A Catalog of BPMN Extensions

Milene Cavalcante[1,*,†], Enyo Gonçalves[1,†], João Araújo[2,†] and Tiago Heineck[3,†]

[1]*Federal University of Ceará (UFC)*
[2]*NOVA University of Lisbon*
[3]*Federal Institute of Catarinense (IFC)*

Abstract

BPMN is a business modeling language that has been extended since its creation. Creating a new BPMN extension or using an existing extension involves searching for existing extensions and their constructs as a starting point. This identification of extensions can be done through searches in scientific libraries or through a systematic review, which requires effort and time and is subject to failure. In this context, catalogs have proven to be effective for gathering and organizing knowledge, including information on modeling language extensions. Therefore, the existence of a catalog of BPMN extensions and their constructs can make this identification faster, with less effort and less prone to failure. Motivated by this scenario, this work proposes a catalog containing 80 BPMN language extensions and 409 extended constructs, classified into three main categories: those that cater to specific domains, application areas and those aimed at general language improvements. The results indicate that the proposed catalog is useful for retrieving information and stands out for its ease of use.

Keywords

BPMN, Extension, Catalog

1. Introduction

Business Process Model and Notation (BPMN) [1] is a diagrammatic modeling language widely used to represent and manage business processes. It offers a standardized set of symbols that facilitate the visual representation of processes, making them more understandable to users [2]. The main objective of BPMN is to increase the competitiveness of organizations by optimizing employee productivity and improving the definition and organization of internal processes [3].

An extension of a modeling language refers to the broadening of its original capabilities by adding new constructs or adapting existing ones in the standard definition. These extensions are particularly useful to meet the specific needs of a domain, an application area or to introduce general improvements [3]. They offer greater flexibility and practicality, without the need to create a new language or make direct changes to the original definition. In this context, BPMN has often been extended to meet different demands, such as those found in healthcare, logistics and the Internet of Things (IoT).

Several modeling languages, such as UML [4], iStar [5] and KAOS [6], have sought to identify and document their existing extensions, with the aim of supporting the community and providing a comprehensive view of the work done to extend these languages, as presented by [7], [8] and [9]. This extension process is generally motivated by two main factors: improving existing elements and adapting the language to meet the needs of specific domains. The first approach focuses on improving aspects of the language that are considered relevant, while the second aims to adjust it to particular contexts, such as application areas.

In this context, adopting extensions is preferable to creating a new modeling language, since developing a language from scratch can be more costly and time-consuming. Extensions offer the flexibility

ER2025: Companion Proceedings of the 44th International Conference on Conceptual Modeling: Industrial Track, ER Forum, 8th SCME, Doctoral Consortium, Tutorials, Project Exhibitions, Posters and Demos, October 20-23, 2025, Poitiers, France
*Corresponding author.
†These authors contributed equally.
cavalcantemilene01@alu.ufc.br (M. Cavalcante); enyo@ufc.br (E. Gonçalves); joao.araujo@fct.unl.pt (J. Araújo); tiagovda@gmail.com (T. Heineck)
0009-0007-0771-5737 (M. Cavalcante); 0000-0003-4571-1044 (E. Gonçalves); 0000-0001-5914-1631 (J. Araújo); 0000-0003-4489-036X (T. Heineck)

needed to meet specific demands while preserving the benefits of the original language, such as standardization and tool support. This optimizes the development and application of complex business models, as discussed in [10].

Identifying BPMN extensions can be a complex, time-consuming and error-prone task when performed without adequate support. Two possible approaches to performing this task include: conducting a database search, selecting the extensions and then analyzing the results; or analyzing articles obtained through a systematic review, seeking to identify the desired information [11]. However, the use of tools such as catalogs can help to systematize the presentation of data and facilitate search and retrieval tasks. These tools include catalogs, which have been widely and successfully used to gather accumulated knowledge, including language extensions.

In this context, this paper proposes a web catalog for extensions of the BPMN process modelling language, with the aim of supporting teams in formalizing processes. In addition, we carried out an evaluation of the BPMN extensions catalog with users. Previous studies presented in [12] [1] identified 80 BPMN extensions from 2019 to 2024, which were gathered in the catalog developed in this work. This study is part of a set of initiatives that seek to analyze and systematize extensions to modelling languages, following similar approaches to those carried out by [13] for iStar extensions and by [14] for KAOS extensions.

This article is organized as follows: Section 2 presents the theoretical framework, covering modeling languages, BPMN, its extensions, and catalogs. Section 3 discusses related works. The methodology adopted is detailed in Section 4. Section 5 presents the catalog of BPMN extensions. The evaluation of the catalog is described in Section 6. Finally, the conclusions of the study are presented in Section 7.

2. Background

2.1. BPMN Language Overview

BPMN is defined in [15] as a modeling language that is widely used to represent business processes and is recognized in both academia and industry. BPMN is standardized by the Object Management Group (OMG) and has an ISO standard specification. This work deals with version 2.0 of BPMN [16], its most recent version, which presents significant changes in relation to the previous version. The most recent formalization of the standard addresses the execution semantics of all BPMN elements, establishes an extensibility mechanism and resolves inconsistencies and ambiguities, among other important advances [17].

BPMN elements are organized into five main categories: flow objects, data, connection objects, lanes and artifacts. The language is widely valued for its semantic robustness and expressiveness, facilitating the interpretation of models and reducing the risk of misunderstandings. In addition, BPMN is supported by various modeling tools, such as Activiti, BPMN2 Modeler and Bizagi, which allow models to be converted into executable languages efficiently [18].

2.1.1. BPMN Extension Mechanism

As mentioned earlier, BPMN 2.0 introduces an extensibility mechanism that allows new attributes and/or improvements to be added to standard constructs, with the aim of meeting the specific needs of different domains, without contradicting the originality of the modeling language. According to [16], extension attributes must be compatible with the semantics of the original elements and must not lead to contradictions. Even with the possibility of adapting or proposing a new element, the diagrams generated must maintain their basic visual structure to ensure that they are easily understood by any tool or viewer, as illustrated in Figure 1.

This feature is essential for representing concepts that are specific to certain contexts in general-purpose modeling languages. It also facilitates the integration of essential information for transforming models into formats that can be adapted to specific platforms or codes [20]. BPMN stands out by

[1] https://sites.google.com/view/systematicreviewbpmnextensions

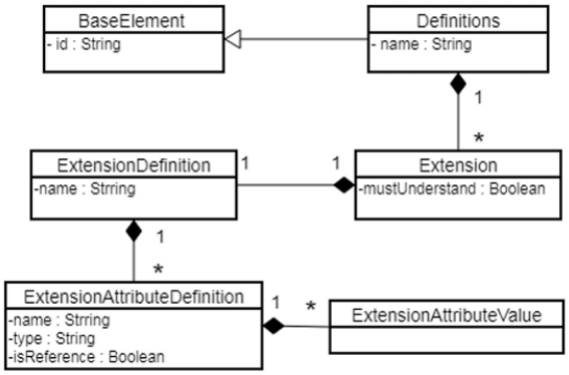


Figure 1: Standard representation of BPMN extension in class diagram. Source: [19].

