Understanding Process Models Using the Eye-Tracking: a systematic mapping

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**Abstract.** The use of business process models in requirements elicitation is a common practice. Business process modeling can involve multiple stakeholders, so it is natural that problems may occur in building and understanding business process models. One way to perceive these problems is to evaluate the comprehension of these models through the collection of data related to the readers' awareness with an eye-tracking device. This device allows collecting data of specific facial reactions of the people, such as the movement of the eyes and dilation of the pupils and the number of blinks in a specified time interval. The objective of this paper is to provide an overview of researches that evaluate the understanding of process models through eye-tracking techniques. A systematic mapping study was developed to achieve this goal, following the best practices in the area of Software Engineering. This study consolidated 16 papers for the analysis and extraction of data from the 1,161 studies initially found in the last ten years.

**Keywords:** Business Process Modeling, Understandability, Comprehension, Eye-Tracking, Evaluation, Systematic Mapping Study.

1. Introduction

Establishing efficient processes is the goal that all companies must pursue [1]. In this view, business processes are a set of activities, well determined, coordinated in time and space to achieve goals and organizational objectives [2]. Besides, we can represent them in models or diagrams composed of visual components [3]. These models are used as an instrument to facilitate the understanding or even to identify points of improvement in an organization [4]. In this perspective, business process models are essential so that the organizations keep control of their flows of activities.

Also, business processes help in specifying the requirements and design of information systems, representing all the data flow of processes. Thus, the path taken by many organizations to produce quality information systems has been to invest in the improvement of business process models. Therefore, processes are expected to result in quality information systems [5]. Studies show that the growth of the models both increases the quality of the information systems produced and the productivity of this development [6, 7,8].

Recent and more innovative researches analyze how these models are explained and perceived by their stakeholders [9, 10]. In this sense, users understand models differently, resulting in different abstractions [11]. Contrary to this statement, in [12], the authors state that one of the main objectives of a process model is to facilitate communication between stakeholders. However, according to these authors, little is known about the factors that influence the understanding of a process model by human agents. That is, despite the research already done in this field, there are still open questions about the perception of process models. Cognitive neuroscience and psychology, in turn, can provide valuable information about this field.

There are several alternatives to evaluate the understanding of business process models. These include experimenting with the collection of data, sometimes with the use of biometric sensors, on the performance of designers and other stakeholders in a given modeling task to know their level of understanding and preference about the use of a modeling artifact to the detriment of another. Biometric sensors have been explored in recent years as data collection devices become more accessible. One of the technologies that have deserved particular attention is eye-tracking.

Thus, based on these pillars (business process, comprehension, and eye-tracking), the purpose of this article is to present a mapping of the first studies in the specialized literature, classifying them concerning the information presented in them. That is, to give an overview of the literature regarding the mediation of terms: business processes, comprehension, and eye-tracking. This article will provide an adequate position for new research activities in this area. However, it is not the purpose of this article to present a comparison between the studies identified here.

The remainder of this paper is organized as follows. Section 2 gives an overview of introductory concepts. Section 3 the method used in this study is described with the description of the planning phase and the research questions addressed by this study. Section 4 describes its execution, presenting the selected reviews, the classification scheme adopted and reports the findings. Finally, Section 5 discusses related work, and Section 6 concludes this paper and summarizes directions for further action.

1. Background
   1. Business Process Modeling

Business process modeling is an interdisciplinary area that has adopted a variety of paradigms and methodologies of different contexts, such as organizational management theory, computer science, mathematics, linguistics, semiotics, and philosophy [13]. The purpose of business process modeling is to build Business Process Diagrams (BPD), which are technical drawings that translate abstract representations of processes [14].

