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Comparative Analysis main Methods Business Process Modeling: Literature Review, Applications and Examples

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Abstract— *Purpose: The offer of business process modeling methodologies is very extensive, making it difficult for BPM scholars to make a sustained choice. In this context, this paper aims to present the main modeling methodologies, with applications, examples and comparisons. Approach: A systematic bibliographic survey and a comparative analysis of these notations used in the implementation of BPM projects were carried out. Findings: According to the bibliometric analysis, the business process modeling notations most portrayed in the works surveyed are: BPMN, UML, EPC e IDEF. From the construction of a consistent overview that allows the comparative analysis of the methodologies, in order to select the one that best suits its specificities it can be verified that, although they share the same objective, each notation has its specific characteristics. Originnality/Value: This study has the main purpose of providing a basis for the adequate indication of the application of studies in the area, in particular those for papers, dissertations and theses.*

Keywords— BPM, Business Processes Modeling, Business Processes Methodology.

I. INTRODUCTION

From the 1990s, organizations have experienced an evolution in terms of structural and technological models, bringing new paradigms to change and knowledge (Silva, 2015).

This fact has demanded a new attitude in the personal and managerial styles, directed for a differentiated and emerging reality. In this sense, contemporary companies are gradually becoming organized in a way oriented to the processes that permeate them, following the logic of them, and no longer the departmental reasoning of the functional approach (Malamut, 2005).

Nowadays there is an environment of high competitiveness in the organizational world, this fact leads the current organizations to create and implement mechanisms that promptly and effectively promote the development and optimization of their information systems. In fact, the agility factor is increasingly an aspect of differentiation among organizations, for them to act and respond in advance to the pressures, needs and opportunities of the market.

In this way, companies started to focus on their business processes in order to present high levels of competitiveness and realize that these processes are key factors of organizational success. A Business Process Management (BPM) approach through a set of organized activities ensures greater control, flexibility and ability to align processes with organizational strategy (van der Aalst, 2013). One of these activities present in this approach is the business process modeling that has the ability to define and change organizational processes in a more logical and structured way (Silva, 2015).

The offer of different types of process modeling methodology is quite extensive, making it difficult for project designers to make an appropriate and sustained choice. In this sense, Silva (2015) carried out a study in order to produce a solution to support the analysis of business process modeling notations, with the purpose of facilitating the selection of a methodology in the stage of process modeling, in a BPM approach by the teams that perform it.

This article aims to analyze the main methodologies of business modeling, based on a systematic bibliographic survey, and present a comparative discussion of these main methodologies used in the implementation of BPM projects in organizations, based on the study carried out by Silva (2015), with the main purpose of serving as a basis for indicating the appropriate methodology to apply BPM projects. Additionally, these results are configured as a theoretical reference for application in papers, dissertations and theses.

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The paper is organized as follows: Section 2 addresses the theoretical framework on Business Process Management and Business Process Modeling Section 3 presents the research method applied in the article; section 4 presents the results of the bibliometric analysis, showing the main methodologies used in the BPM context; section 5 contains a comparative analysis of the main Business Process Modeling Methodologies from the study carried out by Silva (2015) and section 6 points out the final considerations of this work.

II. THEORETICAL FRAMEWORK

2.1 Business Process Management - BPM

BPM is a holistic management approach (Draghici, Draghici, Olariu & Canda, 2012) developed with great focus on the adoption of Information Technology (IT) (Brocke & Sinnl, 2011). The methodologies, techniques or tools used, act by designing, approving, controlling, as well as analyzing business processes involving the organization, humans, applications, documents and any other source of information (Pyon, Woo & Park, 2011), being increasingly used by organizations in order to promote the effectiveness and efficiency of their business. In addition, according to Toor and Dhir (2011), it strives for innovation, flexibility and integration with technology, all with a focus on aligning the organization with customer needs.

BPM can also be evaluated as a continuous, structured, analytical and multisectoral process improvement that presents several critical factors (Trkman, 2010), to which are associated several methods that allow companies to establish a high orientation for business processes (Skrinjar&Trkman, 2013). It is worth stressing how important is the understanding and involvement of top management, the recognition of information systems, clear responsibilities, as well as a culture that is responsive to business processes (Draghici*et al*., 2012).

According to Siriram's (2012) understanding, BPM demands a systemic and balanced view, since the business process links the organization, resulting in a harmonization of resources, such as processes, people and systems. For the author, BPM actions demand the assimilation of a niche area, so that one can focus on the critical processes, which are aligned with the strategic objectives of the organization.

For Repa and Bruckner (2015), BPM is a well-established management model for managing the life cycle of a business process, including design, execution and analysis. Haddar, Makni and Abdallah (2014) complement this definition, indicating that BPM is based on the design of a model that satisfies a set of quality criteria, which is a non-trivial task due to the complexity of the current Business Processes.

In fact, the heterogeneity of these kinds of projects motivated the search for approaches to assist in the design of high quality models at reduced costs. BPM can also be evaluated as a continuous, structured, analytical and multisectoral process improvement, presenting several critical factors (TRKMAN, 2010), to which are associated several methods that allow companies to establish a high orientation for Business Processes (SKRINJAR and TRKMAN, 2013). According to the Association of Business Process Management Professionals, BPM is a managerial discipline with a structured approach to identifying, executing, measuring, monitoring and controlling Business Processes whether they are automated or not, to achieve consistent and targeted results, aligning business processes with the organization's strategic objectives, creating value, and enabling the organization to achieve its business goals more quickly (ABPMP, 2017). BPM, according to Arevolo (2006), seeks to map and improve the company's business processes by means of a life-cycle approach composed of the phases of definition, modeling, testing, distribution, execution, monitoring, analysis and optimization of business processes, as shown in Figure 1.

