Introduction

In this paper, we analyze the 14 most used BPMN's graphical elements [1, 2] to clarify whether they represent the intended object, besides how language and interpretation should be understood from a semiotics' point of view. Semiotics is revisited as a means to reduce the communication gap between stakeholders.

Business Process Models (BPM) have been implemented in organizations to promote improvements in strategies, obtain competitive advantages in the market [3], and elicit information systems requirements [4]. However, it has been known that there is some difficulty in the communication between the interested parties due to different aspects (*e.g.*, linguistic and social differences). It is paramount that the languages used to build these models are actually concerned with decreasing validation errors, when stakeholders mistakenly interpret representations in a diagram and accept specifications that do not meet the needs, which compromise implementing information systems, for instance. Thus, incurring in high costs for projects that do not adequately achieve their purpose [5, 6]. Therefore, it is essential to establish a vocabulary that can be understood by the majority of stakeholders.

B. Shishkov (Ed.): BMSD 2023, LNBIP 483, pp. 225–234, 2023.
https://doi.org/10.1007/978-3-031-36757-1_14

[7] DUARTE, E.B; DUARTE, R. B.; SILVEIRA, D. S. da. A Semiotic Analysis of the representativeness of BPMN Graphic Elements. In: **Business Modeling and Software Design**: 13th International Symposium, BMSD 2023 Utrecht, The Netherlands, July 3-5, 2023 Proceedings. Edt. Boris Shishkov. Springer. P.225-2234. Cham: 2023.

Business Process Model and Notation (BPMN) [7] has been the most used Business Process Modeling Language (BPML) among business professionals to describe business behavior [8]. It is also considered an expressly complex grammar, hence rich in symbology [9]. In the context of this paper, BPMN was the selected modeling language. Being this paper's aim to perform a semiotic assessment to verify whether the BPMN graphic elements are indeed representative of its semantics.

This paper is structured as follows: In Sect. 2 we give a brief overview of semiotics. In Sect. 3 we describe how this study was conducted. In Sect. 4 we discuss validity threats and mitigations. In Sect. 5 we present related work. Finally, in Sect. 6 we conclude the paper by suggesting possibilities for future work.

2 Background

Any modeling language is based in three characteristics [3]: (*i*) syntax (set of constructs and rules); (*ii*) semantics (meaning of the constructions defined in the syntax); and (*iii*) the notation (graphic elements' set, used in diagrams' representation). Hence, to comprehend the graphical elements represented users must be familiar with the modeling language used [10]. Since the main goal of languages is to present a comprehensible notation for all stakeholders, it is important to ensure that the graphic elements presented in this notation are indeed representative for the stakeholders. Semiotics is the science that studies visual and verbal signs, such as the graphic elements of a language. Therefore, to assess the representativeness of these signs, it is important to understand semiotics as summarized in this section.

Semiotics is the science that studies visual and verbal signs, such as BPMN's graphical elements. Therefore, to assess the representativeness of those signs it is important to understand semiotics, as summarized in this section.

2.1 Semiotics

Signs are anything that communicates a meaning, to the interpreter, that is not the object itself [11, 12]. They can be subdivided as follows: (*i*) an icon is a sign which refers to the object it represents by its proper characters. Whether it is an existing object or not, as long as a sign is similar to the object, it can be an icon (*e.g.*, the drawing of a tree); (*ii*) a symbol is a sign that, by virtue of a law, refers to the object it represents. It is usually an association of general ideas that leads to the symbol being interpreted as referring to that object. There must be instances of what the symbol denotes, even if it is in the realm of imagination (*e.g.*, skull with crossed bones symbolizes a poisonous area); (*iii*) an index is a sign that refers to the object by actually being affected by it. Its properties are what they are, independent of anything else. By being affected by the object, the index has a property in common with it (*e.g.*, seeing the footprint of a large animal and suspecting dinosaurs exist).

Graphic languages must make use of physical analogies, visual metaphors, common logical properties and cultural associations to make meanings accessible to all [13]. The goal is for signs to have visual similarities to their objects so that meanings can be easily understood. The design of signs needs to be carefully thought, because if it is not designed correctly, stakeholders may interpret a sign with the wrong meaning, leading to a misinterpretation of the process model.

3 Research Design

The *quasi*-experiment presented here was divided into four stages (adapted from [14]), namely: *scope*, *planning*, *operation* and *analysis and interpretation*. These stages are explained in more detail below.

