

RESEARCH PAPER

SIM Family: The Semiotic Inspection Method and Its Variants

Caíque Bruno Fortunato   [Federal University of Minas Gerais | caiquefortunato@ufmg.br]

Ricardo Bruno da Cruz Costa  [Federal University of Minas Gerais | ricardobrunoc@ufmg.br]

Raquel Oliveira Prates  [Federal University of Minas Gerais | rprates@dcc.ufmg.br]

 *Departamento de Ciência da Computação, Universidade Federal de Minas Gerais, Av. Presidente Antônio Carlos, 6627, Pampulha, Belo Horizonte, MG, 31270-901, Brasil.*

Abstract. **Background:** The Semiotic Inspection Method (SIM) is a qualitative evaluation method grounded in Semiotic Engineering that focuses on the assessment of communicability in interactive systems through the analysis of metalinguistic, static, and dynamic signs. As interactive technologies have evolved toward more complex scenarios, limitations in the scope of the original method have motivated the proposal of several adaptations. **Purpose:** This study aims to provide a systematic overview of the adaptations and modifications of the Semiotic Inspection Method, clarifying their motivations, methodological changes, and application contexts. **Methods:** A systematic literature review was conducted using Google Scholar as the primary search platform. The search strategy included the full name of the method in English and Portuguese and resulted in an initial corpus of 604 records. After processing and classification, studies proposing structural modifications to SIM were analyzed. A web-based platform, SIM Studies, was developed to support data organization, classification, and visualization. **Results:** We have identified five distinct variants: Scientific SIM, Cross-Platform SIM (CP-SIM), SIM with the addition of Deictic Signs, SIM mediated by Screen Reader (SIM-SR), and SIM for Human–Computer Integration (SIM-HInt). These variants introduce methodological extensions such as new procedural steps, additional classes of signs, mediated interaction analysis, and the inspection of distributed systems. **Conclusion:** The proposed variants maintain the SIM’s underlying theoretical grounding. Together with SIM, they can be considered a “family” of methods, as they apply to different contexts and are complementary to the original method. By identifying and conducting a comparative analysis of these adaptations, this study contributes to organize the “SIM family”.

Keywords: Semiotic Inspection Method, SIM, Communicability, Evaluation, Semiotic Engineering

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1 Introduction

Over the last decades, the rapid expansion of digital technologies has promoted substantial transformations in both social and technical domains. These changes, largely propelled by ongoing advances in Information and Communication Technologies (ICTs), are commonly referred to as Digital Transformation [Weiss, 2019]. Such transformation has progressively redefined how individuals interact, cooperate, and engage socially, as digital technologies increasingly shape the organization of contemporary life. Within this context, the emergence of new interaction paradigms characterized by distributed and context aware environments mediated by multiple devices has amplified the complexity of Human Computer Interaction (HCI).

This challenge has been explicitly recognized by the II Grand Research Challenges in Human-Computer Interaction in Brazil for 2025-2035 (GranDIHC-BR) initiative, which outlined seven major societal and technological challenges for Brazil between 2025 and 2035 [Pereira *et al.*, 2024]. Among the challenges identified, it has been pointed out the need for new theoretical and methodological perspectives capable of addressing emerging technologies and novel interaction dynamics [Zaina *et al.*, 2024], as well as incorporating broader conceptions of technology, human practices, and social relations [da Silva Junior *et al.*, 2024].

Although the GranDIHC-BR challenges take into consideration the Brazilian context, most of the challenges are

also relevant to the HCI community as a whole [Pereira *et al.*, 2024]. Furthermore, the international HCI community has also proposed global research challenges, such as those outlined by Stephanidis *et al.* [2019] and later revisited by Stephanidis *et al.* [2025]. Although these initiatives do not define a grand challenge explicitly focused on methodology, several of their challenges emphasize emerging technologies and new interaction paradigms (e.g., smart environments, immersive systems, and VR), and include the need to review and develop new methodological approaches, including evaluation methods. Other HCI researches focused on specific technologies have also pointed out the need to review, adapt or propose new evaluation methods (e.g. [Barbosa *et al.*, 2024; Mueller *et al.*, 2024]). In this context, the present study relates to these discussions by investigating how the Semiotic Inspection Method has been adapted to address emerging interaction contexts.

Among the qualitative evaluation approaches in HCI, the Semiotic Inspection Method (SIM) [de Souza *et al.*, 2006], grounded in Semiotic Engineering Theory (SemEng) [de Souza, 2005], stands out for its focus on communicability. SIM was originally conceived to examine how interactive systems communicate their designers’ intentions, assumptions, and interaction principles to users. Given its emphasis on communicative aspects, the authors initially suggested that SIM could be employed across different technologies and contexts [de Souza *et al.*, 2006]. This claim was later empirically examined by Reis and Prates [2011], who demonstrated that

SIM could indeed be applied to diverse scenarios without requiring structural changes to the method.

Nevertheless, the increasing sophistication of digital systems and interaction contexts has motivated the proposal of several adaptations to the original SIM. In recent years, new versions of the method have been introduced, aiming to address specific evaluation demands posed by emerging technologies. However, there is currently no consolidated overview of how the method has been structurally adapted over time, nor a clear characterization of the resulting variants as a coherent set of methods. This gap motivates the central research question addressed in this study: *“What modifications have been proposed to the Semiotic Inspection Method (SIM), and in which contexts have these adaptations been applied?”* To answer this question, we investigated the adapted versions of SIM, analyzing how the original method [de Souza *et al.*, 2006] has been modified to support its application in particular contexts. To do so, we examine the motivations behind these adaptations, the methodological changes they introduce, and how these new versions have been initially applied and evaluated.

The main contribution of this study is twofold. First, we provide a systematic characterization of how SIM has been structurally adapted since its original proposal, clarifying the motivations, methodological changes, and application contexts of each adaptation identified in the literature. Second, based on this characterization, we introduce and organize the “SIM Family” – a unifying framework that groups the original SIM together with the five variants identified (Scientific SIM, CP-SIM, SIM with Deictic Signs, SIM-SR, and SIM-HInt) as a cohesive, complementary set of methods for evaluating communicability across increasingly diverse interaction contexts. This organization supports researchers and practitioners in selecting the SIM variant most appropriate to their evaluation needs.

The systematic literature review identified five distinct methods derived from SIM (see Section 3). While each variant addresses specific evaluation challenges, all of them preserve the core principles of the Semiotic Inspection Method. Broadly, the adaptations either introduce new stages to the inspection process, propose the evaluation of multiple system versions or components, or adopt alternative strategies for generating and contrasting evaluation results.

This paper is an extended version of the work presented in Fortunato *et al.* [2025a,b], incorporating additional content beyond the original publication. We have extended the presentation of each method (SIM variant) - subsection Application including a description of a case study that illustrates its application and a preliminary analysis of whether and how it has been used in the literature. We have included a description of the SIM Studies platform, developed for the study and publicly available – including its features, data organization, and interactive visualizations. Finally, we have extended and deepened the discussion about the methods, exploring not only their focus and structure, but also including a discussion about their consolidation and the potential for combining them.