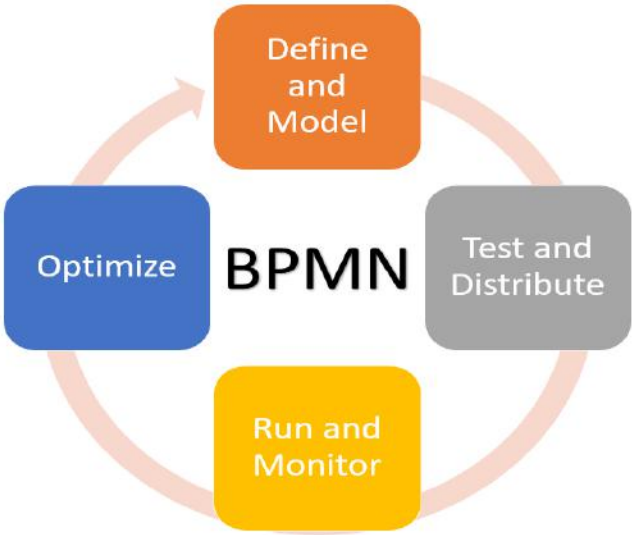

Fig. 1: BPM macroprocesses
Source: Adapted from Arevolo (2006)

Studies in the area of BPM, approach this organizational model as a global vision of the business and highlight the transition from a functional management to a process-oriented management, suggesting the application of BPM from a systemic approach, in which the interrelations of the processes in their contexts are highlighted. Unnecessary and misdirected steps are eliminated and remodeled using the resources available in the main processes (Segatto, Pádua & Martinelli, 2013). It is worth noting that to achieve the desired effectiveness it

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is important that BPM is not only addressed as a simple set of IT tools, but rather as an environment in which a process-oriented view and the media requires the organization of the business as a whole (Cho & Lee, 2011). For this, it is necessary to have a well-organized team (Neubauer, 2009), to have knowledge of processes in their individual or collective form (Seethamraju, 2012), and a good selection of crucial processes (Cho & Lee, 2011). Finally, it is observed that in order to understand the operation of the processes and what the existing types, it is essential to determine how they should be managed in order to obtain the best result (Siriram, 2012). Thus, in order to reproduce an organizational structure by processes, it is necessary to have a defined scenario of the company through the mapping of activities, rules and relationships that make up the processes, as well as an adequate business process modeling methodology.

2.2 Business Process Modeling

Process modeling is an activity of representing the processes of an organization that allows the analysis of its current form so that it is improved in the future (Toor & Dhir, 2011) since organizations need to understand them (Rub & Issa, 2012) in order to be able to improve them. A modeling is useful for describing and graphing the important aspects of a given process, distinguishing people, departments, and the link between them (Climent, Mula & Hernández, 2009) in order to portray them or to represent them adequately, emphasizing the aspects that need to be communicated and treated (Vergidis, Turner & Tiwari, 2008).

In general, the process modeling aims to describe characteristics of business processes, showing its structure, the sequence of activities and their relations, the resources used, among others. This is an important tool for understanding and analyzing processes (Rub & Issa, 2012) and has been widely used by organizations to document and improve their operations (Smirnov*et al*., 2012).

For Silveira, Cruz and Schmitz (2016), process modeling has been developed as a technology to describe processes such that they can be understood and developed with greater transparency.

Through this modeling it is possible to plan, create procedures and document them in a consistent way, making it possible to demonstrate the reality of the company and make changes according to the desired future situation (LEOPOLD; MENDLING; GÜNTHER, 2016).

According to Pinggera et al. (2015), real process models present a wide range of problems that converge to the syntactic, semantic and pragmatic quality dimensions of a model. For the authors, the syntactic and semantic quality is related to the construction of the model and addresses the correct use of the modeling language and the extent to which the model truly represents real-world behavior, respectively. In addition, pragmatic quality addresses the extent to which a model supports its use for purposes such as understanding the behavior and development of the system. For the different aspects that constitute a business process to be captured, it is necessary to use methodologies, techniques and standards of process modeling (Cull & Eldabi, 2010). Some of the available techniques are: Business Process Modeling Notation (BPMN),Cognition enhanced Natural language Information Analysis Method (CogNIAM), Extended Business Modeling Language(xBML), Event-driven Process Chain (EPC), Integration DEFinition (IDEF); Unified Modeling Language (UML), Petri Nets, Rapid Application Development(RAD), among others (Toor & Dhir, 2011).

Process modeling methodologies are a set of graphical constructs and rules for how to combine such elaborations. In this universe of methodologies of business process modeling, there are very simple to extremely sophisticated languages. For Georges (2010), the most sophisticated methodologies of business process modeling are those aimed at the development of information systems whether these transactional systems, supervisory systems or workflow management systems. In subsequent sections will be described the main methodologies for representation of business process models, raised through bibliometric research.

III. RESEARCH METHOD: BIBLIOMETRIC ANALYSIS

For the definition of the main methodologies of business process modeling, the bibliometric revision research method proposed by Marasco (2008) was used. For the composition of the bibliographic portfolio, the Scopus database was defined.

Research was carried out in journals without temporal delimitation of published studies. The total amount of works found in this database was a result of the keyword combinations searched in the titles and abstracts. In the step of defining the keywords for the bibliographic review, the keywords "Business Process Modeling" AND "Business Process Management" or "BPM" were used, as shown in Figure 2.

Fig. 2: Keywords of bibliometric research

Business Process Management	Business Process Modeling
"Business Process Management" *"BPM"*	AND *"Business Process Modeling"*

Source: Elaborated by the author (2019)

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The works found with these two combinations of terms were mostly chapters of journals, books, norms and articles of congress, in which the results of the bibliometric revision will be presented. Thus, 243 papers were obtained.

IV. MAIN BUSINESS PROCESS MODELING METHODOLOGIES

The origin of the term Business Process Modeling emerged in 1967 in a paper by S. Williams entitled "Business Process Modeling Improves Administrative Control," published in Automation Journal (WILLIAMS, 1967). Since then, this term has gained momentum and a very large number of methodologies and business process modeling languages have emerged (GEORGES, 2010).

In the beginning, business process modeling was done using flow and data representation languages from other areas, such as flowcharts, flow control diagrams and PERT (Program Evaluation and Review Technique) diagrams. Such process modeling languages, which were developed in the first half of the twentieth century, were not enough to model all the aspects necessary for the development and deployment of information systems, emerging the need for the development of more elaborate business process modeling languages that could represent the different aspects necessary for the development and implantation of information systems. Considering Business Process Management as the fundamental object of this review, the Business Process Modeling Methodologies most discussed in the articles collected in the Scopus database from the bibliometric revision are BPMN, UML, EPC and IDEF. The BPMN methodology stands out for being present in about 55% of these published works, as shown in Figure 3, followed by UML (21%), EPC (12%) and IDEF (7%), other methodologies are about 5%. The results of a survey conducted by Kocbek et al. (2015) also showed that BPMN is the default language in the process modeling field.