3.1 Scope

This research was developed from the perspective of researchers, with the participation of subjects (students and professionals from the fields of business and IT) who answered questionnaires. Thus, the scope of this research was: to analyze which BPMN graphical elements are more or less representative for these participants and ask for suggestions for more representative signs for the less representative elements; collect and categorize this information to understand which new signs are most representative in the context of these participants.

3.2 Planning

A pilot application of the *quasi*-experiment occurred to make sure the models presented and the questionnaires had no mistakes to later present them to participants. A scale from 0–10 for the familiarity with BPMN was added after the pilots to make sure participants had been properly selected.

The instruments (used in two different phases) consisted in the first phase of (*i*) a consent letter; (*ii*) a BPMN model (Fig. 1) specially created in the laboratory to represent the process of a "*Property Appraisal*"; (*iii*) a questionnaire to illustrate the graphical BPMN elements and in the second phase of (*iv*) a model with new signs proposed by the participants (Fig. 2); (*v*) a questionnaire to check the understanding of the model with the proposed signs.

The research was accompanied by two phases of researcher interactions developed in controlled environments (*e.g.*, classrooms or meeting rooms). Participants were purposely selected and divided into two groups: those with prior knowledge of BPMN (first phase) and those who had no knowledge of BPMN (second phase). They were presented with the models and asked to rate the representativeness of the signals. The first phase evaluated the graphical BPMN elements, while the second phase analyzed the elements proposed in the first phase.

As in a *quasi*-experiment according to [14], this directed selection of participants is possible. We decided on two different profiles of participants. In the first phase, only those who had prior knowledge of BPMN, and in the second phase, only those who had not yet been formally introduced to the notation, in order to avoid any kind of bias in the results. However, all participants were working in business or IT.

For the time being, this study was conducted with 89 participants: 54 in the first phase and 35 in the second phase. These numbers already have statistical value [15], but we still intend to increase the sample. Then, the hypotheses are stated formally, including a null and an alternative hypothesis: (H_1) BPMN's graphical elements have representativeness according to their semantics; (H_0) BPMN's graphical elements haven't got representativeness according to their semantics.

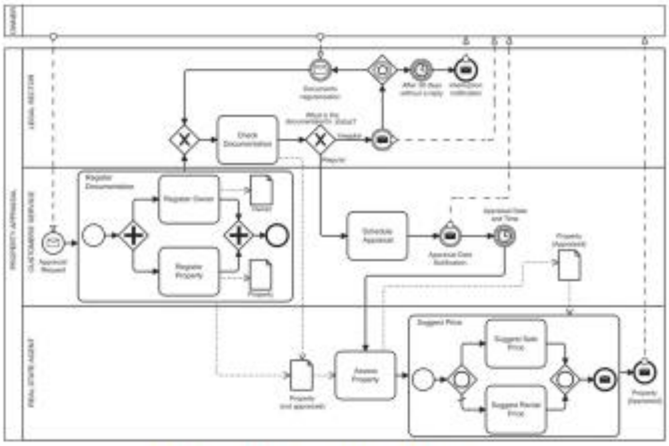


Fig. 1. BPMN Model from First Phase.

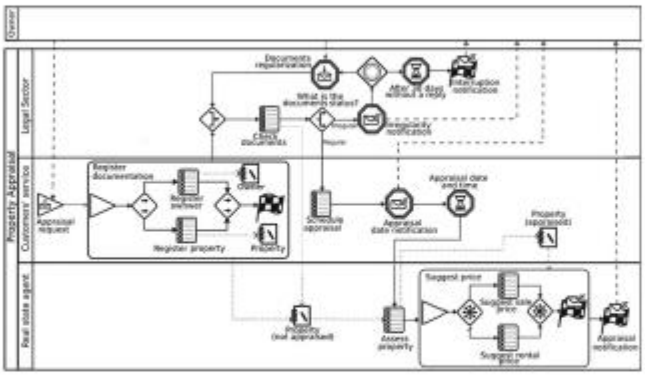


Fig. 2. Model with New Signs from Second Phase.

3.3 Operation

To understand how participants perceive the representativeness of BPMN signs' representativeness, we divided the operation into two phases: the first phase (Fig. 3) to understand how participants perceive the representativeness of BPMN signs and to collect different graphical elements proposed by them; and the second phase (Fig. 3) to test whether different graphical representations can influence representativeness.