The remainder of this paper is organized as follows. The next section, *Theoretical Framework*, presents an overview of Semiotic Engineering and the Semiotic Inspection Method

(SIM). *Methodology*, describes the systematic literature review methodology adopted in this study and the initial analysis regarding how each method has been applied. The following section presents the SIM Studies platform and its main features. The *Results* section presents each of the variants that comprise the “SIM Family”, highlighting their methodological differences and describing how they have been applied. Next, the *Discussion* section discusses the implications of the findings and highlights limitations and research opportunities. Finally, we conclude the paper and outline directions for future work.

2 Theoretical Framework

This section presents an overview of Semiotic Engineering Theory, which is necessary to understand the Semiotic Inspection Method (SIM), also briefly defined herein.

2.1 Semiotic Engineering Theory

Semiotic Engineering is a theory of Human-Computer Interaction (HCI) perceives HCI as a designer-to-user communication mediated by an interactive computer system [de Souza, 2005].

The theory [de Souza, 2005] defines this system as an intellectual artifact that encodes the designer’s interpretation of a problem and its corresponding solution. As users interact with the system, it conveys to them the designer’s intent and principles. Thus, the user interface is perceived as a message sent from the designer to the users. This message is considered a one-shot unidirectional communication, as the content being conveyed by the designers’ is encoded in the system (and cannot change at interaction time) and users do not have the chance to communicate back to designers.

Thus, Semiotic Engineering theory considers three interlocutors as part of the meta-communication process: designers, users, and the system. Designers are the senders of the message, who craft the design solution and encode it into the system. Users are receivers of the message, who interpret the system’s signs to achieve their specific goals. Finally, the system (or the designer’s deputy) acts as a proxy agent for the designer at interaction time, conveying the intended message on behalf of the designer to guide the users’ interaction.

The content of the message being conveyed from designers to users can be paraphrased by the **meta-communication template**:

“Here is my understanding of who you are, what I’ve learned you want or need to do, in which preferred ways, and why. This is the system that I have therefore designed for you, and this is the way you can or should use it in order to fulfill a range of purposes that fall within this vision.” [de Souza, 2005, p.84]

This message is composed of signs – i.e. *“anything that stands for something else, to somebody, in some respect or capacity”* [Peirce, 1934]. Specifically, in the case of interactive systems, Semiotic Engineering classifies interface signs into three classes: static, dynamic and metalinguistic signs [de Souza *et al.*, 2006; de Souza and Leitão, 2009]. **Static signs** are those who express the state of the system and are interpreted independently of time, such as layouts, labels, and

icons. **Dynamic signs** represent system behavior and causal relations over time, for instance the system's behavior that is triggered by clicking on a button. **Metalinguistic signs** refer to other signs to explain their meaning, such as help systems, tooltips, and error messages.

Considering the interface as a meta-communication from designer to user, Semiotic Engineering theory proposes communicability as the main property regarding the quality of the metamessage being conveyed [Prates *et al.*, 2000]. Thus, it defines **communicability** as the distinctive quality of an interactive system that communicates its logic, intent, and design principles to the user in an organized and consistent manner, thereby achieving its purpose with the user [de Souza and Leitão, 2009; de Souza *et al.*, 2010].

In order to assess a system's communicability, different methods have been proposed, namely the Communicability Evaluation Method (CEM) [Prates *et al.*, 2000; de Souza and Leitão, 2009], the Semiotic Inspection Method (SIM) [de Souza *et al.*, 2006; de Souza and Leitão, 2009], and the Intermediated Semiotic Inspection Method (ISIM) [Oliveira and Prates, 2018]. Each method analyzes different aspects of the communication process taking place, and can be considered complementary to each other.

The **Semiotic Inspection Method (SIM)** [de Souza *et al.*, 2006; de Souza and Leitão, 2009] is an inspection method in which evaluators analyze the **message being sent** by the designers. To do so, they examine three classes of signs to reconstruct the designer's message and identify potential inconsistencies. **Communicability Evaluation Method (CEM)** [Prates *et al.*, 2000; de Souza and Leitão, 2009] is a user based evaluation method that focuses on how the designer's message is being received by users. CEM requires users to perform predefined tasks in a controlled environment, at which time their interactions are recorded. During the analysis, evaluators identify communicative breakdowns and examine their impact in the overall designer-to-user communication. Finally, the **Intermediated Semiotic Inspection Method (ISIM)** [Oliveira and Prates, 2018] collects stakeholders understanding of the designer's message. To do so, the evaluator guides stakeholders through an inspection of the system, and later reconstructs the meta-communication, identifying communicative breakdowns, based on their perspective. In this paper, our focus is on the Semiotic Inspection Method, so next we present the method in more detail.

2.2 The Semiotic Inspection Method (SIM)

The Semiotic Inspection Method (SIM) allows evaluators to conduct a systematic analysis of the communicability of interactive systems by examining how effectively the interface communicates the designers' intentions, assumptions, and design rationale to users [de Souza *et al.*, 2006]. Through the analysis of metalinguistic, static, and dynamic signs, the evaluator can reconstruct the designer's intended meta-communication message and identifying potential communicability breakdowns. These breakdowns indicate situations in which users may misinterpret, fail to understand, or (potentially) assign unintended meanings to the designers' messages. The method is organized into the following steps (Figure 1):

- **Preparation (Step 0):** The evaluator conducts a prelim-

inary and informal inspection to define the focus of the analysis. This step involves characterizing the intended users, identifying the main goals and activities supported by the system, and defining representative inspection scenarios that delimit the context in which the analysis will be carried out.

- **Step 1 – Analysis of Metalinguistic Signs:** This step focuses exclusively on the metalinguistic signs, *i.e.* signs used by the designer to explicitly explain the system to users. At this stage, the evaluator's goal is to reconstruct the designer's message based solely on the instructions, explanations, and guidance that are explicitly provided by the interface. The analysis encompasses artifacts such as documentation, manuals, online help systems, tooltips, error messages, and instructional interface texts. The evaluator's action consists of inspecting how the system "talks about itself," identifying how concepts, functions, and procedures are introduced, described, and justified to the user.
- **Step 2 – Analysis of Static Signs:** This step shifts the focus to the visual elements of the interface as they appear in a non-interactive, time-independent state. In this phase, the evaluator reconstructs the designer's message by interpreting only what static signs. Elements examined at this stage include screen layout, menus, labels, icons, images, and the spatial arrangement of interface components. The evaluator's action involves examining the interface in a "frozen" state, such as through screenshots, and interpreting the meaning of visual elements and their organization, independently of their behavior.
- **Step 3 – Analysis of Dynamic Signs:** This step concentrates on the system's behavior over time and on the unfolding of interaction. The evaluator analyzes how the system responds to user actions and how interface states change, reconstructing the designer's message based on these dynamic interactions. This stage considers elements such as transitions between screens, animations, the opening and closing of windows, visual or auditory feedback, changes in focus, and the sequence of steps involved in completing tasks. The evaluator's action consists of traversing interaction scenarios and observing causal and temporal relationships in order to interpret the communication conveyed through interaction itself.
- **Step 4 – Collating and Comparing the Meta-communication Messages:** In this step, the meta-communication messages reconstructed in the previous steps are compared and contrasted. Since different types of signs possess distinct expressive and interpretative power, the evaluator examines whether inconsistencies, ambiguities, or contradictions may arise when users interpret the combined messages conveyed by the interface.
- **Step 5 – Final Appreciation:** The final step consists of assessing the system's overall communicability. The evaluator integrates the findings from all previous steps and produces a report presenting a global appreciation of the reconstructed meta-communication message and its adequacy in supporting user understanding.