Since the introduction of flowcharts in the 1920s [15] several notations have been developed to represent BPD. In [16] these notations are classified into two categories:

* semiformal: languages that share concerns with comprehensibility and are amenable to various informal or heuristic analyzes, e.g., BPMN [17], UML ActivityDiagram [18], and Event-DrivenProcess Chain (EPC) [19];
* formal/executable: languages that syntax and semantics are precisely defined) and/or executables (Eg, Business process execution language (BPEL) [20], Petri Nets [21], yet another Workflow Language (YAWL) [22], andSubject- OrientedBusiness Process Management (S-BPM) [23].

But regardless of the notation used for a process model, its understanding by all its stakeholders is of paramount importance to organizations. The next section presents some concepts about understanding.

* 1. Understanding

In [24], understanding is a criterion that helps to measure whether the information contained in a model can be understood (or understood) by all stakeholders. The authors also point out that understanding is one of the criteria used to evaluate the quality of a model. This definition implies that the opinion can be investigated from two central angles: personal factors, related to the reader of the model and the factors that relate to the model itself. In corroborating this definition, in [25], the authors emphasize that the understanding of a process model is a function related to the characteristics of the model and to the users who will interpret the model. For these authors, the understanding of the models by the stakeholders is a prerequisite for several tasks related to the model, such as communication, design, organizational reengineering, project management, end-user queries etc. As presented in [26], a stakeholder understands a process model when it can explain the model. In other words, there is an understanding of a model when the user can explain its structure, its behavior and its effects on a particular context.

* 1. Eye-Tracking

Eye-tracking is a mechanism for collecting cognitive data from its users. This mechanism is used to conduct empirical studies and to study understanding models [27], to realize what can be improved to facilitate, e.g., the interaction of systems their users. The systems that use this technology are based on theories of the human physiological system, such as the theory of visual perception, and cognitive theories, such as visual attention theory [28]. Thus, such technology allows analyzing user performance in reading and interpreting business process models.

This technology is used for research in several areas of human knowledge, especially in the areas of medicine, cognitive psychology, management and marketing, aeronautics, industrial design, among others. Specifically, in the context of model usability, there has been increasing interest in the application of this technology to empirical studies [29]. Researchers try to understand what cognitive processes underlie the various activities of a business designer, for example.

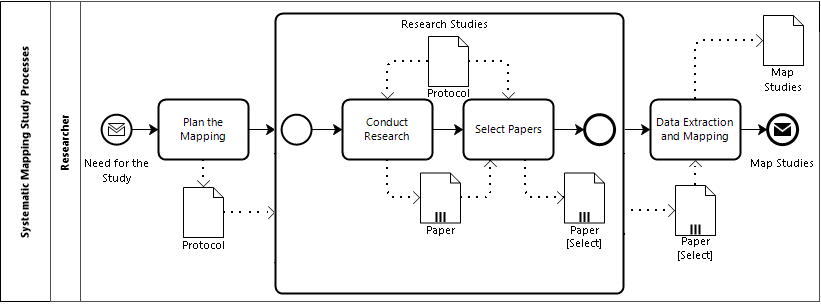
* 1. Systematic Mapping Study

Systematic mapping study (also referred to as scoping study) is an extensive review of primary studies in a specific subject area that aims to identify what evidence is available on a particular topic [30]. That is, a mapping study should review a broader issue, classifying the main research works in that domain. In this context, the research questions for this study are of higher levels [31, 32]. Thus, mapping study may be of great importance to researchers by providing an overview of the research topic. Although, with different results, when compared with systematic literature reviews (SLR), they may contain overlapping in their methods [33]. However, there is a significant difference. Conventional SLR seeks to aggregate primary studies in terms of the research results, verifying whether these results are consistent or contradictory. On the other hand, a systematic mapping study usually only aims to classify the relevant studies by categorizing them concerning the previously defined categories. These categories are typically based on publication information (authors 'names, authors' affiliations, source of publication, type of paper, date of publication etc.) and/or information about the search methods used. Thus, it is not the scope of systematic mapping studies to explicitly aggregate the results of the primary studies.