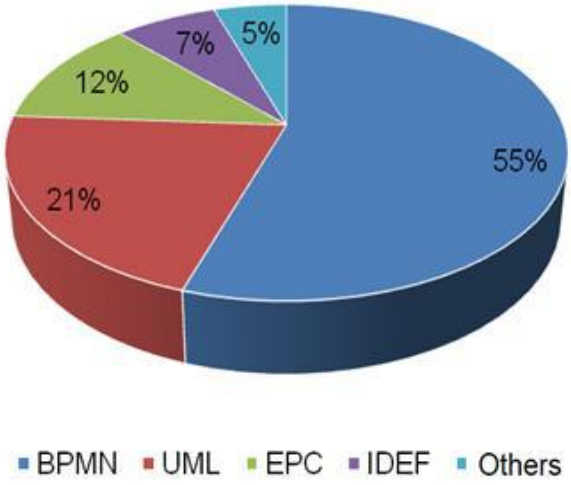

Fig. 3: Business Process Modeling Methodologies addressed in articles in the Scopus database
Source: Elaborated by the author (2019)

In the following subtopics, the main methodologies raised from the bibliometric review applied in this study will be discussed, highlighting works present in the scientific literature with the application of such notations.

4.1 Business Process Modeling Notation (BPMN)

BPMN is the largest and most widely accepted methodology for business process modeling (Pavani & Scucuglia, 2011). It is the result of an agreement between several companies of modeling tools, which had their own notations, with the purpose of creating a unique and standard language for business process modeling capable of facilitating the understanding and training of the end user (Almeida, 2009).

BPMN is a set of graphical conventions to describe business processes, specifically designed to coordinate the sequence of processes and the exchange of messages between processes. Zhang, Liang, Shi and Ma (2012) agree with this idea by emphasizing that BPMN represents processes in a standardized way, facilitating the understanding of the organization's stakeholders and employees.

According to Rachdi, En-Nouaary and Dahchour (2016), BPMN is an emerging modeling method that has received much interest and support from academia and industry as an open standard for Business Process Modeling. In addition to being one of the latest modeling notations standardized by OMG (Object Management Group) and BPMI (Business Process Management Initiative), BPMN is considered easy to use for all stakeholders of the organization (managers, analysts, developers, etc.) (KOCBEK et al., 2015) and allows to model a business process with a single type of Business Process Diagram (BPD), avoiding the fragmentation of

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the problem inherent in other modeling languages such as UML.

BPMN notation is used to model the current state of processes called AS-IS (current state). Process simulations are performed with the features that the notation offers, they allow to automate the activities in a simple and quick way with the control through visual indicators, thus generating a proposed model with improvements known as TO-BE (future-state) (SCHERUHN; VON ROSING; FALLON, 2015).

The BPMN notation is based on four large aggregates of symbolic elements for the representation of processes: the connection objects; flow objects; swimlanes or sting rays; and artifacts. Through these categories it is possible to find the representative elements of events, activities, roles, workflows, etc. (Chiarello, Emer & Neto, 2014).

Among the most recent papers are publications that apply BPMN methodology in the following areas: health (Onggo et al., 2018), manufacturing (Witsch & Vogel-Heuser, 2012), offshore (Joschka et al., 2015) (Petrasch & Hentschke, 2016), educational (Strîmbei, Dospinescu, Strainu, & Nistor, 2016), e-commerce (Bukhsh, Van Sinderen, Klaas & Barratel, 2017), service (Geiger, Harrer & Lenhard, 2016), etc.

Joschka et al. (2015) described a holistic approach to O & M processes in the field of offshore wind farm power generation. The acquisition and visualization of the process is performed by a risk analysis of all relevant processes. From then on, a tool was designed, which is able to model the processes defined in a BPMN notation, as well as connect and simulate them. n addition, the notation was enriched with new elements, representing other relevant factors that could only be displayed with a much greater effort.

Figure 4 shows the return trip process modeling by personnel transfer vessel.