The first three steps of SIM promote a segmented analysis of the interface, as each step focuses on a specific class of

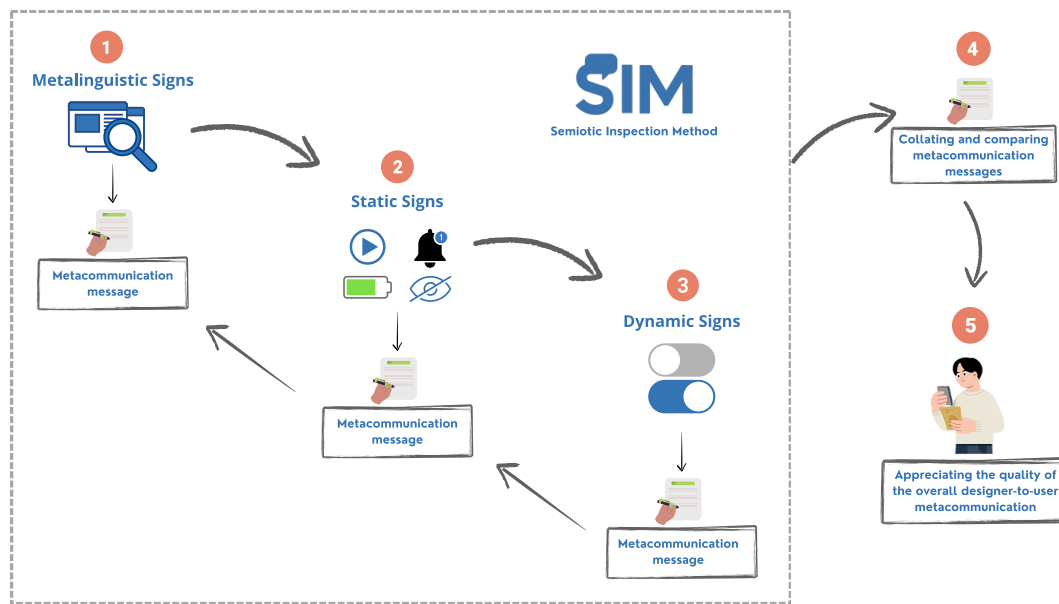


Figure 1. Steps of the Semiotic Inspection Method

signs and on what is communicated through that class alone. This analytical separation allows evaluators to explore the communicative role and limitations of each type of sign in depth. In contrast, Steps 4 and 5 shift the focus to an integrative analysis, in which the evaluator reconstructs and interprets the complete meta-communication message by contrasting and synthesizing the partial messages generated in the segmented analyses [de Souza and Leitão, 2009; Leitão and Prates, 2017].

Throughout the inspection process, evaluators act as informed user representatives, interpreting users' interests, expectations, and potential interpretations of the interface. This role requires evaluators to rely on their technical expertise and theoretical knowledge to anticipate how users may make sense of the designers' messages. Consequently, evaluators applying SIM are expected to have solid expertise in HCI as well as of Semiotic Engineering Theory.

A previous study investigating SIM's applicability, characterized SIM as a method that is independent of both application domain and technological platform [Reis and Prates, 2011]. The investigation carried out a systematic review of studies applying SIM across a wide range of interactive systems, including educational, collaborative, entertainment, and specialized applications. As a result, it indicated that the method can be applied without requiring adaptations to its steps. This evidence supports the claim that SIM's analytical focus on communicative phenomena, rather than on task performance or technological constraints, allows it to remain applicable across heterogeneous contexts. Moreover, the investigation pointed out that SIM has been used both for technical purposes (i.e. evaluating a system's communicability) and scientifically (i.e. as a qualitative research method to analyze the designer's discourse), reinforcing its relevance

for scientific investigations in Human-Computer Interaction [de Souza *et al.*, 2010; Reis and Prates, 2011].

Nonetheless, more recent works have identified new contexts that require new aspects to be considered in the analysis, and propose a new method, based on an extension to the original method. Thus, in this paper, our goal is to identify how many and which variants have been proposed and analyze and organize these methods.

3 Methodology

To identify and examine the adaptations of the Semiotic Inspection Method (SIM) proposed for emerging application contexts, we conducted a systematic literature review. This section presents the methodological procedures adopted in the study, detailing the research question, inclusion and exclusion criteria, selected data sources, search strategies, methodological limitations, and the analytical steps used to examine the selected studies.

According to Kitchenham [2004], a systematic literature review (SLR) is a rigorous and structured process aimed at identifying, evaluating, and synthesizing all relevant evidence related to a specific research question, thematic area, or phenomenon of interest. This approach is particularly suitable for organizing and consolidating existing knowledge about a given method or technology, enabling the identification of research gaps and providing a solid foundation to inform and guide future investigations.

In this context, the goal of this study is to investigate the modifications proposed to the Semiotic Inspection Method (SIM) with the purpose of generating new or adapted versions of the method. Accordingly, the following research question was defined: "What modifications have been proposed to the Semiotic Inspection Method (SIM), and in which contexts have

these adaptations been applied?”

To answer the research question, the methodological process was organized into five main stages: (1) search strategy formulation; (2) data collection; (3) data preparation for system input; (4) data classification; and (5) analysis of method modifications. Figure 2 depicts the steps conducted in our methodology.

After identifying the SIM variants, i.e. the new methods proposed based on SIM adaptations, we proceeded to perform a preliminary analysis of their application. Thus, besides analyzing the application of the method presented by authors of the method, we identified all publications that referenced the main articles presenting the method. Then, we examined whether any of these papers had applied the method.

3.1 Data Collection

To identify and map the different contexts in which SIM has been applied in the scientific literature, *Google Scholar* was selected as the primary search platform. Google Scholar¹ functions as a meta-search engine that aggregates academic content from multiple sources, including peer-reviewed journals, institutional repositories, books, theses, dissertations, and conference proceedings.

As a result, its coverage includes a wide variety of publication types, such as journal and conference papers, theses, dissertations, and workshop contributions, many of which are not consistently indexed in curated databases such as Scopus, Web of Science, or the ACM Digital Library. This broader coverage enabled the construction of a more comprehensive corpus of studies addressing SIM.

The search string adopted was: “*semiotic inspection method*” OR “*metodo de inspecao semiotica*” OR “*método de inspeção semiótica*”, including the designation of the method in both English and Portuguese, with and without diacritics.