1. Method

In [34] the authors describe the process that was used as a starting point for our work. However, we blend the ideas presented in [34] with the right practices defined for the SLR in [30]. In this way, we apply a systematic mapping process, including some good practices used in SLRs. An example of this is the use of a search protocol. This artifact defined a plan, which established the necessary mapping procedures presented here.

Other activities of the process, as proposed in [34], were also altered and/or rearranged in this study. As can be observed in Fig. 1, the process was divided into three main activities: (A) "Plan the Mapping", whose objective is to identify the need for the review, defining the research protocol that will be used to conduct the mapping ; (B) "research studies", which aims to collect the studies (conduct research) to select the primary studies (SelectPapers), applying the inclusion and exclusion criteria; (C) "Data Extraction and Mapping", which aims to format and communicate the results.



**Fig. 1** Typical Systematic Mapping Study Processes[[1]](#footnote-1) adapted from [32].

* 1. Plan The Mapping

The "Planthe Mapping" activity aims to generate the protocol that must be composed of the following: research questions, research sources, search strings and the inclusion and exclusion criteria of the studies. These artifacts are detailed below.

On the research question, it needs to be broad enough to include all relevant studies but still focused enough to be active and selective in the size of the search space. According to [35], it is useful to consider the PICOC method, first proposed in the medical field [36]. The PICOC is an acronym constructed from five elements: population (referring to "who?"); intervention (referring to "what or how?"); comparison ("compared to what?"); outcomes ("what are you trying to achieve? or improve?"); and context ("what kind of organization or circumstances?"). In our study, the population referred to the use of eye-tracking in the analysis of the understanding of process models. Intervention refers to the use of eye-tracking in the analysis of understanding. In our case, we are looking for the opportunity to create a catalog on the use of eye-tracking in the study of process understanding, useful for those who want to measure their knowledge of their processes. The comparison did not apply to our mapping because we are interested in collecting the information to build a catalog. The results relate the factors of interest to the professionals, such as the metrics used to analyze the understanding, the notations used to map the processes, when and where the studies were published and which researchers are used eye-tracking in the analysis of the knowledge of the process models. For our case, the result we are looking for is the catalog with this information. Finally, the context is the organization or scope in which the use of eye-tracking occurred.

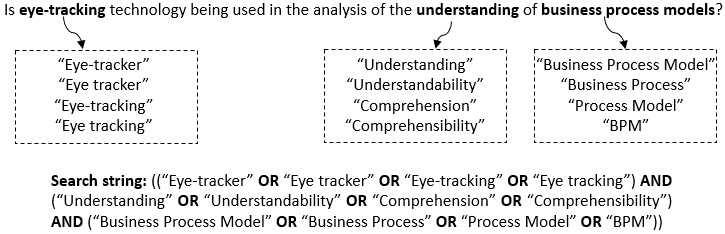
After considering the PICOC method, we move on to the definition of the research questions. ATable1 presents these questions.

**Table1.** Search Questions.

|  |  |
| --- | --- |
| ID | Search Questions |
| RQ1  (Principal) | Is eye-tracking technology being used in the analysis of the understanding of business process models? |
| RQ2 | What metrics are used to measure the visual comprehension of eye-tracking business process models? |
| RQ3 | Which business process model notations are evaluated in the studies? |
| RQ4 | What contributions have been reported about the application of the eye-tracker device to evaluate the understanding of the process models? |
| RQ5 | When and where have the studies been published? |
| RQ6 | How many researchers are using the eye tracking device to evaluate understanding in process models? |

Regarding the bases of the research, we chose to use digital databases, where the results are collected through a search query execution. The research bases selected for this study were: ACM[[2]](#footnote-2), Engineering Village[[3]](#footnote-3), IEEExplore[[4]](#footnote-4), Scopus[[5]](#footnote-5), Springer Link[[6]](#footnote-6), Web of Science[[7]](#footnote-7), and Science Direct (Elsevier)[[8]](#footnote-8).