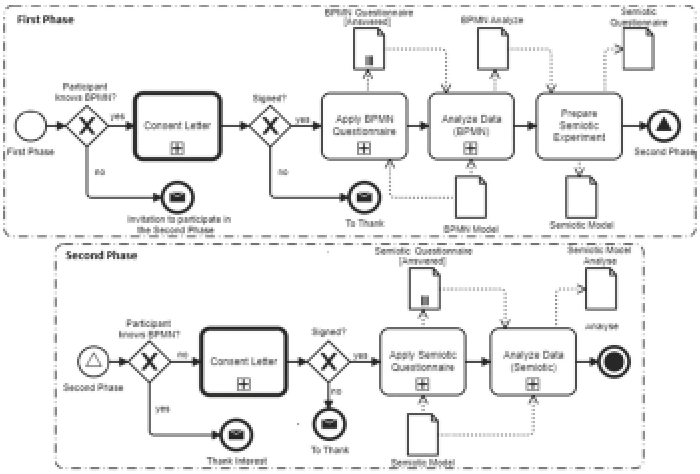


Fig. 3. Research Design.

3.4 Analysis and Interpretation

This section contains the analysis and interpretation of data collected during both phases of the operation. When asked to rate their familiarity to BPMN, during first phase, 49% of participants declared numbers from 6 to 10,46% from 0 to 5, and 2% did not reply. It can be seen that, even in the group of participants who had had previous formal training in the notation there is still a large number of participants who do not feel familiar with it. The analysis, after data collection from the first phase, consisted of separating the replies for each graphic element (sign) from all the participants, comparing the drawings, and separating them into semantic fields (*e.g.*, circles, squares, circles with letters).

`Message` (catch) event received in total 9 suggestions (Table 1), approximately 22.2% used arrows inside the graphical element to indicate the direction the notification is flowing in the process. Participants chose to keep the essence of a notification as a letter (icon), and the generalized idea of arrows to indicate direction (symbol). The average of representativeness from first phase to the second decrease from 8.74 to 7.11. The same happens to `Message` (throw), 16 suggestions, approximately 18.7% included checkmarks to indicate that a message is being sent (Table 1). Such symbol has become a routine in the lives of those who make use of messaging social networks, therefore this might be why it is engraved in the minds of participants. Its average went from 8.32 to 7.2.

Table 1. Messages, Start, End and Intermediate Events.

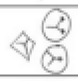
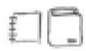
	Message (Catch)	Message (Throw)	Start Event	End Event	Intermediate Event
BPMN					
First Phase					
	22.2%	18.7%	25.7%	25.6%	24.1%

As for `Start`, `End` and `Intermediate Events`, it was possible to see that BPMN elements are mostly characterized by being symbols. In other words, their meanings are arbitrarily chosen and lawfully stated, while participants chose to suggest more iconic items showing preference to seeing similarities between what is represented and the object intended to represent (Table 2). There were in total 35 drawings for `Start Event`, 25.7% of those were on the semantic field of gaming, specifically the start button of a joystick. Slight improvement of 0.2 in the average. BPMN's language, then, opts for a symbolic sign, while suggestions directed for an iconic one recalling a joystick start button. The `End Event`, 39 suggestions, 25.6% related to racing, mostly related to a Formula 1 finish line flag. It showed the most positive feedback, going from 5.18 to 7.02. Showing that signs in racing semantic field, such as the finish line or a flag, could be more representative of a process ending than the circle displayed with a thick border. It was clear for a good number of participants that the icon symbolized the end of the process, therefore reaching its communicative purpose. `Intermediate Event`, 24 suggestions, 24.1% of ideas were similar to traffic signs, particularly the stop sign. It decreased 1.87 in its average, but both symbols still scored lower than 5. So, neither element is effectively representative for participants.

Even though the number of suggestions for the `Time Event` were low, 9, it was our decision to test if the hourglass suggested by 44.4% would still affect the element's representativeness. Both signs using clock and an hourglass are iconic, since both share resemblance with the real object recalling their actual meaning (Table 2). It decreased 0.47, still reaching an average of 8.9. The `Exclusive Gateway`, another example of a symbol, 24 suggestions, approximately 33,3% drew arrows inside the gateway to symbolize possibilities. Most importantly, it was suggested to create different symbols to represent "*multiple entries*" and "*multiple exits*", therefore this element was transformed into `Exclusive Gateway` split and join (Table 2) for the second model. Separating the `Exclusive Gateway` into two different elements showed a positive response, in first phase the artifact scored 6.38 and in second phase, the split-gateway increased to 7.25 and the join-gateway to 7.2. The symbols of split and join complement each other's meanings, though the notation has as premise to minimize the number of artifacts to lessen the burden to learn the language, some symbols would benefit from a paired element to make meaning clearer for stakeholders.