The initial search was conducted between March 19 and March 25, 2025, resulting in 662 records, including publications and citation entries [Fortunato *et al.*, 2025a]. No additional filters were applied, as Google Scholar, by default, returns heterogeneous types of documents ordered by relevance. As no publication year filter was applied, the review covers the entire publication history of the Semiotic Inspection Method, from its first publication in 2006.

On January 24, 2026, the search was conducted again for the years 2025 and 2026, and the database was updated with records that had not been included in the initial extraction, resulting in the analysis of 32 new studies. From this set, duplicates and false positives were removed, leading to the addition of 27 studies. This increase over a short period of time is mainly due to the release of new journal issues and the occurrence of annual events, especially the 24th Brazilian Symposium on Human Factors in Computing Systems (IHC 2025) and the 20th edition of the International Conference of Technical Committee 13 on Human–Computer Interaction (INTERACT), both held in September 2025. As a result, the final set contained papers from SIM’s first publication in October, 2006 to January 24th, 2026.

The retrieved records were exported in the same sequence presented in the search results and stored in a spread-

sheet containing the following attributes: title, authors, source, number of citations, and year of publication. In addition to the metadata provided directly by Google Scholar, supplementary information, including the data source, type of publication (e.g., journal article, conference paper, thesis, or dissertation), language of the text, country of publication, and authors’ institutional affiliations were collected. The records were manually extracted in CSV format, organized into the data spreadsheet, and subsequently imported into a relational database to support systematic classification and filtering.

To support the systematic review and classification process, we developed a web-based platform, SIM Studies² aimed at centralizing, organizing, and visualizing publications related to the Semiotic Inspection Method (SIM) included in the constructed database [Costa *et al.*, 2025]. It is worth noting that the data collected in our 2026 update was manually added to SIM Studies through the platform’s own registration interface. SIM Studies will be described in detail in Section 4.

3.2 Processing and Classification of Results

After all records were inserted into the database, they were individually processed using the SIM Studies platform in order to define the final corpus of publications. This procedure followed the steps described below:

- **Duplicate removal:** records that appeared more than once in the search results were identified and excluded;
- **Analysis of citation-only results:** Google Scholar often returns entries classified solely as citations when the original document is not indexed but referenced by other works. Below, there is an example of a citation result:

[CITATION] *Evaluating and Investigating Game Accessibility for Deaf Players with the Semiotic Inspection Method.*
F Coutinho, RO Prates, L Chaimowicz - *Workshop on Game User Research at CHI*, 2012

Thus, citation results were manually examined to verify whether their complete versions were already included among the retrieved documents. In all such cases, the corresponding full papers were already present in the dataset;

- **Removal of full conference proceedings:** some search results referred to complete conference proceedings because at least one paper contained the search string. In these cases, individual papers were retained, while the proceedings as a whole were excluded.

In the initial search (March 2025), after completing the processing steps, 85 records were removed. The resulting database comprised 577 individual works (later updated to 604), including conference and journal papers, doctoral theses, master’s and undergraduate dissertations, short papers, extended abstracts, educational materials, books, and book chapters.

The next stage aimed at identifying studies that proposed new versions of SIM by explicitly describing modifications to the method. For this purpose, we defined a set of categories representing the role played by SIM in each publication. The

¹<https://scholar.google.com/intl/en/scholar/about.html>. Accessed on 22 September 2026.

²SIM Studies is available at: <http://bit.ly/3GQHGaI>

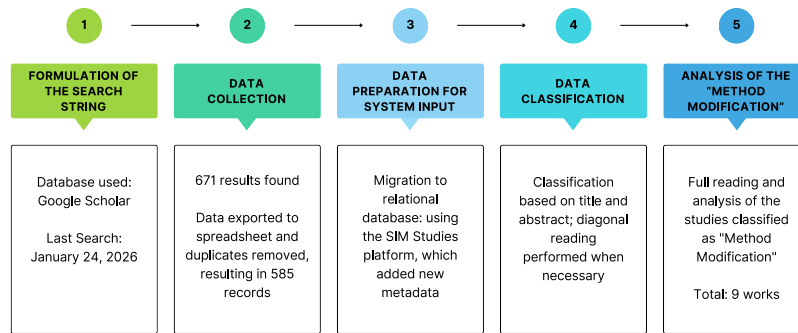


Figure 2. Methodology

initial set of categories was informed by prior familiarity with the literature, but it remained open to the inclusion of additional categories if new patterns emerged during the analysis. The initial classification was based on the examination of titles and abstracts. When this information was insufficient to determine the role of SIM, a diagonal reading of the full text was performed.

The classification process was a qualitative process conducted by the research team [Gibbs, 2008]. In a first step, the two first authors independently categorized the studies and subsequently compared their results. Any differences or doubts were resolved in a discussion session, in which the third author, senior researcher expert in SIM, also participated. In this session, researchers re-examined the paper in question, discussed and reached a consensus³ about the best classification.

The final set of categories is described below:

- **Discussion on SIM:** the method is presented and examined in depth, as in books or critical analyses;
- **Semiotic Engineering Discussion:** the focus is on Semiotic Engineering as a theoretical framework, with references to SIM;
- **Application:** SIM is applied to evaluate a system or interface within a specific context;
- **Tools:** the study presents a tool intended to support the application of SIM;
- **Applicability:** SIM is employed to assess interfaces in a particular domain or context;
- **Application adaptation:** the method is adapted for use in specific contexts without altering its original structure, although some components may be reframed;
- **Method modification:** changes to the original structure of SIM are proposed, such as the introduction of new steps or phases;
- **New method:** a new method inspired by SIM is proposed, but it does not preserve the original goal of SIM, as in the case of the Intermediated SIM [Oliveira *et al.*, 2008; Oliveira and Prates, 2018], which is a method to collect stakeholders' perceptions and understanding of the designer's meta-communication;
- **Citation:** SIM is only mentioned, either in the theoretical background or through isolated references.

In this study, the analytical focus was placed on publi-

Table 1. Classification of studies and their respective quantities - Jan/2026

Classification	Number
Citation	298
Application	231
New method	19
Discussion on SIM	13
Semiotic Engineering Discussion	12
Applicability	9
Method modification	9
Application adaptation	6
Tools	7
Total	604

cations classified as "*Method modification*". Consequently, all works initially categorized as "*Application adaptation*" or "*Applicability*" were fully read to confirm whether they indeed did not propose structural changes to the method. The final distribution of records across categories is presented in Table 1, considering the exclusion of duplicate entries, citation-only results, and the new inclusions made in 2026.

3.3 Focus on the Analysis

After the classification phase, 9 studies were identified as belonging to the "*Method modification*" category and were subsequently analyzed in full. To record the data about each modification proposed, a structured registration form was created, containing the following fields: title, author(s), publication year, application context, name of the proposed method, summary of its motivation, description of the proposal, objective of the new method, and a summary of the changes introduced in relation to the original SIM.

This structure enabled the grouping of publications referring to the same method and supported the identification of differences between proposals, as well as the analysis of the historical evolution of each modified version. It should be noted that multiple publications may address the same version of SIM, either by initially proposing it, refining its description, or applying it in new application contexts.