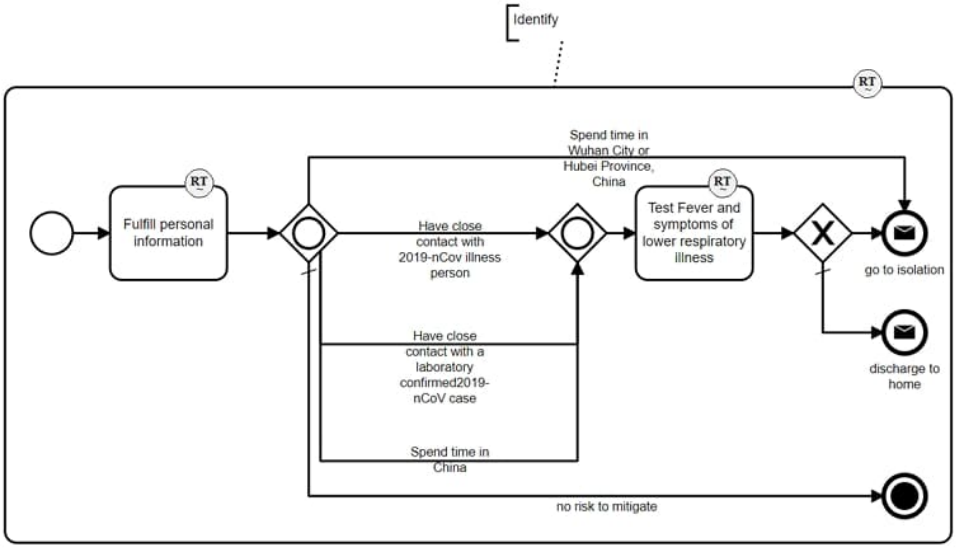


Figure 2: Representation of a new construct of a BPMN extension. Source: [21].

offering generic extension elements, allowing adaptations to be created for different domains, while ensuring that the core elements are preserved [3]. Recently, Braun et al. [18] proposed a new approach to developing these extensions, broadening the possibilities for customizing and adapting the language.

As an example of an extension, we present an adaptation of the activity element proposed in [21]. This adaptation provides a clearer representation of a real-time process by incorporating a circle at the top of the activity builder with the initials 'RT'. Thus, the activity illustrated in Figure 2 represents tasks that are taking place in real time.

3. Related Works

According to [11], catalogs are a widely used solution to support software engineers in obtaining practical resources for their projects. A catalog consists of a body of knowledge, which can include general information, such as that found in books etc., or more specific knowledge, such as the SLR developed in [12] on BPMN extensions. Often, catalogs are created with the aim of facilitating the reuse of resources in different contexts, as evidenced by [22] in the elicitation of non-functional requirements.

Catalogs related to modeling language extensions have been identified, as detailed below. A related

piece of research was proposed in Gonçalves et al. [8], in which the authors present a list of extensions to the iStar modeling language, resulting from a Systematic Literature Review (SLR). The aim of the study was to identify and analyze existing extensions to the language, based on an SLR that resulted in 96 articles and 307 identified constructs. As future work, the authors developed and published a catalog of iStar extensions, presented in Gonçalves et al. [13]. That catalog, similar to the one presented here, shows a list of studies that have proposed new extensions for modeling languages, all of them obtained from an SLR.

Similarly, Sousa's work [23] aimed to identify and analyze extensions to the KAOS language. The SLR identified 35 articles in seven electronic databases, considering publications up to 2019. Subsequently, the review was updated by Gonçalves and Monte [9], finally reaching the identification of 50 KAOS extensions. The data collected was incorporated into the catalog of KAOS extensions proposed in [14], following procedures similar to those adopted in the work on iStar extensions and in this study.

The SLR on which our catalog is based is described in [12]. We identified reviews on BPMN extensions proposed in three periods, according to the articles respectively: from 2007 to 2014, from 2014 to 2018 and, more recently, from 2019 to 2025. The studies collected were incorporated into the database that makes up the catalog.

Although the objective of this work is similar to that of the aforementioned studies - to catalog modeling language extensions based on SLRs - it differs in that it deals exclusively with the BPMN language, while the previous works focus on the iStar and KAOS languages. In addition, our analysis is more focused and objective, considering specific aspects such as types of extensions, compatibility between syntaxes, tool support, among others.

Adopting the catalog in the process of identifying BPMN extensions provides significant benefits by minimizing the time and effort required to consult multiple sources or rely on experts. In this sense, the reuse of extensions is a more efficient and advantageous alternative to developing new ones, as illustrated in this paper.

4. Methodology

This section presents, in detail, the methodological procedures adopted for the development of the BPMN language extension catalog. The process was conducted based on clearly defined objectives and research questions that guided each stage of the study.

From a previously conducted SLR, a solid database was extracted to compose the catalog, which was later implemented in web format to ensure accessibility and organization. The system structure was designed to allow detailed and transparent registration of extensions, encouraging their reuse.

After filling the catalog with the extracted data, a validation stage was carried out through the application of a survey [24] structured based on the UTAUT model [25], with the objective of evaluating the acceptance and perceived effectiveness of the tool by users. Each of these phases—extraction, implementation, feeding, and validation—is described individually and systematically in the following subsections.

4.1. Objectives

General Objective. To develop and evaluate an online catalog of extensions for the BPMN modeling language, with the aim of providing an organized, accessible and useful tool for consulting and registering extensions, contributing to the BPMN community.

Specific Objectives.

- Propose an online tool for cataloging and consulting BPMN extensions.
- Evaluate the accuracy and effectiveness of the catalog.

4.2. Research Questions

The research questions of this study address the central aspects related to the catalog of BPMN language extensions.

- **RQ1: How can the existing BPMN language extensions be catalogued?** This question investigates the main extensions proposed for the BPMN language, with a view to identifying and organizing them in a catalog. In addition, essential criteria are analyzed to ensure that the most relevant information is included in the catalog in a structured way.
- **RQ2: How efficient is the catalog developed to BPMN extensions?** This question assesses the efficiency of the catalog developed, considering its ability to facilitate the organization and consultation of BPMN extensions, promoting a more effective and intuitive interaction for users. To do this, metrics were used based on the UTAUT (Unified Theory of Acceptance and Use of Technology) model, which includes factors such as intention to use, expectation of performance, expectation of effort and facilitating conditions.

4.3. Study Steps

This subsection describes the steps followed to develop the catalog of BPMN extensions. The procedures are presented in the subsections below, highlighting that the results of the SLR on BPMN extensions [12] served as the starting point for the activities carried out in this work.