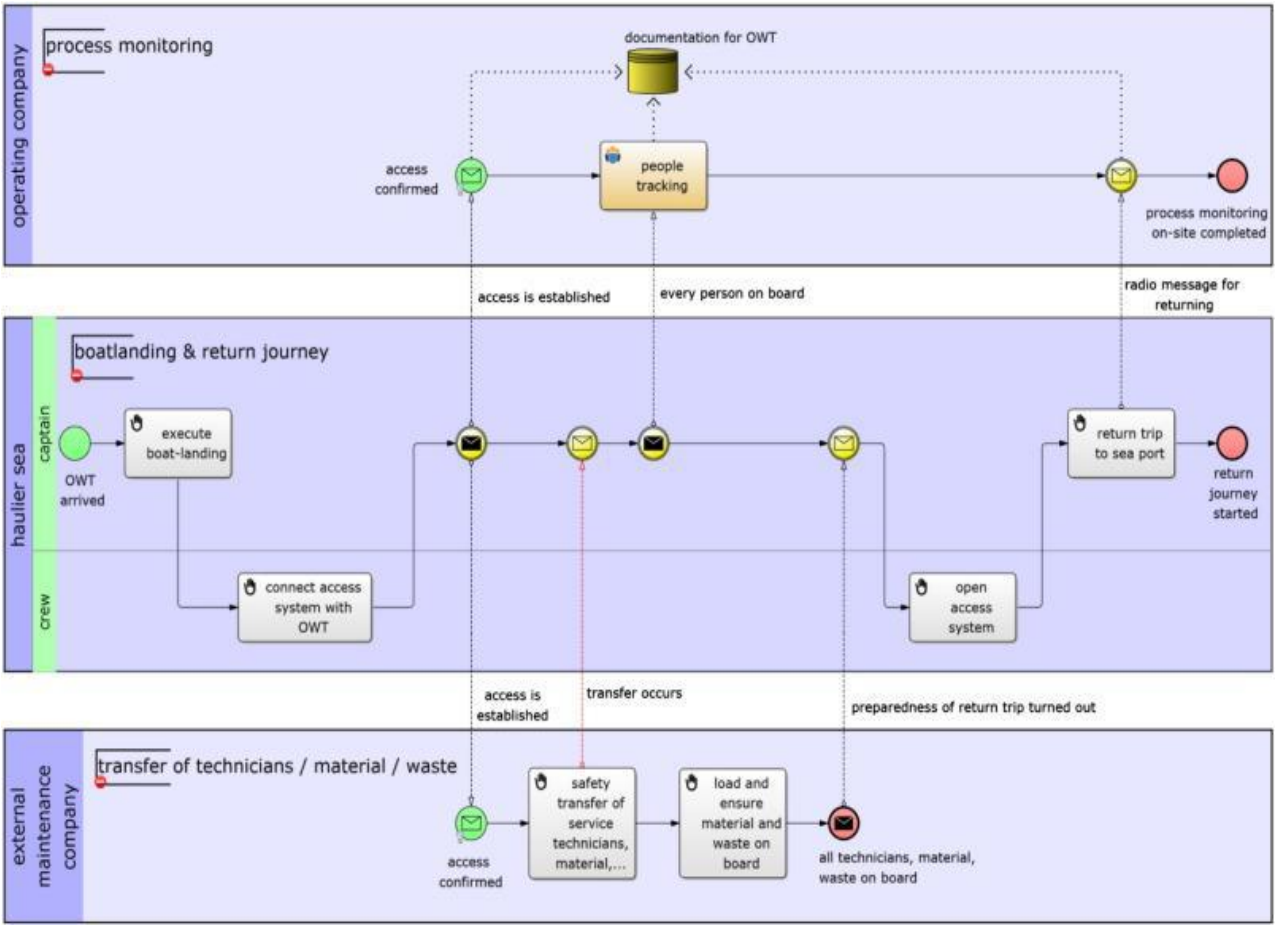

Fig. 4: Modeling of return journey process by personnel transfer vessel
Source: Joschko et al. (2015)

Strîmbei et al. (2016) provided a new view on corporate modeling in the context of BPMN and the university area. This study reveals a specific BPMN approach in the context of university information systems, based on a comparative analysis of some representative universities in the United States and Central Europe. The authors present 4 realistic and complex systems: curriculum and study programs, student admission, student routing, student exchange. Figure 5 shows BPMN modeling for the student exchange process.

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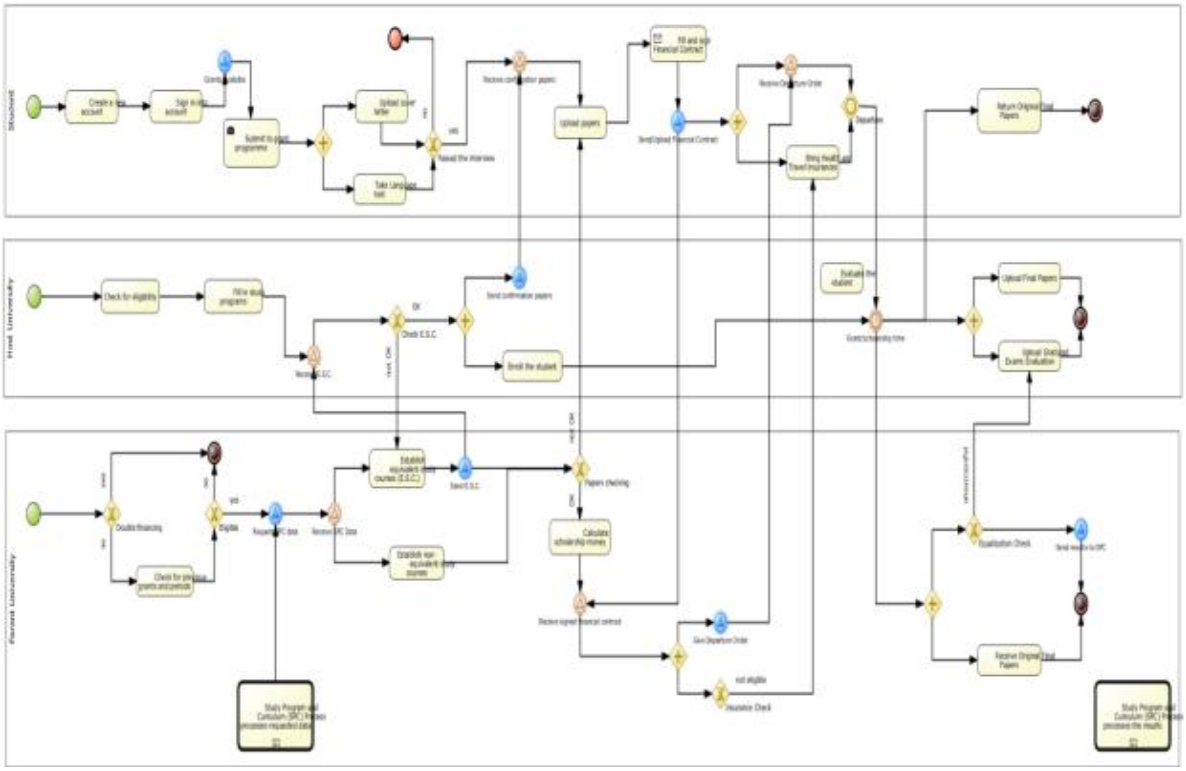

Fig. 5: BPMN modeling for the student exchange process
Source: Strîmbei et al. (2016)

4.2 Unified Modeling Language (UML)

According to Torres (2011), the UML arose from the union of three modeling methodologies: The Booch's method, the Object Modeling Technique method - Jacobson's OMT and the Object-Oriented Software Engineering method - Rumbaugh's.

This technique was developed with the purpose of being a graphical notation for the analysis, specification, construction and documentation of software development support. The main challenge in the development phase of this notation was to create a standardized language with a unique semantics to be able to represent systems of different levels of complexity (Geambasu, 2012). For Booch, Rumbaugh, and Jacobson (2006), the UML is sufficiently expressive to model non-software systems such as workflow, structure and behavior of hardware systems and projects. The success of this methodology has contributed to the adoption of UML models in several systems development initiatives, which include requirements approaches that use business process information often represented in adapted UML diagrams (Torres, 2011). Among the recent publications on the UML methodology, the works with applications in education (De Lope& Medina-Medina, 2016), health (Ferrante, Bonacina& Pinciroli, 2013), industry (Latif, Nadeem& Lee, 2011), services (Zheng, Feng & Zhao, 2014), e-commerce (Maman, Sugiarti & Kumaladewi, 2017), etc stand out.

Ferrante et al. (2013) performed the post-stroke rehabilitation process modeling. In healthcare organizations where rehabilitation procedures are provided for stroke patients, It becomes necessary greater detail in relation to the workflow. The proposed model, implemented in UML, is based on international guidelines and has been refined following the clinical pathway adopted locally by a specialized rehabilitation center. This model describes the organization of delivery of rehabilitation and facilitates the monitoring of recovery during the process. The flexibility of the model guarantees an easy update after the evolution of the process. Figure 6 discusses the class diagram of the rehabilitation process of the study in question.