Subsequently, for each proposal, we applied a forward snowballing search⁴ to identify any papers that applied the variant method. To do so, for each method, we defined the article that first published the method, describing its steps and included it in the seed set. We analyzed the other articles

³In qualitative research, consensus coding is a well-established practice and common in HCI and CSCW research [McDonald *et al.*, 2019].

⁴Forward snowballing involves searching for studies that cite the studies contained in the seed set – i.e. set of studies as a starting point [Felizardo *et al.*, 2016].

that included the authors who proposed the method and that could be perceived as presenting the method (e.g. an extended version of the initial article, or an article that illustrated the method's application) and also included them in the seed set for that method. We then used Google Scholar (through the 'Cited by' option) to identify all other articles that referenced one or more of the articles in the seed set. Next, we proceeded to examine each of these articles to verify whether they included an application of the method. For each study that applied the method, we analyzed these applications to understand how the method has been used in the literature and in which contexts, as will be discussed in Section 5.7. We did not consider for the seed set books or texts that included other methods as well as the variant SIM. The snowballing search was conducted on August 12, 2026.

3.4 Limitations

Although this study resulted in a substantial collection of publications related to the Semiotic Inspection Method (SIM), some limitations must be acknowledged. First, the search was restricted to Google Scholar. While this platform aggregates content from a wide range of academic repositories, it is possible that relevant publications indexed exclusively in other databases were not retrieved. Therefore, future studies are encouraged to replicate or extend this review by incorporating additional academic databases in order to cross-validate the results and potentially expand the identified corpus.

A second limitation concerns the construction of the search string, which included only the full name of the method. Alternative terms and abbreviations that could refer to related works were not explored, such as searches based on "SIM" or "Semiotic Engineering". Although it is reasonable to assume that studies proposing new versions of the method would explicitly mention its full name, further investigations could assess whether alternative search terms might reveal additional relevant publications.

Additionally, the classification of publications was primarily based on the analysis of titles and abstracts, with diagonal or full readings conducted only when necessary. Despite the fact that this initial classification was independently performed by two researchers and discussed with a third, more experienced reviewer, there remains the possibility that some studies were misclassified. Furthermore, although all publications categorized as "*Method modification*" were read in full by one researcher and any uncertainties were discussed with the other authors, certain aspects of these works may not have been explored in as much depth as would be possible with multiple full reviewers.

Finally, regarding the analysis of the application of each SIM variant, Although the forward snowballing search considered the publications that introduced or substantially described each SIM variant as the seed set, an important limitation remains for Scientific SIM. While the seed set included the publications specifically devoted to Scientific SIM, its conceptual foundations are also discussed in de Souza and Leitão [2009]. Since this book presents SIM, CEM and discusses its scientific application, it was not included as a seed publication. Thus, if any studies applied Scientific SIM and exclusively cited de Souza and Leitão [2009], they were not retrieved or considered in the consolidation analysis. Conse-

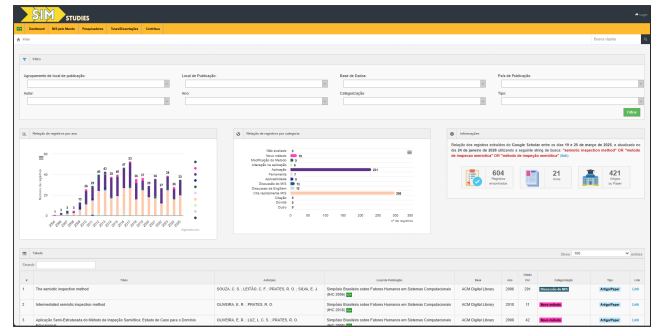


Figure 3. SIM Studies Dashboard

quently, the number of applications reported for Scientific SIM should be interpreted as a lower-bound estimate rather than an exhaustive count. Although we only identified this limitation regarding Scientific SIM, similar situations could have happened to other variants.

3.5 Ethical Considerations

This study did not involve human participants nor the collection of sensitive personal data and, therefore, did not require approval from a research ethics committee, in accordance with Resolution 510/2016 of the Brazilian National Health Council⁵. All data analyzed were derived from publicly available scientific publications and are properly cited in compliance with academic standards. The research was conducted in accordance with principles of research integrity, methodological transparency, and respect for intellectual property. The authors declare that there are no conflicts of interest associated with this study.

4 The SIM Studies Platform

Conducting an SLR entails significant challenges for researchers, as it involves a series of complex and labor-intensive activities, including the definition of search strategies, the selection of appropriate databases, the organization of extensive sets of references, and the synthesis of relevant evidence to support the research objectives. Thus, as mentioned, **SIM Studies** – a platform designed to support researchers in streamlining the systematic literature review (SLR) process with a specific focus on the Semiotic Inspection Method (SIM) was developed [Costa *et al.*, 2025]⁶.

The platform was developed in the first semester of 2025 using the PHP programming language, and the data collected for this study (as described in 3.1). The Highcharts/Highmaps⁷ library was used across the entire platform to generate the charts and interactive maps. The platform is a web-based system composed of five main sections.

4.1 Dashboard

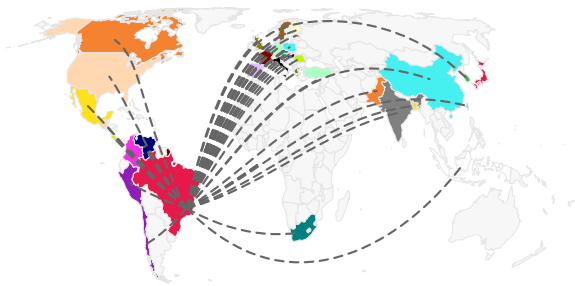
The first tab of the platform, which also serves as its homepage, is called Dashboard (see Figure 3). This section presents an overview of the dataset to users. On the left, it presents a vertical bar chart that depicts the total number of records per year, using different colors to represent the distribution across

⁵Available at: <https://bit.ly/4xBhNjI> Accessed on 22 September 2026

⁶SIM Studies is publicly available at <https://ricardo.bib.br/mis/> Accessed on 22 September 2026.

⁷<https://www.highcharts.com/> Accessed on 22 September 2026.

Publicações por país



Highcharts.com © Natural Earth

Figure 4. “SIM Around the World” Screen

categories. Next, a horizontal bar chart shows the number of publications per category. On the right, it presents general data about the SLR conducted (e.g. search string, period, total number of publications and articles found, and number of years of publications on SIM).

Below these visual elements, a table displays all identified publications. The table contains information such as the title, authors, publication source, repository, publication year, number of citations, SIM approach category, publication type, and a link to the original publication. Both the charts and the table are dynamically updated according to the filters selected by the user. The dataset can be filtered by author, year, publication source, country, publication type, database, and category. Whenever a filter is applied, all information displayed on the screen is updated accordingly.