Extracting the Extensions. The extraction of existing extensions is based on a database drawn up from the SLR research questions [12], containing all the information needed to complete the catalog. In addition, this stage includes storing the data of all the builders, which will now be preserved to be attached to their respective publication - an aspect that had not been addressed in the review.

Catalog implementation. The BPMN Extension Catalog is developed in a web version, using the PHP language [2], in conjunction with the Laravel framework [3]. The adoption of Laravel enables the application of the MVC (Model-View-Controller) architectural pattern, favoring the separation of responsibilities between layers and code maintainability. The database used is MySQL [4], which ensures query optimization and broad compatibility with analysis and integration tools. The entire application is packaged in Docker containers [5], allowing it to run in heterogeneous environments with high portability and facilitating the continuous deployment process. The catalog is pre-structured to allow the inclusion of data through forms, enabling the registration of the fields necessary to feed each publication. These fields are based on the research questions addressed by SLR [12], providing better organization and availability of information. In addition, the catalog is unique in that it includes a review mechanism that lists all extended constructs, allowing them to be reused by the community.

Inclusion in the Catalog. With the information gathered and the catalog available, the final update is made to include the necessary data, completing the process of registering extensions. Each publication receives the information according to the topics listed below, plus the addition of image-type attachments representing the extended constructs in cases where there is concrete extended syntax, accompanied by an example of their use.

Catalog Validation. To assess the acceptance of the BPMN Extension Catalog, a survey [25] based on the UTAUT model was conducted. The study involved 17 master's students, who answered a questionnaire structured around the main constructs of the model: Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions. The answers were recorded on a five-point Likert scale, ranging from "Strongly Disagree" to "Strongly Agree". Before the final application, a pilot test was carried out with five master's students, whose suggestions were incorporated to ensure the clarity and suitability of the questionnaire. The suggestions obtained were analyzed and incorporated into the final version of the questionnaire, ensuring its clarity and suitability. The UTAUT model, proposed by [25],

[2] https://www.php.net
[3] https://laravel.com/
[4] https://www.mysql.com/
[5] https://www.docker.com/

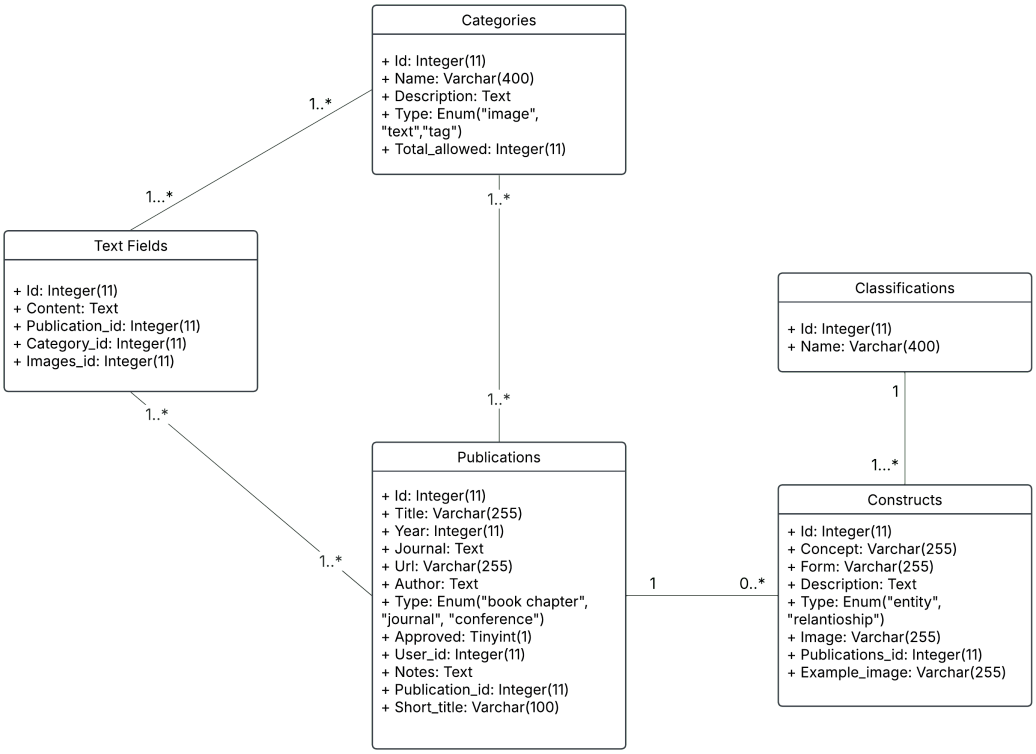


Figure 3: Conceptual model for the BPMN extension catalog

is widely used to study technology adoption and integrates eight theories on technological acceptance, including the Theory of Reasoned Action (TRA), the Technology Acceptance Model (TAM) and the Theory of Planned Behavior (TPB). Its main objective is to understand the factors that influence the intention to use a system, with four constructs having a direct impact on this process: Performance Expectancy, Effort Expectancy, Social Influence and Facilitating Conditions. Thus, this study seeks to identify whether these factors influence the adoption of the catalog, helping to understand its acceptance and feasibility of implementation in the BPMN community.

5. The BPMN extension Catalog

The catalog is available online at [6], where you can view the complete list of registered extensions and select any of them to access detailed information about their attributes and respective constructions. Figure 3 shows the conceptual model of the tool, while Table 1 illustrates an example of how category-based evaluation is applied to one of the extensions.

The tool offers search capabilities by author or title and allows filters to be applied by various categories, such as application area, specific domain, proposed improvements, presentation of new constructs, type of conservativity, compliance with OMG standards, type of representation, availability of support tools, syntax level and compatibility between different syntaxes.

Figure 4 shows the list of extensions cataloged, including the information mentioned and a link to access the full details of each extension. Figure 5 shows the details of an extension, where the title is clickable and provides all the information previously described. Figure 6 highlights the extended constructs related to the extension.

In addition, more detailed information can be accessed via the “Details” option, as illustrated in Figure 7. This detailed information offers a comprehensive view of each extension and its specific features.