`Parallel Gateway`, 24 suggestions, approximately 33,3% suggested parallel lines, the sign used in the second model (Table 2) is an attempt to merge some of these ideas. It is therefore, an attempt to transform a symbol into an icon, getting its abstract characteristic and implementing a more visual connection to its meaning. It is of the biggest decreases, dropping its score by 1.76 and reaching an average less than 5 marks. Which can show that even though arrows are more iconic, not always they will be ideal to represent certain meanings. Even if the arrows in the element created for the second model were placed in parallel with the intention to work as a sign for paths to be followed in parallel, participants could not reach that level of abstraction. Making the symbol of a plus sign in a diamond shape more representative, because its meaning had previously been internalized as such.

Table 2. Time Event, Gateways and Data Object.

	Time Event	Exclusive Gateway	Parallel Gateway	Inclusive Gateway	Data Object
BPMN					
First Phase					
	44.4%	33.3%	33.3%	25.6%	24.1%

Another item that tries to transform symbol into icon is the `Inclusive Gateway` (Table 2), confirming the tendency of participants to prefer gateways to indicate the number of directions they could follow. In total 20 suggestions, approximately 45%, made use of lines to symbolize more than one path, since this specific symbol appeared twice it was chosen to represent the `Inclusive Gateway`. Note that, BPMN already uses this element as the `Complex Gateway` to express splitting or merging of complicated process flow scenarios. Even though we knew about this case, the models presented in this research would not make use of `Complex Gateways`, so it was decided to use the participants' suggestions to understand if they would actually consist of better representation. The `Inclusive Gateway` did not change much in its score, only 0.51.

As for the symbolic `Data Object`, 13 suggestions, 23% suggested some type of notebook or notepad (Table 2). It, then, would still continue being a symbol since it would only represent the idea of keeping track of data, when writing in notebooks is only one of them. It represented the most drastic decrease, decreasing 2.24 marks, from 8.29 to 6.05. The blank paper brought by the notation has proven to be more representative than the sign of a notebook, at least for the participants of this re-search.

The same happens for the representation of `Task`, the notation conveyed and spread the idea that boxes with labels inside the `Pools` of a process mean a Task, as for the suggestions (12), 25% believed the most representative would be lists of activities/checklists (Table 3). However, they do not possess direct resemblance to a `Task` to be considered an icon. It decreased from 7.47 to 6.94.

`Sequence Flow` (Table 3) was discarded because out of 54 participants, there were only 5 drawing contributions. They presented striking similarity to the symbol used in BPMN (a continuum line with an arrow to the directed end). The only suggestions that could be effective in helping stakeholders make meaning out of the models were to implement the "*token*" idea, but since the models presented in this research were printed in papers researchers decided using a token would be more confusing than helpful at this point. So, it was pertinent maintaining this flow as suggested in the notation.

Table 3. Task, Flows, Association and Event-Based Gateway.

	Task	Sequence Flow	Message Flow	Association	Event-Based Gateway
BPMN					
First Phase					
	44.4%	Not representative	Not representative	Not representative	Not representative

As for the `Message Flow` (Table 3), 13 contributions, keeping the essence striked lines and an arrow head at the end pointing the direction. Although one of the participants complemented the drawing by writing that his/her difficulty is to differentiate the connectors for exchanging `Messages` and `Data Objects`, the decision to keep both artifacts the same as BPMN was made because there weren't enough similarities between drawings to come up with a representative proposal.

`Association` (Table 3), was also kept the same from the notation when the second model was presented. Even though there were 10 suggestions they barely differed the graphic representations of what is currently in use. Finally, `Event-Based Gateway`, remained the same sign, despite 23 suggestions, most of them were similar to the one already used in BPMN. The different ones had no similarities between them, making it impossible to suggest a different graphic element.