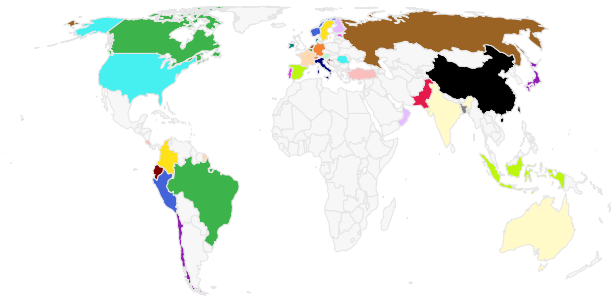
4.2 SIM Around the World

The second section, entitled “SIM Around the World”, presents information about the dissemination of the method across different countries. This page is divided into two main parts. The first part contains an animated map that represents the global reach of the method, based on the country associated with each publication. For conference proceedings, the platform considers the country where the event took place. For journal articles and books, it considers the country of the publisher. The visualization shows that the method has been published in all continents, as illustrated in Figure 4.

On the right side of the screen, the same information is presented in a tabular format. This table lists each country and the number of publications associated with it, ordered by publication count. Brazil appears at the top of the list with 426 publications⁸ followed by the United States of America and then the United Kingdom. Users can also click on the “Filter” button to return to the dashboard with the selected country filter applied.

4.3 Researchers

The “Researchers” section provides quantitative data about the indexed authors. This page is divided into three main sections. The first section presents the data in a tabular format, listing all authors identified in the study, their institutional affiliation, the country of the institution, and the number of publications



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Figure 5. Researchers by country (considering the country of the author's institution in publication)

associated with each author. The list is ordered by the number of publications, and is currently headed by two of the authors who originally proposed the method. As in the previous page, users can return directly to the Dashboard with the selected author applied as filter.

Next to the table, two maps highlighting the local of the authors' institutional affiliations is displayed. The first one is a world map, showing the distribution of the researchers in different countries. The second one is a Brazilian map indicating the distribution of institutions in each state. The world map shows that researchers that have published anything on SIM are affiliated with institutions in 33 countries, covering almost all continents, with the exception of Africa, as illustrated in Figure 5. The Brazilian map (see Figure 6) shows that researchers on SIM are present in all five regions of Brazil but not all states – there are no researchers affiliated with institutions in the states of Acre, Rondônia, Roraima, Amapá, Tocantins, Piauí, Alagoas, and Espírito Santo.

4.4 Other Sections

Finally, the platform presents two other tabs: “Dissertations” and “Contribute”. The “Dissertations” tab was motivated by the fact that many works proposing adaptation to SIM are the result of a larger research, often part of master's theses, doctoral dissertations, or even undergraduate theses. This section presents an overall count of studies, their distribution over time, organized by year, a word cloud with the most frequent institutions within this data subset and a heatmap that displays the advisors most frequently associated with these academic works.

The “Contribute” page allows researchers to submit other studies to the platform that may not have been found in our search for any reason. Each submission request is reviewed by the research team, and if it aligns with the objectives and scope of the platform, the study is incorporated into the dataset.

5 Results

In this section, we present the results of the analysis regarding the adaptations and modifications of SIM, as described in the literature according to the application of the methodology.

⁸Number shown based on the January 2026 update conducted for this paper.

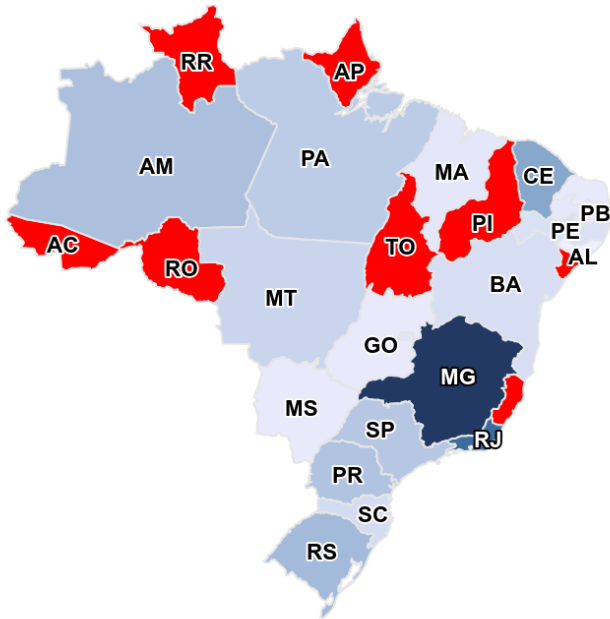


Figure 6. Researchers by Brazilian state (considering the state of the author's institution in publication). The blue indicates states os authors' institutions (the darker blue indicates states that with more publications); red indicates states with no researchers among the authors.

5.1 Overview

The first publication introducing SIM dates to 2006 and was entitled “*The Semiotic Inspection Method*” [de Souza *et al.*, 2006]. This work formally presents the original method. Within the corpus analyzed, it is the third most cited publication⁹, accumulating 291 citations, surpassed only by two widely referenced books: *Semiotic Engineering Methods for Scientific Research in HCI* [de Souza and Leitão, 2009], with 348 citations (the book includes both SIM and CEM), and *Interação Humano-Computador* [Barbosa and Silva, 2010], with 1304 citations (the book presents an overall introduction to HCI, including SIM in the methods presented).

Additional insights can be obtained through data visualizations, such as the distribution of publications over time shown in Figure 7. From 2006 onward, the number of studies exhibits a gradual increase, reaching its peak in 2017, when 53 publications related to SIM were recorded.

After 2017, the volume of publications shows an overall downward trend, although with noticeable fluctuations, including renewed growth in 2023, with 39 publications, and in 2025, with 35 publications. Studies classified as “Method modification” represent a relatively small subset of the total and appear in specific years, namely 2010, 2013, 2014, 2017, 2019, 2021, 2023, and 2024.

As previously stated, this paper focuses specifically on studies that proposed modifications to the original SIM, resulting in the creation of new versions of the method. In total, nine publications were identified, describing five distinct SIM variants: the *Scientific Semiotic Inspection Method* (*Scientific SIM*), the *Cross-Platform Semiotic Inspection Method* (*CP-SIM*), the *Semiotic Inspection Method with the addition of Deictic Signs* (*SIM with Deictic Signs*), the *Semiotic Inspec-*

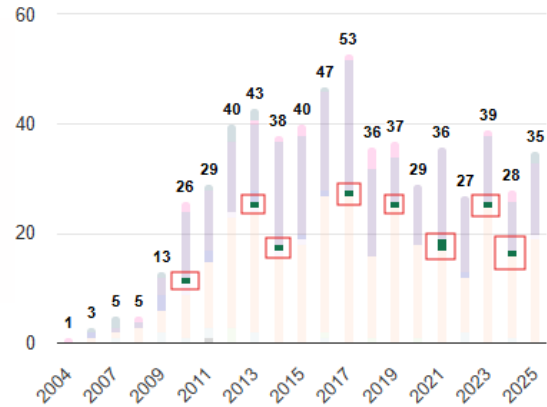


Figure 7. Publications per year with green highlight inside a red square on studies classified as “Method modification”

tion Method Mediated by Screen Reader (SIM-SR), and the *Semiotic Inspection Method for Human-Computer Integration (SIM-HInt)*.