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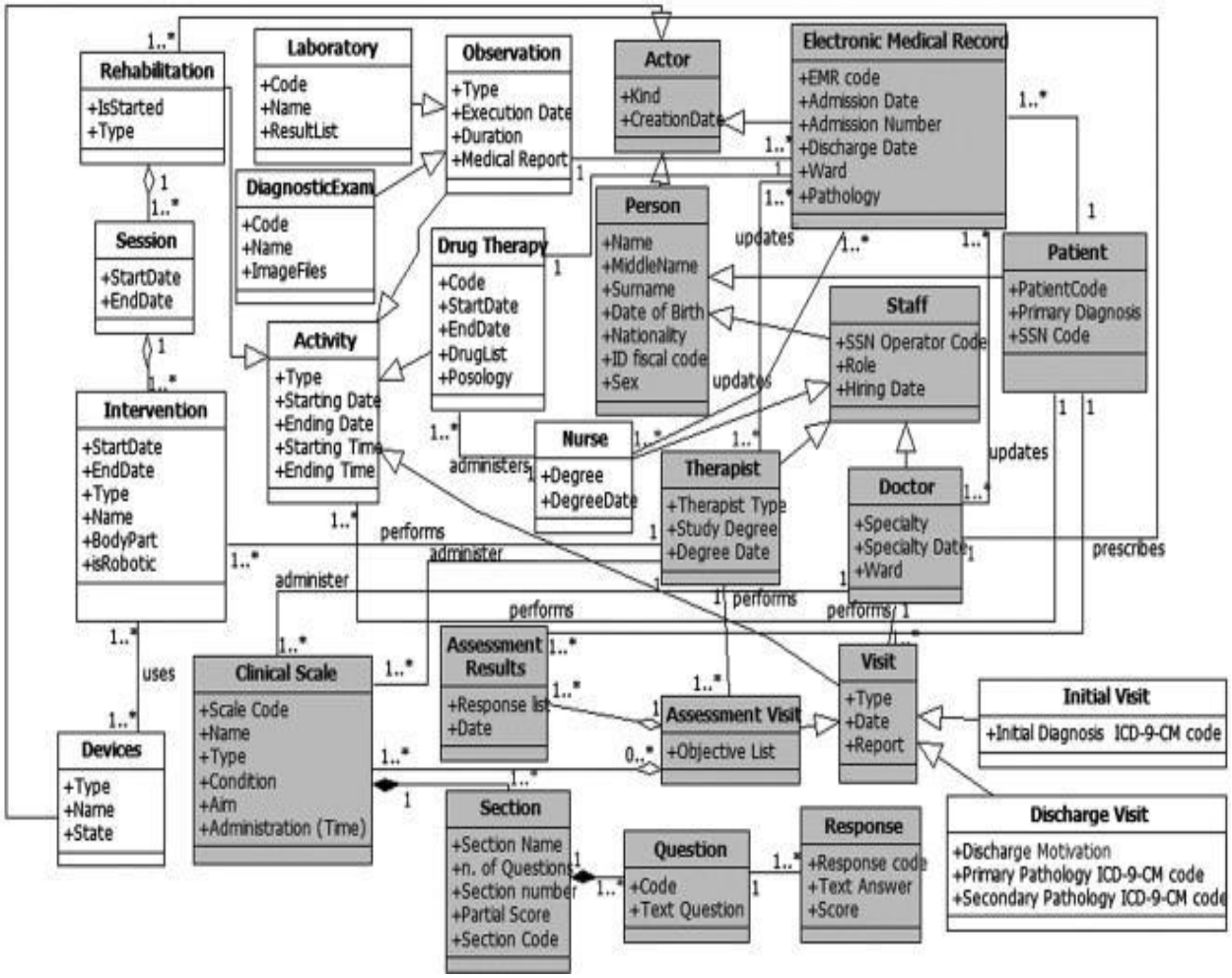

Fig. 6: Process modeling in UML - class diagram of the post-stroke rehabilitation process
Source: Ferrante et al. (2013)

Zheng et al. (2014) developed and designed a library management system based on the UML modeling mechanism to analyze a simple library management system. The authors state that UML can convey information among users, developers, designers and managers efficiently, which enhances their collaboration capabilities and increases the degree of industrialization in software development projects. The design process indicates that, as a software engineering modeling language, UML has a very good application perspective. Figure 7 discusses the UML design classes diagram of book lending management.

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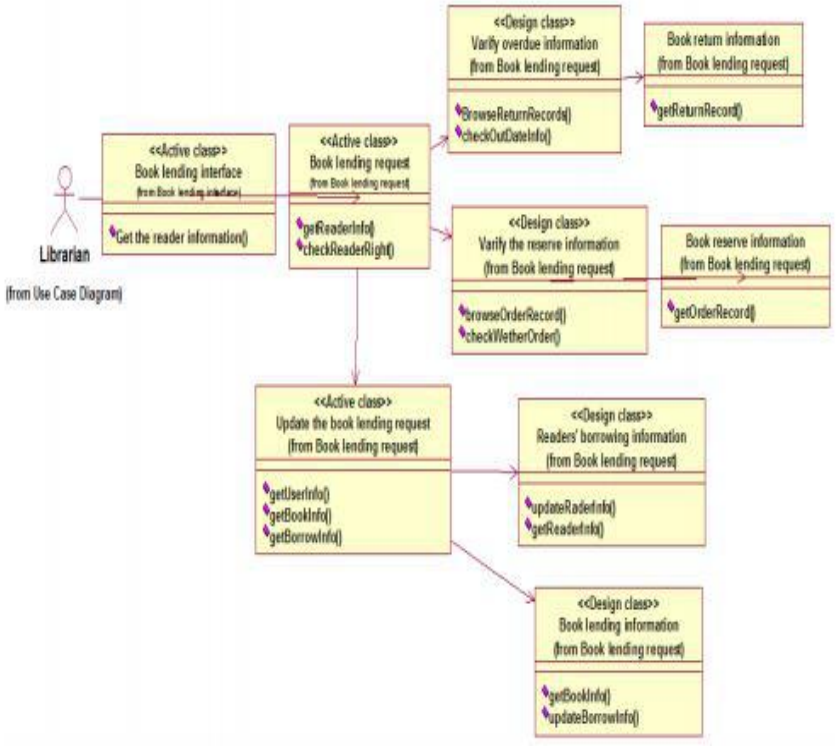

Fig. 7: Diagram of design classes for book lending management
Source: Zheng et al. (2014)

4.3 Event-driven Process Chain (EPC)

The EPC methodology is also one of the most widely used business process modeling languages worldwide (Devillers 2011). It is a notation that was developed in 1992 by researchers from the University of Saarland in partnership with SAP, one of the largest world powers in the production of integrated management software (Mili et al., 2010). Like most notations for process modeling, the EPC also resembles in its structure the flowcharts for representing logical and temporal dependencies between activities in the construction of business processes (Keletso, Chioasca & (Keletso, Chioasca & Zaho, 2014). The main focus of EPC notation is to provide users with a graphical representation of organizational processes in an intuitive way that is quick and easy to understand for both process analysts and business people (Van Wel, 2013). In addition, the EPC is the main language for the representation of business processes of the ARIS methodology (*Architecture of Integrated Information Systems*), which aggregates resources related to the business and organizes them to ensure the development of sequences of activities and tasks that produce value (Davis & Brabander, 2007). Pavani e Scucuglia (2011) consider the EPC a simple and easy to understand methodology, very similar to flowcharts. The authors point out that the basic difference is that the EPC uses the concepts of logical operators.