[6] http://bpmnextensionscatalogue.quixada.ufc.br/

Table 1
Example of applying categories in an extension

Field	Description
Author	Zarour, Karim; Benmerzoug, Djamel; Guermouche, Nawal; Drira, Khalil
Type	Conference
Name	New Knowledge in Information Systems and Technologies (WorldCIST 19 2019)
Year	2019
Description	Application Area / Specific Domain
Application Area	Cloud Computing
Conservative	Non-conservative
Construct Modified	New element
Extension Proposal	Application Area
Meaning – Concepts Introduced	Not Present
New Graphical Representations / Adaptation	New representation
OMG	Yes
Syntax Compatibility	No
Syntax Level	Both
Tool Support	MS Visio, Bizagi

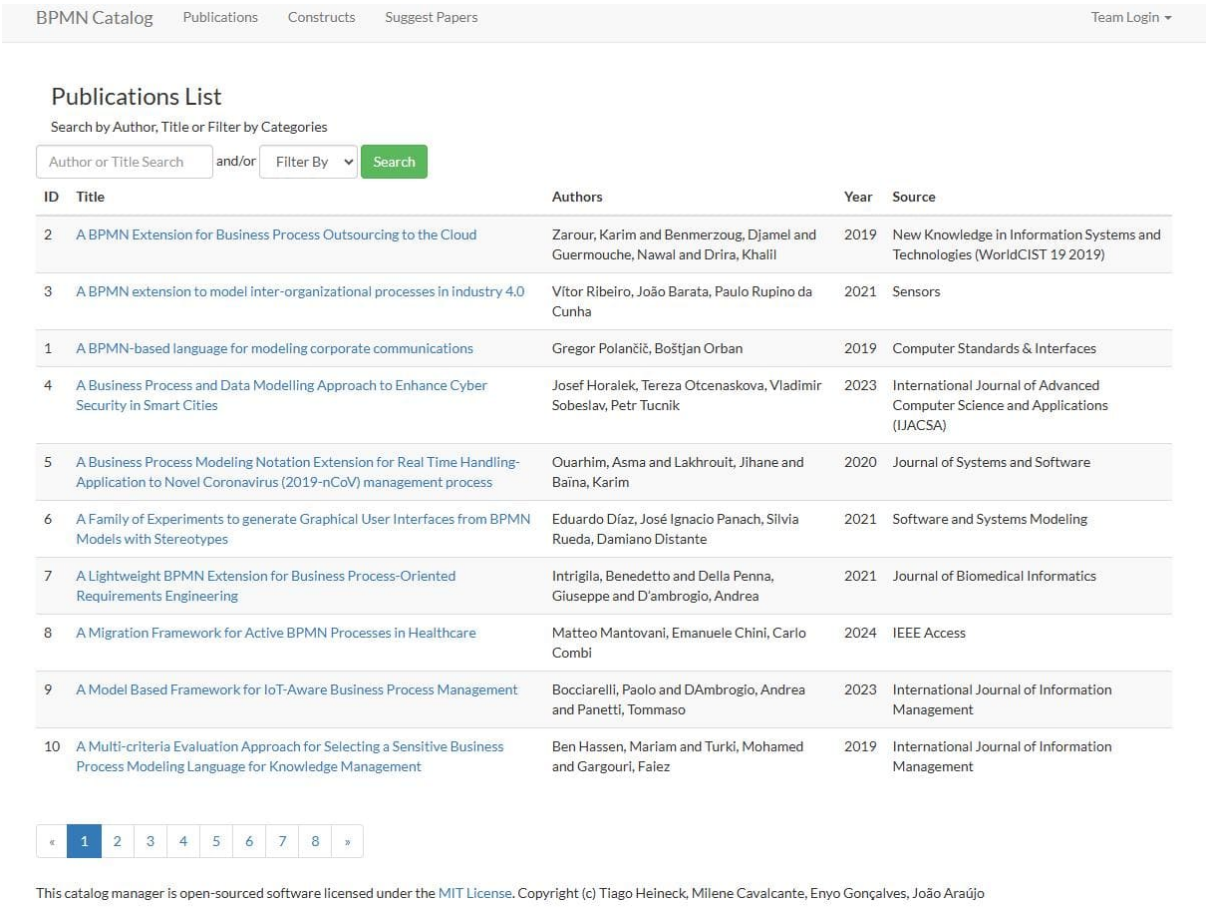


Figure 4: Page dedicated to listing publications related to the proposal for BPMN extensions

Similar to the list of extensions, you can also access the list of all cataloged constructs. The tool allows you to search for constructs by name or apply specific filters, such as Shape (construct format), Type (Node or Link) and Classification (Adaptation or New Representation), as shown in Figure 8. By clicking on the name of a construct, detailed information is displayed on a dedicated page, the same one accessed via publications, as shown in Figure 7.

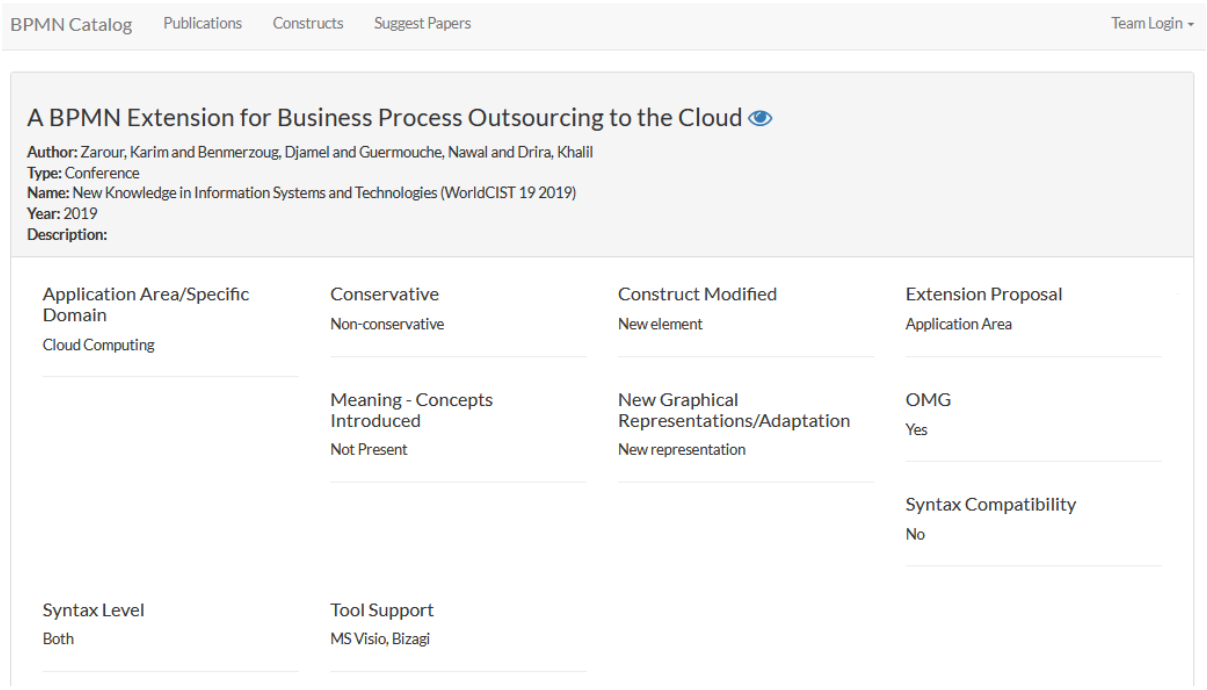


Figure 5: BPMN Extension Details Page – Information

6. Preliminary Evaluation of the BPMN Catalog

The questionnaire was administered after an introductory presentation lasting approximately one hour, covering BPMN notation, its extensions, and the usual process of searching for these extensions on an ad hoc basis. The session also included a practical demonstration using the catalog developed. Due to the large number of items, the complete questionnaire is also available online at: [7].