Over the investigation period, no date restriction was applied because we did not want to risk ignoring useful information that would limit the value of our findings and, after all, we would like to know that it was the first publication using eye-tracking in the analysis of the understanding of the process models. After laying the foundations, we move on to the next step: identification of keywords. In this mapping, the keywords were extracted from RQ1. Figure 2 illustrates the keywords used in the queries, already grouped with the Boolean operators in the search string.



**Fig. 2.**Search string construction based on Silva *et. al.* [37].

It is interesting to emphasize the search on all bases. The resulting number of studies can be reviewed through a set of inclusion and exclusion criteria, which aim to increase the quality of the resulting studies. Table 2 shows our criteria, with some more general that can be applied in any other study.

**Table2.** Inclusion and Exclusion Criteria.

|  |  |
| --- | --- |
| Criteria | Detail |
| I1 (inclusion) | Articles that address in the title and/or abstract the use of eye-tracking technology in the analysis of the understanding of process models. |
| I2 (inclusion) | Paper's keywords are among our keywords. |
| E1 (exclusion) | Duplicated papers. |
| E2 (exclusion) | Papers that did not apply to research questions. |
| E3 (exclusion) | Paperswithunavailableaccess. |
| E4 (exclusion) | Papers written in other than English language. |
| E5 (exclusion) | Papers with only abstract available; extended abstracts or short paper (less than six pages). |

* 1. Research Studies

This subprocess consists of two activities: conduct research and Select Papers. The conduct research activity, which is responsible for performing the searches in digital libraries, required some specific settings during each search in the databases. Here it is worth noting that the databases used have characteristics and limitations themselves and that their search engines work in different ways. Thus, the resulting strand (Fig. 2) was adapted to rotate appropriately in each of the bases. For example, it was considered whether the database accepts a search with plural terms or whether they should be added to the string or whether the database allows searches to be performed considering only parts of the text or whether searches are always performed considering the full text. research are presented in Table 3, for our mapping.

**Table 3.** Summary of search in databases.

|  |  |  |
| --- | --- | --- |
| Database | Findings | |
| ACM | [75](https://dl.acm) |
| Engineering Village | 15 |
| IEEE | [0](https://ieeexplore.ieee.org) |
| Scopus | 23 |
| Springer Link | 636 |
| Web of Science | 8 |
| Science Direct | 404 |
| TOTAL | 1,161 |

In the Select Papers activity, the studies were analyzed in two stages: initial selection and final selection. In the initial range, the inclusion and exclusion criteria were applied in all the studies identified, through the evaluation of titles, keywords, and abstracts. However, in some cases, it was difficult to determine whether or not the research was relevant only by reading those data. Thus, whenever there was any doubt about the inclusion or not of a particular study, the recommendation adopted - at this stage - was by its inclusion, being the decision for the stay postponed to final selection. In this initial selection, 1,158 studies were excluded, 30 of which duplicated. Based on this selection of 27 included primary studies, the final selection was made.

During the final selection, the inclusion and exclusion criteria were applied again in the studies included in the first stage, through the evaluation of their complete texts. This new evaluation resulted in 16 primary studies that fully met all the criteria and will be able to contribute results for this work.

After each of the two selection stages, initial and final, a review was performed. This review was conducted to increase the reliability and transparency of the selection process, to avoid the exclusion of relevant studies. It should be noted here that the selection stages were performed by two researchers (the first two authors) independently since studies can be classified differently.

In this case, the two researchers evaluate all the studies independently and compare the results. Conflict cases were presented to another researcher (the third author) who sought consensus among the first two researchers.

1. Data Extractionand Mapping

This section provides an overview of the extracted data, consolidating the results. To facilitate data consolidation, each of the 16 primary studies received a unique identifier in the data extraction form, listed in Appendix A.

* 1. RQ1- Is eye-tracking technology being used in the analysis[[9]](#footnote-9) of the under-standing of business process models?