Among the works based on a literature review that use the EPC methodology, the publications with applicability in the following areas stand out: services (Giviani & Argourd, 2015), *supply chain*(Mohammadi & Mukhtar, 2012), education (Rostanski,2013), *marketing* (Fleacă, Fleacă & Maiduc, 2016), health (Zarabzadeh*et al*., 2012), among others.

Giviani and Argourd (2015) mapped the processes of the technical treatment division of the Integrated Library System of São Carlos, São Paulo, Brazil, from its acquisition to its availability to the user, who is responsible for receiving works, classification and indexing, tipping, availability in the collection and inventory of all bibliographic material of the libraries integrating the system. For this, the authors made use of business process modeling through the EPC methodology.

Figure 8 shows the macro processing detail of the library inventory activity.

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Fig. 8: Modeling of the macroprocess of library inventory activities
Source: Givianie Argourd (2015)

Fleacă, Fleacă and Maiduc (2016) applied the EPC methodology to model the variables of the marketing research process of an organization. The results highlight the benefits of the marketing research workflow that increases the value of market information while lowering the costs of obtaining it in a consistent manner. The authors also highlight the high impact on stakeholder satisfaction.

This work aimed to decipher modern trends in innovation and business process management as well as business process management and provide a useful diagram of marketing research process using the BPMN graphical vocabulary EPC tool (Figure 9).

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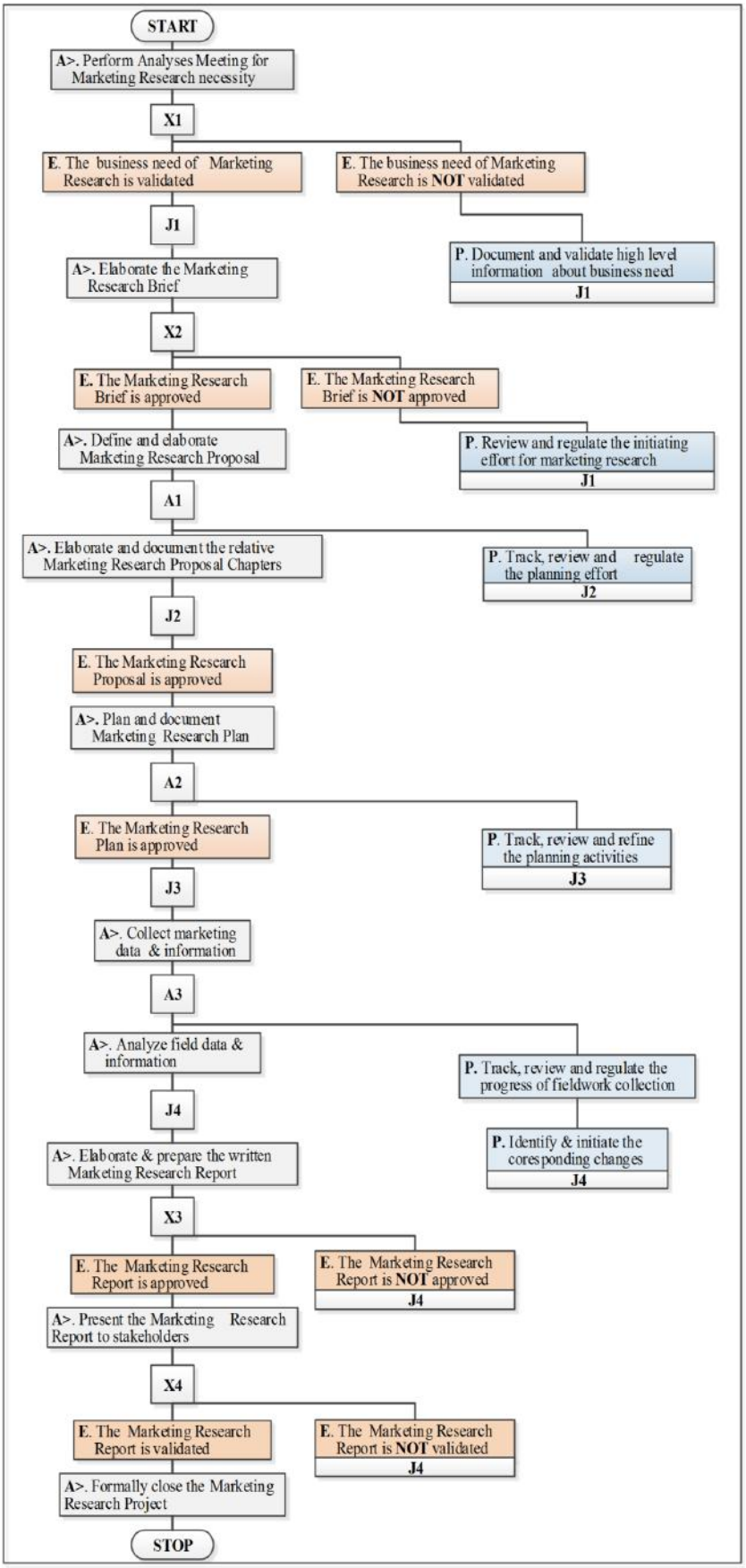

Fig. 9: EPC modeling of the BPMN graphic vocabulary - Diagram of the marketing research process
Source: Fleacă et al. (2016)

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4.4 Integration DEFinition (IDEF)

The IDEF technique originated from an initiative of the United States Department of Defense aiming at the creation of a method that would allow the modeling of requirements for systems. Its initial use was in the 70's, and later standardized by the National Institute of Standards and Technology. This methodology allows to analyze processes by means of the construction of models that reflect their current functionality to design the ideal situation of business operation (Almeida, 2009).