Seventeen master's students in Computer Science participated in the evaluation, all with prior knowledge of Unified Modeling Language (UML), which facilitated their understanding of the BPMN notation presented. Although some were already familiar with BPMN, the initial presentation aimed to level the participants' knowledge and provide an introductory experience in the use of notation extensions.

Before the official application, a pilot test was conducted with five other master's students to review and adjust the collection instrument. The questionnaire was structured based on an adaptation of the UTAUT model, covering dimensions such as prior knowledge of BPMN and extensions, intention to use, performance expectations, effort expectations, facilitating conditions, and effective use. Each of these dimensions was evaluated using multiple statements, answered on a Likert scale of agreement.

The research was conducted with master's students, a group often considered appropriate in experimental studies in the field of Software Engineering. According to Tichy [26], the use of students is particularly valid in experiments whose objective is to compare methods or tools, provided that the participants' level of experience is clearly described. This recommendation was followed in this study, considering that the participating students were already familiar with UML and received a formal introduction to BPMN notation before completing the questionnaire.

In addition, the study by Höst et al. [27] demonstrated that, in specific tasks, data collected from students can be comparable to that obtained from professionals in the field, especially when participants are properly trained. Thus, the profile of the subjects and the design adopted reinforce the validity of the results obtained in this research.

Of the participants, 82.4% (14) said they had beginner-level knowledge of BPMN, while 11.8% (2) were intermediate and only 5.9% (1) said they had advanced knowledge. With regard to knowledge of

[7] https://bit.ly/3FUoSqZ

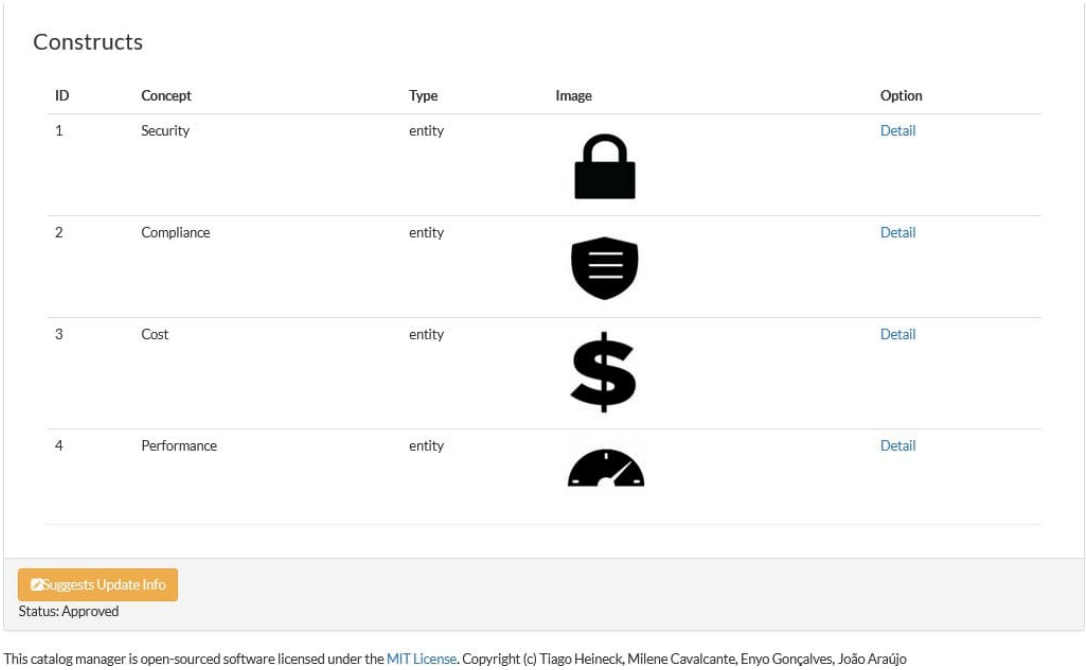


Figure 6: BPMN Extension Details Page – Constructs

BPMN extensions, 88.2% (15) classified themselves as beginners and 11.8% (2) as intermediate, with no participants having advanced knowledge in this category.

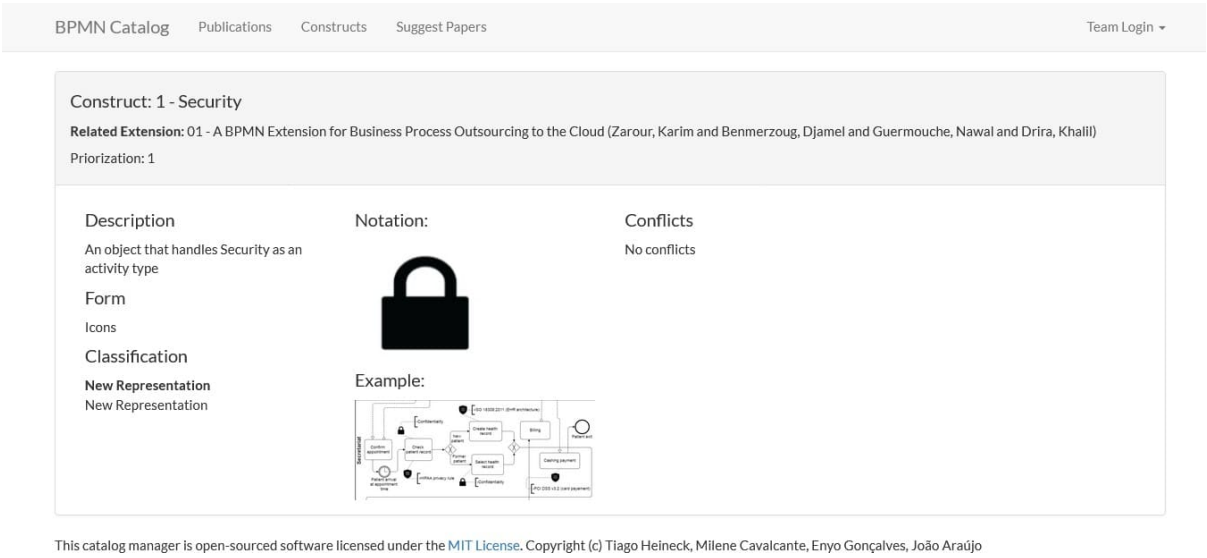


Figure 7: Construct Details Page

The survey data was analyzed based on the levels of the 5-point Likert scale used in the questionnaire, in which participants indicated their degree of agreement with each statement (1 = Strongly disagree; 5 = Strongly agree). The answers were quantified in order to calculate averages per construct of the UTAUT model, allowing a numerical assessment of users' perceptions of the catalog. However, some statements were deliberately worded negatively, such as: "I don't want to use the catalog" or "The catalog will not be compatible with other tools I use". In these cases, the answers were reversed (5 = Strongly disagree; 1 = Strongly agree) in order to maintain the interpretative consistency of the scores - i.e. to ensure that higher values represent more positive perceptions across all items.