4 Threats to Validity

Some threats to validity have been identified in relation to the *quasi*-experiment presented:

- Participants were free to refuse to answer the questions in the questionnaires, so there were few suggestions for drawings, especially in the first phase. Even though during analysis, this would not pose a difficulty, as only the suggested drawings were taken into account, it was a qualitative analysis, researchers still encouraged participants to reply the most they could.
- There were geographic and time constraints. Due to the need for the presence of a researcher during the application of questionnaires, the amount of data collected wasn't as big as intended. Ideally, connections with the community will allow for the research to be developed in different areas with a bigger sample.
- Also, due to difficulty of getting in touch with specialists in BPMN, it was difficult to find participants with more than 5 years of experience. This might affect quantitative results, but does not affect the discussion since the analysis was qualitative.

5 Related Works

In [16], the authors discuss different BPMLs, focusing on usability and quality of user experience. Whereby some criteria may influence cognitive effectiveness. In their analysis, they considered representational clarity, perceptual distinctiveness, perceptual mediocrity, visual expressiveness and graphic parsimony. They analyzed symbol sets from UML, YAWL, BPMN and EPC and discussed their weaknesses and strengths. They then proposed a preliminary assessment of the cognitive effective-ness of the modelling languages.

[13] discusses languages for requirements modelling, focusing on evaluating the impact of their concrete syntax on cognitive effectiveness. It also addresses understandability and the ability to review models, taking into account novice model users. The authors proposed and tested a method for assessing cognitive effectiveness by determining the ease, speed and accuracy of processing the information represented in the model. They analyzed two languages (KAOS and *i**) and used an eye-tracker to evaluate syntactic aspects.

In both works there is a problem with nomenclature. Not as previously seen, not everything used in notations can be considered symbols, there are also icons. Icons contribute to quicker comprehension because users only have to look at them to relate that graphical representation to its real object. BPMN is based on the use of symbols, hence, it is necessary to learn the notation and the laws created for it to be able to understand the meaning of the model.

6 Conclusions

At this point it should be noted that it is not the aim of this paper to propose new graphic elements. Our aim was merely to understand, with the help of semiotic analysis, whether the elements used in BPMN are representative or not according to their semantics.

It can be concluded that the graphical elements of BPMN are symbolic signs, so training in notation is required to be able to recognize the intended meanings. Participants tend to prefer iconic signs, showing that they can remember the meaning of an object simply by looking at its representation. However, it is important to note that BPMN looks at the language as a whole, connecting the elements and visualizing the roles they play from start to finish. Participants did not have this knowledge because they assessed the elements individually and did not consider the syntax of the language, *i.e.*, how the elements need to be connected in a system to create a meaningful diagram.

Nevertheless, it is important to focus on the meaning of the signals to increase the clarity of stakeholder communication. It is advisable to look in depth at the semiotics of the graphic elements to be used in new modelling languages, as this can help in the development of iconic models that facilitate understanding.

As future work, we would like to highlight the inclusion of a third phase to check how participants will understand the proposed signals (in the second phase) in the same process model with the most representative elements of BPMN (first phase). We also need to analyze the semantic transparency of all these graphical elements.

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References

1. Kunze, M., Luebbe, A., Weidlich, M., Weske, M.: Towards understanding process modeling - the case of the bpm academic initiative. In: et al., Business Process Model and Notation, pp. 44–58. Springer, Heidelberg (2011). Doi:https://doi.org/10.1007/978-3-642-25160-3_4
2. Chinosi, M., Trombetta, A.: BPMN: an introduction to the standard. Comput. Stand. Interfaces **34**(1), 124–134 (2012)
3. Dumas, M., La Rosa, M., Mendling, J., Reijers, H.A.: Fundamentals of Business Process Management, 2nd edn.. Springer, Heidelberg (2018). Doi: https://doi.org/10.1007/978-3-662-56509-4
4. Mendling, J., et al.: Blockchains for business process management - challenges and opportunities. 9(1), Feb 2018
5. Evans, E.: Domain-Driven Design: Tackling Complexity in the Heart of Software. Addison-Wesley Professional, 1st edn. (2003)
6. Caire, P., Genon, N., Heymans, P., Moody, D.L.: Visual notation design 2.0: Towards user comprehensible requirements engineering notations. In: 2013 21st IEEE International Requirements Engineering Conference (RE), pp. 115–124 (2013)
7. OMG-BPMN. Business process model and notation (2.0.2). Technical report, Object Management Group (2014). https://www.omg.org/spec/BPMN
8. Harmon, P., Wolf, C.: Business process modeling survey, 2011. A BPTrends Report - Business Process Trends
9. Kossak, F., et al.: A rigorous semantics for BPMN 2.0 process diagrams, 1st edn. Springer (2014). Doi:https://doi.org/10.1007/978-3-540-79396-0_13
10. Mendling, J., Strembeck, M.: Influence factors of understanding business process models. In: Abramowicz, W., Fensel, D. (eds.) Business Information Systems, pp. 142–153. Springer, Heidelberg, (2008). Doi: https://doi.org/10.1007/978-3-540-79396-0_13
11. Santaella, L.: Semiótica Aplicada. Cengage Learning, 2nd edn. (2018)
12. Peirce, C.S.: Semiótica. Editora Perspectiva, 4th edn. (2017)
13. Santos, M., Gralha, C., Goulão, M., Araújo, J.: Increasing the semantic transparency of the KAOS goal model concrete syntax. In: et al., editor, Conceptual Modeling, pp. 424-439. Springer, Cham (2018). Doi:https://doi.org/10.1007/978-3-030-00847-5_30
14. Wohlin, C., Runeson, P., Host, M., Ohlsson, M.C., Regnell, B., Wesslen, A.: Experimentation in Software Engineering, 1st edn. Springer, Berlin, Heidelberg (2012)
15. Montgomery, D.C., Runger, G.C.: Applied Statistics and Probability for Engineers. John Wiley Sons, 6th edn. (2013)
16. Figl, K., Mendling, J., Strembeck, M.: Towards a usability assessment of process modeling languages. In: Proc. of the 8th Workshop Geschäftsprozessmanagement mit Ereignisgesteuerten Prozessketten (EPK 2009), pp. 118–138. CEUR Workshop Proceedings, Berlin, Germany (2009)