The types of changes introduced by these variants differ according to the objectives of each adaptation. These changes include the introduction of new classes of signs, the addition of new procedural steps, the inspection of different versions of the meta-communication message, whether complete or partial, and distinct strategies for contrasting such messages.

In the next five subsections, we present the proposed versions of SIM in chronological order, according to their first appearance in the literature. For each version, we provide a concise account of the motivation behind the adaptation, a description of the modified method, and how it has been applied. **The modifications to the original method have been highlighted in blue the text.** Furthermore, to facilitate the visualization of the changes in each method, we created a summarized graphical illustration of SIM. Each yellow symbol represents one step of the method, and each rounded rectangle represents a set of steps. Figure 8 presents the representation for the original SIM.

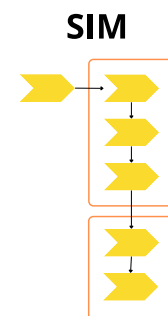


Figure 8. Summarized illustration of the Semiotic Inspection Method

5.2 Scientific SIM (2010)

The Scientific SIM [de Souza *et al.*, 2010] was proposed primarily by the same researchers responsible for the original SIM, with the purpose of extending its use beyond a purely *technical* inspection focused on interaction quality. Its central objective is to support evaluators and researchers in conducting a systematic examination of interactive systems aimed at

⁹Citation numbers updated in Google Scholar search on January 24th, 2026.

producing *scientific knowledge* about the technical solution embodied in the system. In this sense, the method is designed to foster the identification and analysis of communicative phenomena in interaction, contributing to theoretical progress in the field of HCI.

Scientific SIM differs from the original method mainly by introducing an explicit research question at the outset and by incorporating a triangulation phase. While the core inspection steps remain unchanged, the emphasis of the analysis shifts. Instead of prioritizing the identification of communicability breakdowns in the reconstructed metamessage, the evaluator concentrates on uncovering challenges, properties, and relevant aspects of the solution in relation to the defined research question. The triangulation phase aims to assess the robustness of the findings by confronting them with evidence produced through other methods or procedures. These sources may be endogenous, such as comparisons with systems from the same domain, or exogenous, involving systems from different domains that share relevant characteristics.

5.2.1 Modified Method

The following steps describe the application of Scientific SIM (steps highlighted in *blue and italic* indicate modifications or additions relative to the original method):

- **Step 0: Preparation** - informal inspection, definition of the inspection scenario and *explicit definition of the scientific problem to be addressed and the establishment of analysis criteria connected to theoretical advancement in HCI*;
- **Step 1: Inspection of metalinguistic signs**, reconstructing the first metamessage based on these signs and the communicability issues identified *with a focus on aspects of the metamessage related to the defined research question*;
- **Step 2: Inspection of static signs**, reconstructing the second metamessage based on these signs and the communicability issues identified *with a focus on aspects of the metamessage related to the defined research question*;
- **Step 3: Inspection of dynamic signs**, reconstructing the third metamessage based on these signs and the communicability issues identified *with a focus on aspects of the metamessage related to the defined research question*;
- **Step 4: Comparison and contrast** of the three reconstructed metamessages and the communicability issues observed;
- **Step 5: Communicability appreciation** *from an epistemological perspective, seeking to relate the results to the research question posed in the preparation step. Inspectors try and articulate theoretical concerns, revisit established interpretations in HCI or even formulate new research questions.*;
- **Step 6: Triangulation:** *Confronting the inspection results with findings obtained through other methods or procedures, using endogenous sources (such as inspection of similar artifacts, or analyses conducted by other evaluators of the same system) or exogenous sources (artifacts from different domains with relevant comparative properties).*

Figure 9 shows the SIM summarized illustration with

Scientific SIM

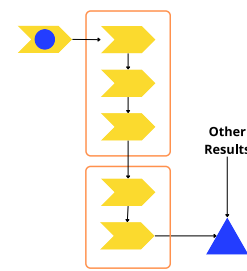


Figure 9. Summarized illustration of the Scientific SIM

the specific additions of this modification highlighted in blue. Specifically, these additions are the research question in the preparation stage and the triangulation step at the end.

5.2.2 Application

In de Souza *et al.* [2010], the authors exemplify the use of Scientific SIM through a case study designed to investigate “how a system’s feedback is communicated to users, which types of signs are employed, what interpretations they elicit, and how these interpretations relate to the system’s semantics”. The object of analysis was Simple CSS (SCSS), a freely distributed Cascading Style Sheet editor. The study involved a detailed inspection of the feedback signs presented by the interface, showing how the method enabled the generation of insights into design practices in authoring tools and the communicability limitations of systems intended for non-expert users.

The findings were subsequently triangulated with empirical evidence from both endogenous and exogenous sources. Endogenous evidence included web-based materials related to SCSS and other freely available CSS editors, such as user opinions, FAQs, and promotional content. The exogenous source consisted of results obtained from a semiotic inspection of selected content from Google Groups.

Based on the inspection, the authors proposed a formulation of semiotic commonalities underlying signification and interpretation processes associated with feedback in general configuration tasks and their implications. With respect to Scientific SIM, they argue that the method can be effectively employed as an epistemological instrument for scientific inquiry in HCI. Consequently, Scientific SIM is positioned as a valuable approach for identifying communicative patterns in interfaces, examining designer intentions, and supporting the production of new theoretical knowledge in the field.

5.3 CP-SIM: Cross-Platform Semiotic Inspection Method (2013)

Cross-communicability refers to the quality of a system’s metamessage when it is considered as a whole and offered across multiple platforms [Maués and Barbosa, 2013]. It emphasizes users’ interaction with a system through different platforms, examining how meanings constructed on one platform affect interpretation and use on others, beyond the communicability of individual interfaces [Barbosa *et al.*, 2021].

The concept highlights that systems may present high communicability when one platform is considered in isolation. However, when users switch platforms and transfer expecta-

tions and interpretations that are not always valid across these versions, it could lead to communicative breakdowns between them.

In this context, sign impermeability is central, since essential signs should preserve their meanings across platforms, while meaning-preserving adaptations may be acceptable and meaning-changing manipulations tend to undermine interpretive continuity. By shifting the evaluative focus from localized interaction to experiences distributed over time and platforms, cross-communicability supports the analysis and design of multi-platform systems that are more coherent, transparent, and aligned with users' expectations [Maués and Barbosa, 2014, 2013].

The *Cross-Platform Semiotic Inspection Method* (CP-SIM), also referred to as the cross-platform extension of the Semiotic Inspection Method (SIM), was proposed with the aim of supporting the systematic evaluation of communicability in interactive systems distributed across multiple platforms [Maués and Barbosa, 2014, 2013]. Whereas the traditional SIM was conceived to analyze individual interfaces in relatively stable contexts of use [de Souza *et al.*, 2006], cross-platform scenarios introduce additional challenges, since users frequently alternate between different versions of the same system —such as desktop applications, mobile web interfaces, and native apps — each subject to distinct technical constraints, interaction patterns, and design conventions.