After this normalization, the averages per participant and per construct were calculated, covering:

intention to use, expectation of performance, expectation of effort, facilitating conditions and use. Based on this normalization, the interpretation of the results considers that the closer the averages obtained are to 5, the more positive the participants' perceptions of the catalog are.

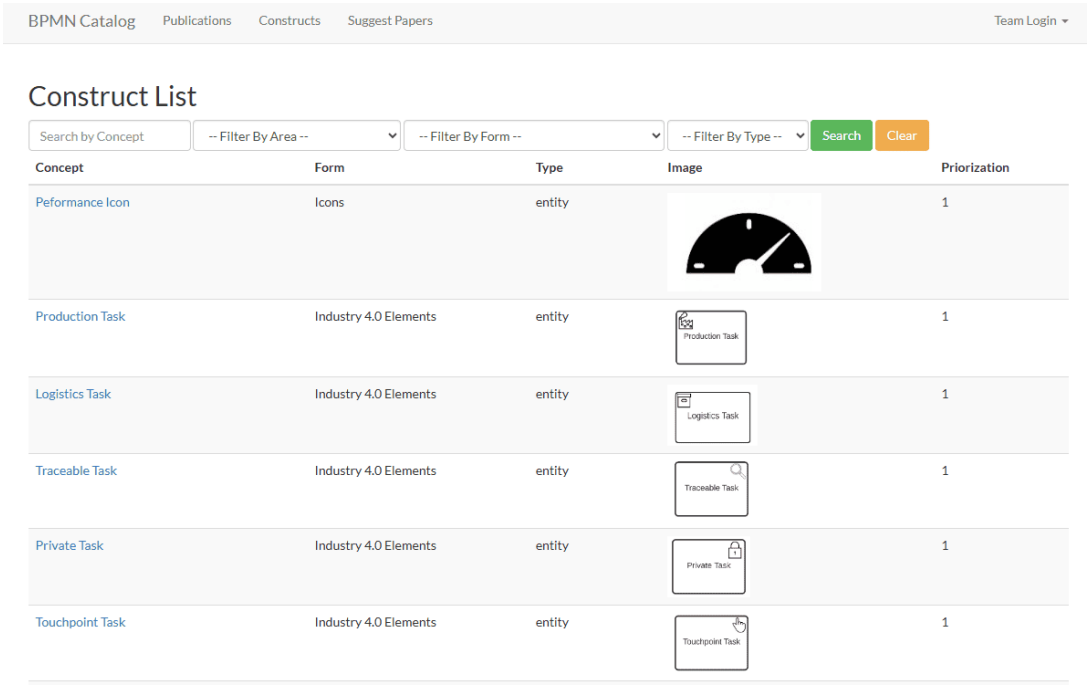


Figure 8: Extended Constructs List Page

Tables 2 and 3 provide a comprehensive overview of the participants' perceptions, based on the answers collected through the survey. Table 2 shows the detailed results by item, enabling a more precise analysis of individual opinions on specific aspects evaluated in the UTAUT model. In turn, Table 3 consolidates this information by construct, facilitating a general understanding of the levels of acceptance and perceived usability. This data helps to assess the potential for adoption of the catalog and points to areas that require improvement, such as strengthening support conditions and adopting strategies to encourage continued use of the tool.

The results obtained show a positive intention to use the catalog on the part of the participants, with an overall average of 4.44 in the Intention to Use construct, indicating agreement with statements that recognize the relevance and usefulness of the tool. Items such as "The catalog is relevant for searching for BPMN extensions" (average of 4.82) and "The catalog will make the search process more agile" (4.59) reinforce this perception. In addition, Performance Expectation had an average of 4.50, showing that users believe the catalog can improve their productivity, speed up tasks and increase the chances of finding suitable extensions, as indicated by the high value of the item "Using the catalog will give me a better chance of finding the extension I need" (4.88).

The perception of ease of use was also favorable, with an average of 4.18 in Effort Expectation, suggesting that participants find the catalog accessible and intuitive. However, the Facilitating Conditions construct obtained a lower average (3.51), with a negative highlight for the item "A specific person or group will be available to help me when I have difficulties" (2.88), pointing to the need for institutional or technical support.

Finally, although the intention to use was high, the average for the Use construct was 3.26, indicating a more moderate willingness to adopt the catalog immediately. This difference may be related to factors pointed out in the statements themselves, such as uncertainty about using it in the coming months (averages of 2.65 and 2.59), the relatively low level of intention to exploit its functionalities to the full (2.94), or even hesitation in adopting it as a first choice over other options (3.76). These results suggest possible external barriers, such as a lack of ongoing familiarity with the tool, the absence of institutional

Table 2
Descriptive Statistics of UTAUT Constructs and Associated Items

ID	Construct [Item]	Average	Standard Deviation
S1	Intention to use [I don't want to use the catalog]	3.65	1.00
S2	Intention to use [Although it can be useful, using the catalog can make work more complex]	4.41	0.87
S3	Intention to use [Using the catalog will not make extension development more productive]	4.71	0.47
S4	Intention to use [The catalog is relevant to the BPMN extension search]	4.82	0.39
S5	Intention to use [The catalog will make the extension search process more agile]	4.59	0.71
S6	Performance expectation [I believe the catalog will be useful when searching for BPMN extensions]	4.71	0.47
S7	Performance expectation [Using the catalog will allow me to perform activities more quickly]	4.18	1.07
S8	Performance expectation [Using the catalog will increase my productivity]	4.24	1.09
S9	Performance expectation [Using the catalog will give me a better chance of finding the extension I need]	4.88	0.49
S10	Effort expectation [My interaction with the catalog will be clear and easy to understand]	4.12	0.60
S11	Effort expectation [It will be easy for me to become a catalog user]	3.71	0.99
S12	Effort expectation [I think the catalog will be easy to use]	4.53	0.62
S13	Effort expectation [Learning to use the catalog will be easy for me]	4.35	0.70
S14	Facilitating conditions [I will have the necessary resources to use the catalog]	4.29	0.77
S15	Facilitating conditions [I will have the necessary knowledge to use the catalog]	3.65	0.93
S16	Facilitating conditions [The catalog will not be compatible with other tools I use]	3.24	1.09
S17	Facilitating conditions [A specific person or group will be available to help me when I have difficulties]	2.88	0.70
S18	Use [I plan to use the catalog in the coming months]	2.65	1.00
S19	Use [I will use the catalog in the coming months]	2.59	0.87
S20	Use [I will explore the catalog to the fullest]	2.94	1.03
S21	Use [I plan to discover new ways to use the catalog when looking for BPMN extensions]	3.35	1.00
S22	Use [Even when other options are available, the catalog will always be my first choice]	3.76	0.90
S23	Use [I plan to make the most of the information provided by the catalog about BPMN extensions]	3.88	0.93
S24	Use [I plan to integrate the catalog when developing BPMN extensions]	3.65	0.86