APPENDIX E – Accepted Paper

UNIVERSIDADE FEDERAL DE PERNAMBUCO

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CLEI 2023 notification for paper 52

CLEI 2023 <clei2023@easychair.org> 11 de julho de 2023 às 11:35
Para: Denis Silveira <dsilveira@ufpe.br>

Dear Denis,

We are very happy to inform you that your submission

Paper ID: 52
Title: Evaluating the Semantic Transparency of BPMN Through a Semiotic Analysis
Track: CLEI 2023 Software Systems track

has been accepted for inclusion in the technical program and presentation at CLEI 2023. Congratulations!

We received a large number of quality submissions this year, leading to a competitive paper selection process. Each submission went through a thorough reviewing process, with each paper receiving at least three reviews from members of the Program Committee (PC). Online discussions have taken place when necessary to reach an outcome. As a result of the reviewing process, we have accepted 61 out of 166 papers into CLEI 2023's four tracks, which means an acceptance rate of 36%. Additionally, we have accepted one journal-first submission for presentation.

You can find the reviews for your paper at the bottom of this email. Please revise your paper carefully according to reviewers' comments and start preparing your camera-ready version. Make sure that the manuscript complies with the IEEE Proceedings template: https://www.ieee.org/conferences/publishing/templates.html. Your manuscript must not exceed the 10-page limit, including figures and appendices (up to 5 pages for short papers). Extra pages will not be allowed.

The deadline to submit your camera-ready version is the 13th of August 2023. You will receive an email with instructions on how and where to submit your final version within the next few days. Please remember that at least one of the authors must register for the conference before the deadline.

CLEI 2021 will be held from the 16th to the 20th of October 2023 in La Paz, Bolivia. Please stay tuned to the conference website (https://umsa-2023.clei.org/) for further information, including registration details which will be posted in the coming days.

Once again, thank you for your contribution and congratulations on your accepted paper. We look forward to seeing you at CLEI 2023!

Please do not hesitate to contact us for any further information.

Best regards,
José Miguel Rojas, Carlos Luna, Hernan Astudillo, Boris Llanos, Sheila Reinehr
Program and Track Chairs
CLEI 2023 Software Systems track

SUBMISSION: 52
TITLE: Evaluating the Semantic Transparency of BPMN Through a Semiotic Analysis

----------------------- REVIEW 1 ---------------------
SUBMISSION: 52
TITLE: Evaluating the Semantic Transparency of BPMN Through a Semiotic Analysis
AUTHORS: Evelyne Duarte, Denis Silveira and Rafael Duarte

----------- Overall evaluation -----------
SCORE: 2 (accept)
----- TEXT:
The authors present a quasi-experiment to assess the understanding of processes defined in BPMN. The experiment includes a semiotic analysis of a BPMN model and a semiotic transparency analysis of the signs proposed by the participants.

The document is well-written and easy to read. The aim of the experiment is interesting for the business process