All the studies found used the eye-tracking device to verify comprehension in business process models, each study using the device to evaluate different topics in the understanding of the models. Table 4 presents the categorization of studies by these topics. Studies A6 and A11 use the eye tracking device to evaluate different business process modeling notations to determine which is best understood. Studies A1 and A13 assess the understanding of structures or specific elements of notation. The remaining studies evaluate how different readers understand business process models in a particular notation.

**Table4.**Studies classification.

|  |  |
| --- | --- |
| Topics | Studies |
| Comparison between notation | A6 and A11 |
| Complementary elements in models | A1 and A13 |
| Evaluation of models | A2, A4, A5, A7, A8, A9, A10, A12, A14, A15, A16 |

* 1. RQ2 - What metrics are used to measure the visual comprehension of eye-tracking business process models?

Table 5 presents the key metrics used to evaluate the understanding of business process models. The eye fixation metric, which consists of the visual attention time of the participant in an area of interest while performing a task [38], is used in most (75%) of the mapped studies. Then, three metrics were used in 37.5% of the reviews. The saccade, which consists of the swift movement that occurs between fixations, has a duration of about 40 to 50 milliseconds [38]. The scan path consists of the way formed by the balconies, in chronological order, between sets of fixations. In turn, the duration represents the time the participant takes to complete a task [39].

Apupillometry, which consists of measuring pupillary dilatation, is considered an indication of excitation by the participant to a visual stimulus, was present in 2 (12.5%) of the studies. Finally, 18.7% of the mapped reviews use questionnaires with questions about the domain of business process models, and according to the number of correct answers, the participant understands the business process models.

**Table5.**Evaluation metrics.

|  |  |
| --- | --- |
| Evaluationmetric | Studies |
| Eyefixation | A1, A2, A3, A4, A5, A6, A8, A9, A10, A11, A12 and A16 |
| Saccade | A1, A4, A5, A6, A10 and A11 |
| Scan path | A4, A5, A6, A9, A11 and A12 |
| Duration | A4, A3, A6, A9, A12and A16 |
| Pupillometry | A8 and A14 |
| Comprehensionquestions | A6, A12 and A16 |

* 1. RQ3 - What business process model notations are evaluated in the studies?

As can be seen in the Table6a majority, 13 studies evaluate the understanding of business process models in BPMN notation [17]. Study A6 does a comparative with the understanding between models in BPM notation [17] and EPC [19]. In this same sense, the work A11 performs the comparison between the understanding of the models in the notations BPMN [17], EPC [19], Petri Net [21] and eGantt [40]. Finally, study A2 uses the DCR notation to evaluate the understanding of business process models; And studies A10 and A12 did not specify the notation used in the respective studies.

**Table6.** Notations assessed by the studies.

|  |  |
| --- | --- |
| Notation | Paper |
| BPMN | A1, A3, A4, A5, A6, A7, A8, A9, A11, A12, A14, A15 and A16 |
| DCR | A2 |
| EPC | A6 and A11 |
| Petri Net | A11 |
| eGantt | A11 |
| Notspecified | A10 and A12 |

* 1. RQ4 - What contributions have been reported about the application of the eye-tracker device to evaluate the understanding of process models?

The selected studies present results that show that the application of the eye-tracking device can offer essential contributions to the understanding of the process models. Table 7 presents the contributions of the selected studies.