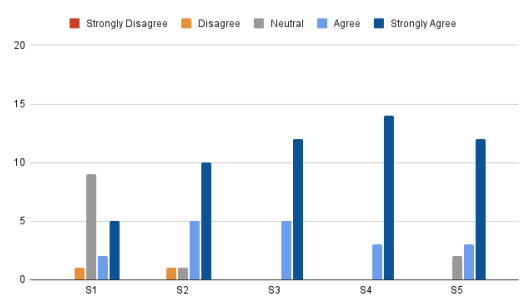
incentives or not perceiving an immediate need to use it at the moment.

Table 3
Descriptive Statistics of UTAUT Constructs

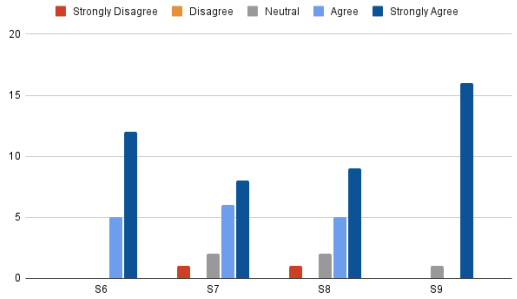
Construct	Average (Mean)	Standard Deviation
Intention to Use	4.44	0.69
Performance Expectation	4.50	0.78
Effort Expectation	4.18	0.73
Facilitating Conditions	3.51	0.87
Use	3.26	0.93

To better visualize these patterns and differences across constructs, Figures 9a, 9b, 10a, 10b, and 11 present the distribution of responses for each statement in the questionnaire. It can be observed that responses related to Intention to Use, Performance Expectation, and Effort Expectation have higher values and less dispersion, reflecting a positive and consistent perception of the catalog. In contrast, the constructs of Use and Facilitating Conditions show more moderate averages and greater variability,

highlighting areas in which participants demonstrated greater hesitation or perceived difficulties. These graphical representations corroborate the previous analyses and underscore aspects that may require attention to encourage effective adoption of the tool.

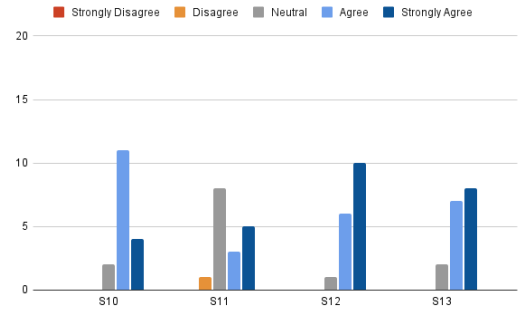


(a) Intention to Use construct

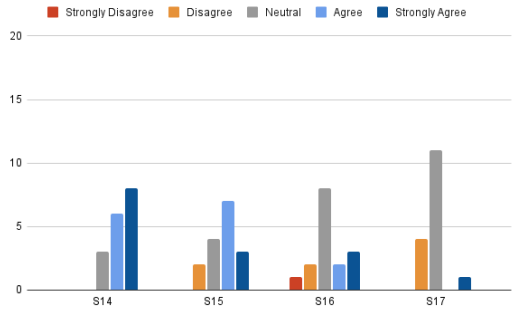


(b) Performance Expectation construct

Figure 9: Detailed results of the evaluation of the results of the applied questionnaire



(a) Effort Expectation construct



(b) Facilitating Conditions construct

Figure 10: Detailed results of the evaluation of the results of the applied questionnaire

6.1. Threats to Validity

This section discusses the main threats to the validity of the survey instrument used in this study, based on the four criteria proposed by [24]: face validity, content validity, conclusion validity and construct validity.

Face Validity refers to the preliminary assessment of the clarity, readability and comprehensibility of the instrument's items by people with no prior knowledge of the subject. For this stage, we applied the pilot of the questionnaire described in the previous section, collecting the results which led to improvements in the fluidity and wording of the questions.

Content Quality refers to the qualitative assessment of the adequacy, comprehensiveness and relevance of the items by experts or people familiar with the topic. To this end, the form was reviewed by two experts in the field, ensuring that all the important dimensions of the object of study were covered.

Completion Validity refers to the instrument's ability to achieve its objective, considering the reliability of the data collected and the possibility of carrying out robust statistical analyses. In this study, 17 students took part in the face-to-face application of the questionnaire. Although this number was sufficient to obtain an initial overview of usability, it limits the ability to make more in-depth statistical inferences, thus restricting the validity of the quantitative conclusions.

Construct Validity assesses whether the instrument effectively measures the constructs it sets out to investigate in the context of the research. To mitigate threats related to this validity, the questionnaire

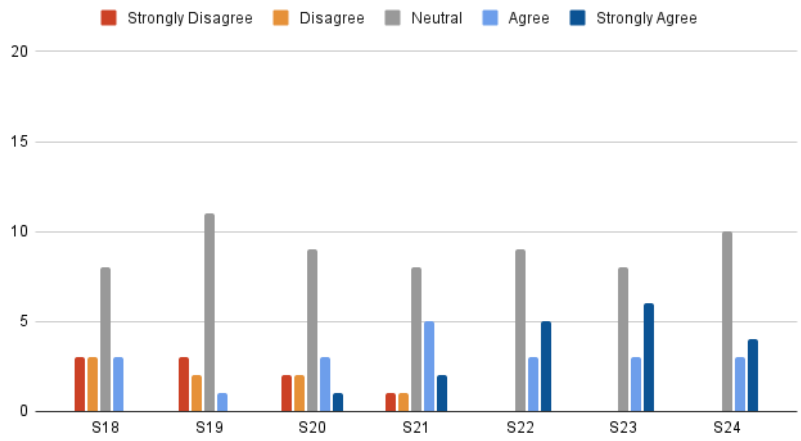


Figure 11: Detailed results of the evaluation of the results of the questionnaire applied in the Use construct

was developed with clear, objective questions and was reviewed and validated in the pilot stages, ensuring that the answers consistently reflected the participants' perceptions of the catalog's usability.

Despite the care taken, these threats to validity should be considered when interpreting the results, and indicate the need for future research with larger samples and complementary methodologies to strengthen the evidence obtained.