The IDEF methodology is composed by 16 techniques for the modeling and analysis of systems, initially designed to be used in the scope of Software Engineering. Each of these techniques is used in different fields of application, however the IDEF0, more directed to modeling business functions, and IDEF3, to concretely model business processes, are in fact the two most and that can be complemented in the modeling of processes, although each of them can also perform individually, in particular the IDEF3 (Costin & Fox 2004).

The IDEF0 technique is capable of representing a set of actions that are supported by ICOMs (Input Control Output Mechanism). ICOM is a graphical representation of one or more activities, which in addition to data and information is able to describe the various elements that are associated with a process (Mykolayczky & Júnior, 2001). The IDEF3 technique was developed specifically to describe the dynamic aspect of the business processes and with the objective of facilitating the survey and description of information systems (Miliet al., 2010).

Among the publications on the UML methodology, the works with applications in manufacturing, (Pınarbaşı, Sel, Alağaş & Yüzükirmizi, 2013), industrial, (Kuo, Hsu, Ku, Chen&Lin, 2013), *supply chain* (Kuo, Hsu, Huang&Gong, 2014), civil construction etc (Tas, Yaman&Tanacan, 2008) are highlighted.

Pınarbaşı et al. (2013) studied flexible manufacturing systems (FMS). The authors proposed an FMS design approach using the IDEF methodology. A systematic layout scheme and a performance evaluation scheme are presented and detailed using this modeling framework. Next, the proposed approach was carried out with a case study of an aeronautical industry to convert an existing traditional production system into FMS. The objective was to find the machine and the mix of products that reach the maximum use, minimizing the cycle time. From the IDEF model, it was observed that the performance of the FMS system was greatly improved when determining the most advantageous level of the system components. Figure 10 shows the IDEF context diagram layout design and performance evaluation.

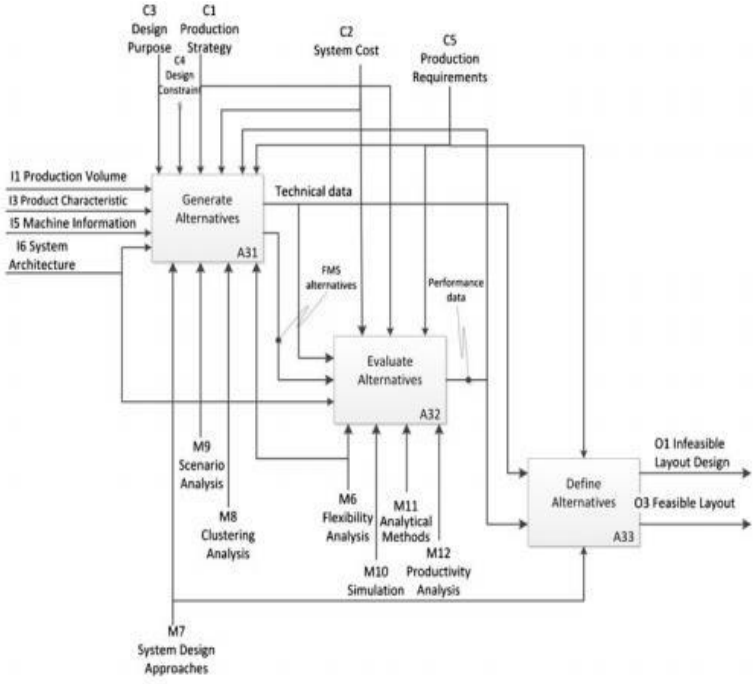

Fig. 10: Modeling in IDEF: Context diagram layout design and performance evaluation
Source: Pinarbaşi et al. (2013)

Ciuriana, Garcia-RomeuaI, Ferrerb and Casadesús (2008) developed a model that can be applied later to the development of an integrated planning and programming tool using an IDEF methodology to design an activity model that integrates process planning and production in metal removal processes.

An activity model was used to develop a system that allows the user to plan the process and the production at

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the same time in collaborative engineering work. To design the activity model, a wide variety of parts were evaluated and processed in a real workshop factory. Several activities have been developed in detail to be tested in real cases.

Figure 11 shows the level of process planning in the IDEF model.

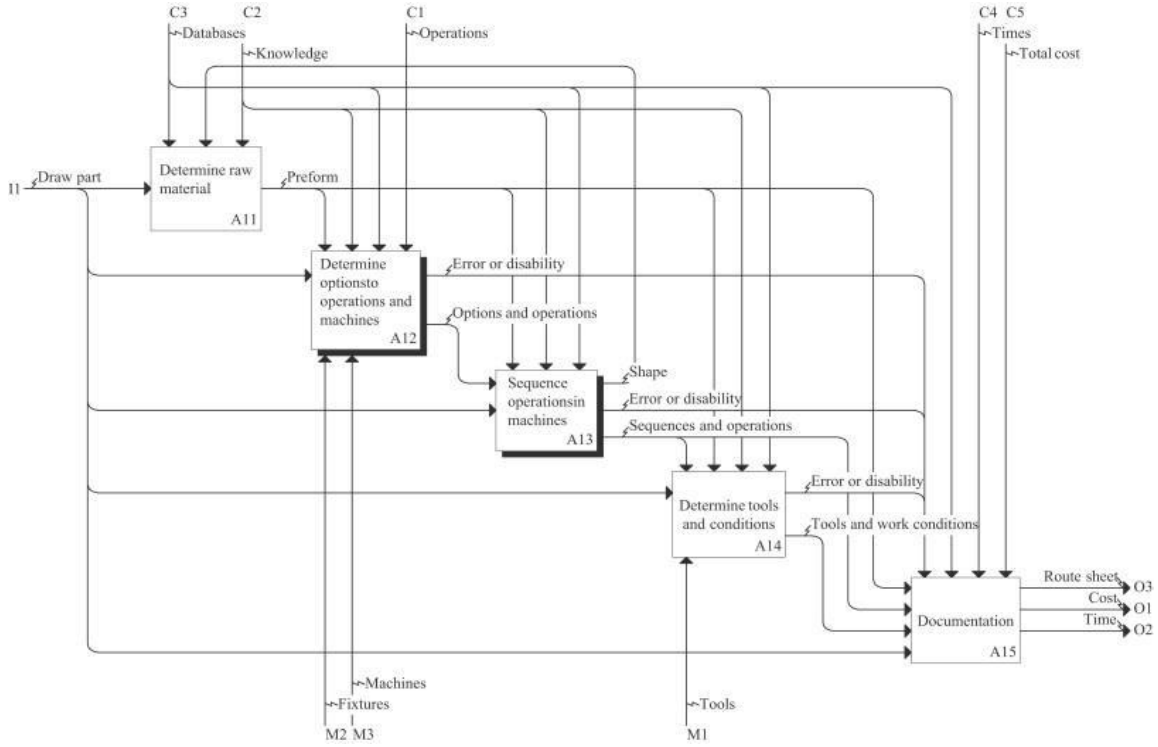

Fig. 11: Process planning level in the IDEF model
Source: Ciuriana et al. (2008)

In the next section, a comparative analysis of the main methodologies of business process modeling raised in this paper- BPMN, UML, EPC and IDEF - is approached, based on the study done by Silva (2015).