**Table7.**Studies Contributions.

|  |  |
| --- | --- |
| ID | Title |
| A1 | The process models with linked rules are associated with a lower cognitive load, shorter comprehension time and higher accuracy comprehension. |
| A2 | The evaluation of the data allowed the study to classify three distinct reading profiles (Graph, Simulation, and Law text) of process models. |
| A3 | The results suggest that successful error diagnoses are linked to shorter total viewing time and shorter fixation duration, with a significant difference between semantic and syntactic errors. |
| A4 | He identified that both samples of participants, beginners, and experts, have similar strategies to understand a process model in the first iteration. However, they argue that specialists understand process models more efficiently; that is, exploration paths reflect fewer fixations and balances. |
| A5 | It is a work in progress, appearing only the strategy of how a future experiment will run. In the pilot experiment, the visual behavior of 10 participants was analyzed to confirm the theory of the existence of different BPD reading strategies. |
| A6 | The performance of participants decreases as the level of difficulty increases. However, regardless of their level of expertise, all individuals have similar standards when faced with process models that exceed a certain level of difficulty. Participants' overall performance demonstrates a better understanding of business process models in EPC notation compared to the BPMN. |
| A7 | The understanding of the model decreases with the increasing number of nesting and with the size of the model. They point out that the enthusiasm of the reader of the process model disappears with the rising complexity of the model. |
| A8 | It is a work in progress, presenting only a description of the experiment that investigates how designers experience challenges by measuring the cognitive load. The authors did not put anything in terms of outcome. |
| A9 | There is no influence between the reader's familiarity with business mastery and the proper understanding of the model. They point out that a Visual Cognition Efficiency (measured by Scan Path Precision and Recall) and Visual Cognition Intensity (measured by Total Fixtures and Total Fixture Length) better explain the comprehension performance (higher efficiency, shorter duration) than a model of personal knowledge and model complexity. For them, higher levels of specialization in business process modeling and lower complexity of the model lead to better cognitive efficiency. |
| A10 | The authors pointed out that participants took longer to understand parts of the gateway models, especially XOR and loops. |
| A11 | Participants faced difficulties in understanding the models as complexity increases, even with the participant knowing the model scenario. Among the modeling languages, only the eGantts notation obtained a higher level of accuracy as the level of difficulty of the models increased. Regardless of the experience, a subject has with process modeling generally in the first iteration of understanding all follow the same analysis of the model. During the experiments, they found that process models with an explicit start and a final symbol make it easier to understand the process model. |
| A12 | The results indicate that intermediate readers tend to be more effective in terms of understanding the process model compared to beginners. As the level of difficulty increases, the time is taken to understand the process model increases as well. Concerning the less complicated process model, it seems that the newcomers show a weaker performance compared to the intermediaries. In turn, the performance of novices is approaching the same level as that of the intermediaries with an increased level of difficulty. In general, they seem that the BPMN process models can be intuitively understood. |
| A13 | The performance in the understanding of the models was better with the collaborative model than the individual and the layout change of the BPMN models proposed by the experiment. |
| A14 | For a modeler, an increase in the cognitive load was observed whenever it is necessary to name activities of the process model from the text information. |
| A15 | The elements of the area of interest are fixed for longer than other elements of the model by the subjects who provided the correct answer to the question of understanding. More elements of the area of interest are set than other elements of the model by issues who provided the correct answer to the question of understanding. |
| A16 | It can be observed that the average durations are smaller for the fixations in the task description compared to the fixations in the process model. The perceived lower complexity, in turn, allows the modelers to consider additional features of the model, such as secondary notation of the process model from the outset. It is noticeable that when the average length of fixings is increased by about 30%, the participants are facing a challenging part of the model. |

Among the main contributions of the studies we observed that the studies A6, A11 and A12 emphasize that the size and complexity of the model influence the understanding of the models. On the other hand, studies A7 and A10 affirm that complex structures like loops and nestings diminish the understanding of process models. It was also observed that studies A6 and A11 that independently of the level of knowledge, all individuals have similar patterns when faced with process models that exceed a certain level of difficulty. In studies A1 and A13, the addition of complementary elements in the models facilitated the understanding of the participants. Only studies A8 and A14 evaluate the understanding of process models from the perspective of the designer, and the other studies estimate the understanding from the standpoint of model readers.