7. Conclusion

Since the creation of BPMN, several extensions have been proposed. However, identifying an extension based on its characteristics or finding a builder that meets a specific need can be a complex task, requiring time and effort. To mitigate this challenge, this article presents an online catalog of BPMN extensions, making them easier to identify and view. The catalog, available online, brings together all the extensions found in the SLR [12] and provides detailed information on each one. In addition, the tool offers advanced features, such as searching by title or author and filters for constructs, allowing refinement by area of application, format and type. This study contributes to the systematization and analysis of BPMN extensions.

The analysis of the results begins with the Intention to use construct, which showed high averages, indicating that the participants show a strong predisposition to use the BPMN extensions catalog. This positive intention suggests that the tool arouses interest and is perceived as relevant in the context of process modeling. However, when looking at the results of the Use construct, a discrepancy can be seen: the averages were considerably lower, suggesting that, despite the intention, actual use has not yet materialized.

This contrast may point to the presence of external barriers - such as lack of time, institutional support or low urgency at the time of application - which hinder the immediate adoption of the tool. Complementing this analysis, the high scores in Performance Expectancy and Effort Expectancy indicate that participants perceive the catalog as a useful and easy-to-use tool, which reinforces its potential for positive impact. On the other hand, the lower values in Facilitating conditions, especially in the item referring to the availability of support, reveal a possible gap in terms of the infrastructure or support needed for continued use of the tool, which could negatively influence its adoption in the long term.

As future work, we plan to deepen the usability analysis by means of a heuristic evaluation conducted by experts. We also plan to carry out a comparative experiment to measure the time needed to identify extensions and their constructs using the SLR and the catalog, dividing participants into two groups and comparing their execution times. Finally, we intend to incorporate a system for recommending extensions based on users' preferences from the catalog, as well as providing the option to export the construction to a structured file in .json format, in order to facilitate its integration with external tools

that support the format and its reuse.

Declaration on Generative AI

During the preparation of this work, the authors used ChatGPT and DeepL Translate for: sentence rephrasing and translation. After using these tools/services, the authors reviewed and edited the content as necessary and assume full responsibility for the content of the publication.

References

[1] S. A. White, D. Miers, BPMN Modeling and Reference Guide: Understanding and Using BPMN, Future Strategies Inc., 2008.

[2] M. Kocbek, G. Jošt, M. Heričko, G. Polančič, Business process model and notation: The current state of affairs, Computer Science and Information Systems 12 (2015) 509–539.

[3] R. M. Pillat, T. C. Oliveira, P. S. C. Alencar, D. D. Cowan, Bpmnt: A bpmn extension for specifying software process tailoring, Information and Software Technology 57 (2015) 95–115.

[4] Object Management Group (OMG), Unified modelling language, specification 2.5.1, 2017. Available at https://www.omg.org/spec/UML/2.5.1/.

[5] E. Yu, Modeling strategic relationships for process reengineering, Ph.D. thesis, University of Toronto, 1995.

[6] A. Dardenne, A. van Lamsweerde, S. Fickas, Goal-directed requirements acquisition, Sci. Comput. Program. 20 (1993) 3–50.

[7] J. P. S. da Silva, M. Ecar, M. S. Pimenta, G. T. A. Guedes, L. P. Franz, L. Marchezan, A systematic literature review of uml-based domain-specific modeling languages for self-adaptive systems, in: 13th International Conference on Software Engineering for Adaptive and Self-Managing Systems (SEAMS), 2018, pp. 87–93.

[8] E. Gonçalves, J. Castro, J. Araújo, T. Heineck, A systematic literature review of i* extensions, Journal of Systems and Software 137 (2018) 1–33.

[9] E. Gonçalves, L. Monte, S. Souza, M. de Oliveira, J. Araujo, A systematic literature review of kaos extensions, in: International Working Conference on Requirements Engineering: Foundation for Software Quality, Springer, 2025, pp. 166–180.

[10] R. Braun, W. Esswein, Extending bpmn for modeling resource aspects in the domain of machine tools, WIT Transactions on Engineering Sciences 87 (2014). doi:10.2495/AMITP20130531.

[11] L. Chung, B. A. Nixon, E. Yu, J. Mylopoulos, Non-functional Requirements in Software Engineering, volume 5, Springer, 2012.

[12] M. Cavalcante, E. Gonçalves, Bpmn extensions updated: A systematic literature review, under review or a copy contact us cavalcantemilene01@alu.ufc.br (2025).

[13] E. J. T. Gonçalves, T. Heineck, J. Araújo, J. Castro, A catalogue of istar extensions, in: WER, 2018.

[14] P. R. de Carvalho Junior, E. J. T. Gonçalves, R. M. Carvalho, M. A. de Oliveira, A catalogue of kaos extensions, in: WER, 2022.

[15] M. Chinosi, A. Trombetta, Bpmn: An introduction to the standard, Elsevier 34 (2012).

[16] Object Management Group (OMG), Business process model and notation (bpmn) - version 2.0, 2011. Available at https://www.omg.org/spec/BPMN/2.0/, accessed 2024-11-27.

[17] G. Aagesen, J. Krogstie, Bpmn 2.0 for modeling business processes, in: Handbook on Business Process Management 1: Introduction, Methods, and Information Systems, Springer, 2015, pp. 219–250.

[18] R. Braun, H. Schlieter, M. Burwitz, W. Esswein, Bpmn4cp revised - extending bpmn for multi-perspective modeling of clinical pathways, in: Proceedings of the 49th Hawaii International Conference on System Sciences (HICSS), 2016.

[19] K. Zarour, N. Guermouche, D. Benmerzoug, K. Drira, The practice of enterprise modeling: 7th ifip wg 8.1 working conference, 2020.

[20] L. J. R. Stroppi, O. Chiotti, P. D. Villarreal, Extending BPMN 2.0: Method and Tool Support, Springer-Verlag Berlin Heidelberg, 2011.
[21] A. Ouarhim, J. Lakhrouit, K. Baïna, A bpmn extension for real time handling - application to covid-19 management, 2020.
[22] L. M. Cysneiros, Evaluating the effectiveness of using catalogues to elicit non-functional requirements, in: Proceedings of WER, 2007, pp. 107–115.
[23] S. C. de Sousa, Uma revisão sistemática de literatura das extensões da kaos, 2019.
[24] B. Kitchenham, S. L. Pfleeger, Principles of survey research part 4: questionnaire evaluation, ACM SIGSOFT Software Engineering Notes 27 (2002) 20–23.
[25] V. Venkatesh, M. G. Morris, G. B. Davis, F. D. Davis, User acceptance of information technology: Toward a unified view, MIS Quarterly 27 (2003) 425–478.
[26] W. F. Tichy, Hints for reviewing empirical work in software engineering, Empirical Software Engineering 5 (2000) 309–312.
[27] M. Höst, B. Regnell, C. Wohlin, Using students as subjects—a comparative study of students and professionals in lead-time impact assessment, Empirical Software Engineering 5 (2000) 201–214.