V. COMPARATIVE ANALYSIS OF METHODOLOGIES

The business process modeling methodologies succinctly presented in the previous sections have different characteristics, strong points and limitations.Therefore, it is important to find a means of comparing them in order to systematize their differences and similarities. For this purpose, a broad review of the relevant literature was carried out, which deals with the characterization of business process modeling methodologies. Different authors use different criteria to evaluate methodologies of process modeling, although some criteria tend to be more or less universal (Silva, 2015), which are:

- **Expressivity**: it tries to evaluate the language as to its capacity of representation, being for this reason a criterion specially focused on the elements of each notation in order to verify if these elements serve all the purposes and needs of the most varied models, from the simplest to the more complex;
- **Formalism:** associated with the existence of a description and formal definition of each notation. That is, whether or not each notation has a formal definition of all its elements, as well as clear rules on the use of each one;
- **Usability:** aims to measure how difficult it is to understand and use process modeling notation for both analysts and modelers. It is a criterion that promotes the evaluation of the ease of use of the notations**;**
- **Amiability:** this criterion is concerned with the importance of the graphic aspect of the notation used, that is, one should look for a notation that is not very complex in relation to the elements and relations between them**;**
- **Legibility:** it is understood as the ease of interpreting processes by all stakeholders, such as business analysts, technical and non-technical modelers of these processes, as well as the organization's own management**;**

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- **Flexibility:** the presence of graphical elements that allow a high level of flexibility and give several modeling alternatives is a privileged factor for some modelers;
- **Support Tools:** verifies that the chosen language has a variety of solutions to support its implementation;
- **Universality**: in choosing a particular process modeling notation, it analyzes whether the notation is sufficiently recognized in a comprehensive universe, presuming some benefits such as greater support from a community of active use or greater proximity to the user and the developer;
- **Purpose:** In a study of the choice of modeling notation to adopt, it is very important to understand what is intended to be done with the final models, it is necessary for the language to allow the automation and execution of the processes or only to perform analyzes and manipulations on the processes, for example.

Based on systematic analytical studies by authors of the reading of the specialty of business process modeling, Silva (2015) listed such works in each of the comparative criteria mentioned above, in order to highlight the characterization of business process modeling methodologies. Figure 12 shows an adapted version of Silva (2015) of the characteristics of each one of the methodologies raised in this study.

Criterion	BPMN	UML	EPC	IDEF
Expressivity	x	x	x	x
Formalism	x	x	x	x
Usability	x	x	x	x
Amiability	x			
Legibility	x	x	x	x
Flexibility	x			
Support Tools	x	x	x	
Universality	x	x	x	
Purpose	x	x	x	x

Fig. 12: Evaluation criteria of business process modeling methodologies.
Source: Elaborated by the author (2019)

Based on the study of systematization of the analysis of the comparative criteria mentioned, performed by Silva (2015) in the specific literature, the criterion of "Expressivity of languages" is the one that has received the most attention by the authors. In this way, it is verified that the capacities of the methodologies raised allow to represent the most diverse organizational situations, whether in behavioral, functional, structural or informational terms.

The criteria "Formalism", "Usability", "Readability" and "Purpose" were also related to the functionalities of the four methodologies raised in this study.

The criteria "Formalism", "Usability", "Readability" and "Purpose" were also related to the functionalities of the four methodologies raised in this study.

The BPMN stood out as the only methodology to present the criteria "Friendliness" and "Flexibility". Thus, it is observed that such methodology presents a graphically pleasant notation that can help the work of the users, facilitating the identification of the desired and necessary elements to face the expected result for the final model; and allows a high level of flexibility and offers various modeling alternatives for users.

Finally, it should be noted that the BPMN, UML and EPC methodologies present the criteria "Supporting tools" and "Universality", according to the literature (Silva, 2015) on business process modeling methodologies. Thus these three notations present a multiplicity of solutions to support their implementation and have several widely used software packages that allow the business process analyst to have a professional tool and tested by the most varied organizations; and are also sufficiently recognized in the business community, academic and in terms of market disclosure.

VI. FINAL CONSIDERATIONS

The main objective of this paper was to present, based on theoretical references, a review regarding the main methodologies of business process modeling, from the systematic bibliographic survey in this area of study and the discussion of the comparative analysis of such methodologies.

It is worth highlighting that the use of a process modeling methodology for the documentation of business processes has many advantages, generally related to techniques and standards, created exclusively to support business process design and aimed at optimizing the modeling task processes. For a better performance in this area of process modeling it was clear that the use of a specific methodology for this purpose is crucial.

Thus, according to bibliometric research, BPMN, UML, EPC and IDEF are highlighted as the most portrayed business process modeling methodologies in the papers surveyed: Among the articles in the Scopus database, it was verified that BPMN stands out for being

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present in most of these published works, and these results are corroborated by Kocbek et al. (2015), which point out that BPMN is the default language in the process modeling field. Unlike other techniques, BPMN is a standard developed to offer a notation more easily understood and used by all involved in the business processes, besides being a comprehensive technique and offering resources for modeling the most varied types of processes, from the most generic to the most specific.

Through a selection of the most important modeling methodologies in this area, it was possible to verify, from examples of analyzed applications, that, although they share the same objective, each methodology has its specific characteristics. Thus, a comparative analysis of business process modeling methodologies proposed by Silva (2015) was presented, based on a comprehensive review of the relevant literature that deals with the characterization of methodologies, based on the selection of different criteria of evaluation.

Finally, it is concluded that the main purpose in the construction of a consistent overview that, before a given organizational context or BPM project, allows the comparative analysis of methodologies of process modeling, in order to select the one that best suits its specificities. This solution will allow a more informed selection of the notation to serve certain designs by the project team without the need to carry out a large study of the various existing languages. In this way, it is enough to indicate among the several criteria identified, those that seem to be more important to the project or organizational context, attributing them the corresponding valorization. Additionally, these results are configured as a theoretical reference for application in papers, dissertations and theses.

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