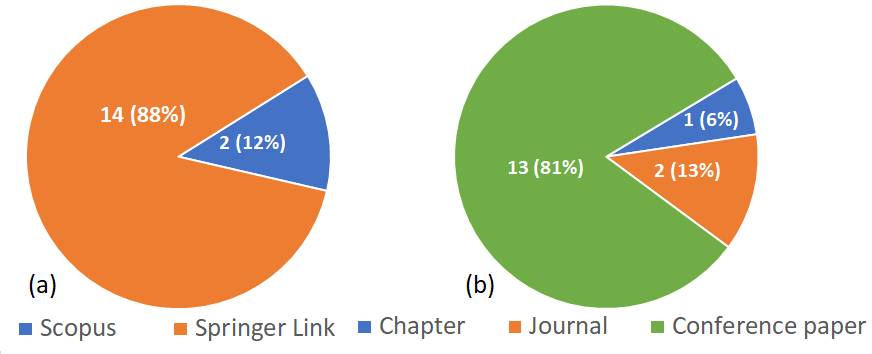
* 1. RQ5 - When and where have the studies been published?

Fig. 3 shows the distribution of the studies considering the year of its publication. The first mapped study is A16 of the year 2012. There is a concentration of publications in the last three years, with the year 2017 the highest incidence of papers.

**Fig. 3.**Distribution of studies per year.

As can be seen in Fig. 4, the Springer Link research database returned most (88%) of the selected studies. Only studies A9, A13 has as source the basis of research Science Direct. No reviews were chosen on the bases: ACM, Engineering Village, IEEE, Scopus and Web of Science. Figure 4.b shows the distribution of the studies according to the type of publication.

Among the selected studies 13 (76%) were published in conferences. The conferences with the most mapped reviews are International Conference on Business Process Management with three studies (A2, A10, A16), A Information Systems and Neuroscience also with three mapped studies (A3, A8, A14) and Enterprise, Business Process and Information Systems Modeling has 2 mapped reviews (A10, A11). Also, we outlined 3 (18%) studies published papers in journals and only study A1 (1%) was released as a chapter of the book Integrating Business Process Models and Rules.



**Fig. 4.** Studies per database and types.

To understand which studies are most relevant, we observed the number of citations of the selected papers as can be seen in Fig. Five of the 16 chosen reviews have a total of 120 quotes. Articles A16, A15, A9, and A13 are the most popular accounting for 70% of citations. The A16 paper has 31 citations, and this may be due to the pioneering nature of this study, being published in 2012. The works A1, A2, A3 and A5 have no citation, the articles being less popular perhaps because they are articles published in more recent years.

**Fig. 5.** Number of citations per study.

* 1. RQ6- Quais e quantos pesquisadores estão utilizando o dispositivo de eye–tracking para avaliar a compreensão em modelos de processo?

Table 8 presents the 38 authors of the 16 mapped studies. Of the 38 authors, 18 (47%) have more than one article included in the mapping. In turn, the author with more review is Barbara Weber owning six studies. They are followed by the authors Manfred Reichert, Michael Zimoch and RüdigerPryss with four studies, these studies that compose a series of experiments of the same research. Study A4, A14 has the most significant number of authors having the same seven authors. All the authors of the study A4 are authors of at least one other study of the present mapping, being thus considered the German university Ulm the most influential for the research area of the mapping in question.

**Table8.**Autores dos estudos mapeados.

|  |  |
| --- | --- |
| Qty studies | Autors |
| 6 | Barbara Weber |
| 4 | Manfred Reichert, Michael Zimoch, RüdigerPryss |
| 3 | Andrea Burattin, Thomas Probst, Winfried Schlee, Manuel Neurauter, Jakob Pinggera, Razvan Petrusel, Jan Mendling |
| 2 | Johannes Schobel, Marco Furtner, Markus Martini, Pierre Sachse, Stefan Zugal, Christopher J. Davis, Hajo A. Reijers |
| 1 | Georg Layher, Marta Indulska, Shazia Sadiq, Wei Wang, Amine AbbadAndaloussi, Thomas T. Hildebrandt, TijsSlaats, Alan R. Hevner, ÉliseLabonté-LeMoyne, Karl-David Boutin, Pierre-Majorique Léger, Heiko Neumann, Sven Vermeulen, Tim Mohring, Klara Jelinkov, Josef Pavlicek, Petra Pavlickova, Radek Hronza, Michael Kaiser, Katharina Reiter |

1. RelatedWorks

The studies [57, 58] investigate the factors that influence the understanding of process models but do not specifically address the use of doeye-tracking as a way of measuring comprehension. However, there is the study [39] that verifies the use of eye-tracking technology in software engineering. This study conducts a comprehensive survey that does not explicitly address business process models.

Moreover, this research [39] is limited until the year 2014 and with only one search source. After the research by similar studies and in the context already mentioned in work, it was necessary to perform the systematic mapping to know the aspects involved in the understanding of the business process models through techniques and eye-traking.

1. Conclusions and Future Work

The primary motivation for this paper was to investigate the state of the art of using eye-tracking, through systematic mapping of the literature to determine which issues were studied, providing an overview to assist researchers in future research planning.

Based on this study, it was possible to verify that there is no standardization about the use of eye-tracking technology in the analysis of the process models. Perhaps a standardization could reduce the risks of failure, mitigating the threats to validity, as emphasized in [39]. In this sense, it is interesting to note that performing an eye-tracking analysis requires specific recommendations regarding the limitations associated with this technology.

As a contribution of this paper, we highlight the identification of the basic terms in the use of doe-tracking, e.g., eye fixation, saccade, scan path, duration, and pillometry [A1, A4, A5, A6]. However, it is interesting to note that the use of this technology presents some limitations in the experiments to understand the process models. Regarding the device, paper [A10] reports that there is a curvature effect in the corners of the screen that causes difficulties in the process of reading the eyes. The studies [A1, A2] identified that in the experiments the low number of participants and their level of knowledge affected negatively in the evaluation of the studies.

In our future agenda, we will carry out another mapping in 2024 to track the progress and results of new eye-tracking studies in analyzing the understanding of business process models.

**Appendix A. Papers from the mapping study**

|  |  |  |
| --- | --- | --- |
| ID | Title | Ref. |
| A1 | The Effect of Rule Linking on Business Process Model Understanding. | [41] |
| A2 | Evaluating the Understandability of Hybrid Process Model Representations Using Eye Tracking: First Insights. | [42] |
| A3 | Attentional Characteristics of Anomaly Detection in Conceptual Modeling. | [43] |
| A4 | Utilizing the Capabilities Offered by Eye-Tracking to Foster Novices’ Comprehension of Business Process Models. | [44] |
| A5 | The Effect of Domain Knowledge on Reading Strategy. | [45] |
| A6 | Using Insights from Cognitive Neuroscience to Investigate the Effects of Event-Driven Process Chains on Process Model Comprehension. | [46] |
| A7 | The Business Process Model Quality Metrics. | [47] |
| A8 | Measuring and Explaining Cognitive Load During Design Activities: A Fine-Grained Approach. | [48] |
| A9 | How visual cognition influences process model comprehension | [49] |
| A10 | Eye Tracking Meets the Process of Process Modeling: A Visual Analytic Approach. | [50] |
| A11 | Eye Tracking Experiments on Process Model Comprehension: Lessons Learned. | [51] |
| A12 | Cognitive Insights into Business Process Model Comprehension: Preliminary Results for Experienced and Inexperienced Individuals. | [52] |
| A13 | Task-specific visual cues for improving process model understanding. | [53] |
| A14 | Measuring cognitive load during process model creation. | [54] |
| A15 | Eye-tracking the factors of process model comprehension tasks. | [55] |
| A16 | Investigating the process of process modeling with eye movement analysis. | [56] |

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9. In this context, analysis can be: verify, validate, measure and so on. [↑](#footnote-ref-9)