From a theoretical perspective, CP-SIM preserves the foundations of Semiotic Engineering, particularly the understanding of the interface as a meta-communication artifact through which designers express to users who they believe the users are, what they want or need to do, and how the system should be used [de Souza, 2005]. However, the method expands this framework by acknowledging that such meta-communication does not occur in isolation within each platform, but rather in a distributed manner, progressively constructed as users traverse different system versions. In this sense, CP-SIM shifts the analytical focus from localized communicability to the coherence of meta-communication across the multi-platform ecosystem.

Methodologically, CP-SIM is organized around two complementary analytical dimensions: vertical analysis and horizontal analysis. Vertical analysis corresponds to the application of the traditional SIM to each platform independently. In this phase, the evaluator inspects metalinguistic, static, and dynamic signs to reconstruct the metamessage conveyed by each system version; identifies potential communicability breakdowns; and assesses the internal consistency of the interface. An additional aspect introduced by CP-SIM is the explicit attention to signs that refer, either explicitly or implicitly, to the existence of other platforms, enabling the identification of how the system communicates its own cross-platform composition.

Horizontal analysis constitutes the main methodological innovation of CP-SIM and directly addresses the problem of evaluating cross-communicability. In this phase, the metamesages reconstructed through vertical analyses are contrasted in order to understand how differences between platforms may affect system interpretation when users switch between versions. To this end, the method adopts a semiotic framing

of design changes, interpreting observed differences as manipulations of signs at the lexical, syntactic, and semantic levels. These manipulations can be classified as meaning-preserving or meaning-changing, allowing evaluators to assess their impact on users' interpretive continuity.

Meaning-preserving manipulations, such as terminological adjustments, spatial reorganizations, or the removal of non-essential functionalities, may be regarded as legitimate adaptations to the constraints and affordances of each platform. Nevertheless, CP-SIM emphasizes that such adaptations must be carefully examined in light of the system's identity and the impermeability of its essential signs. By contrast, manipulations that alter the meaning of supposedly equivalent signs across platforms pose a significant risk to cross-communicability, as they tend to generate ambiguities, misguided expectations, and frustration when users transfer knowledge from one version to another.

By articulating vertical and horizontal analyses, CP-SIM offers a comprehensive approach to the evaluation of cross-platform systems that goes beyond traditional criteria of usability or visual consistency. The method foregrounds a communicational perspective, enabling an understanding of how design decisions affect users' meaning-making processes in distributed interaction contexts. In doing so, CP-SIM provides relevant analytical support for both the evaluation and the design and evolution of cross-platform systems that are more coherent, transparent, and aligned with users' expectations and real-world practices.

5.3.1 Modified Method

The proposed steps of CP-SIM are described below (text in blue and italic highlights steps that are different from or added to the original method):

- **Step 0: Preparation**, including the definition of scope and scenarios;
- **Phase 1: Vertical Analysis (per platform)**
 - **Step 1: Inspection of metalinguistic signs** *highlighting those that denote any compositional aspects of the cross-platform system*, resulting in reconstruction of metamessage 1 and identified communicability issues;
 - **Step 2: Inspection of static signs** *highlighting those that denote any compositional aspects of the cross-platform system*, resulting in the reconstruction of metamessage 2 and identified communicability issues;
 - **Step 3: Inspection of dynamic signs** *highlighting those that denote any compositional aspects of the cross-platform system*, resulting in the reconstruction of metamessage 3 and identified communicability issues;
 - **Step 4:** Comparison and contrast of the metamesages and communicability breakdowns found;
 - **Step 5:** Communicability appreciation.
- **Phase 2: Horizontal Analysis (across platforms)**
 - **Step 6: Identification of sign manipulations across platforms**;
 - **Step 7: Examine the manipulations collected and categorized in the previous step to assess**

how they might negatively impact horizontal meta-communication, intensifying already identified vertical communication failures;

- **Step 8:** *Qualitative evaluation of the system's cross-communicability by unifying the meta-communication message obtained in each previous step, assessing the costs and benefits of the identified cross-platform manipulations, and then producing an evaluation report.*

Figure 10 shows the SIM summarized illustration with the specific additions of this modification highlighted in blue.

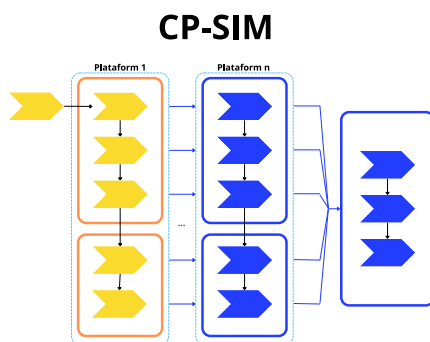


Figure 10. Summarized illustration of the CP-SIM

By comparing the metamessages conveyed by different system versions, CP-SIM can expose additional ambiguities and communicative breakdowns. Moreover, issues identified in a single platform may be amplified, propagated, or, in some cases, alleviated by features available in other versions of the system. By supporting a systematic horizontal analysis, the method allows evaluators to uncover problems related to cross-platform composition, continuity, and consistency, thereby informing the design and evolution of cross-platform systems, including strategies such as graceful degradation.

5.3.2 Application

The authors Maués and Barbosa [2014] applied CP-SIM to the *8tracks* system, a cross-platform music streaming service offering a desktop web version, a mobile web version, and a native mobile application. The evaluation was guided by a continuous usage scenario that required users to move between platforms in order to accomplish their goals, since not all functionalities were available in every system version. This context emphasized the need to assess not only the communicability of each interface individually, but also the coherence of the system as an integrated multi-platform whole.

The application of CP-SIM combined vertical and horizontal analyses. In the vertical analysis, the traditional Semiotic Inspection Method was applied independently to each version of the system, allowing the authors to reconstruct the designer to user metamessage, identify local communicability breakdowns, and observe how each platform communicated the existence and role of other versions. In the horizontal analysis, the reconstructed metamessages were systematically contrasted across platforms, and the observed differences were interpreted as semiotic manipulations at the lexical, syntactic, and semantic levels.

This comparison revealed inconsistencies in terminology, interface organization, and the availability and meaning of functionalities, leading to communicability breakdowns that emerged specifically from platform switching. The study showed that issues that appeared limited in a single version could be intensified or mitigated when considered across platforms, and that insufficient transparency about feature distribution negatively affected cross-communicability, reinforcing the relevance of CP-SIM for evaluating and improving cross-platform systems.

5.4 SIM with Deictic Signs (2017)

In Lopes *et al.* [2015], the authors analyze the applicability of the Semiotic Inspection Method (SIM) in the evaluation of communicability in software from the digital games domain, considering interactive contexts marked by high complexity and a strong immersive character. The study highlights limitations in the interface classes of signs traditionally adopted by Semiotic Engineering, namely metalinguistic, static, and dynamic signs. In particular, regarding the representation of phenomena external to the system, such as the personal, spatial, and temporal contexts of interaction, pointing to the need to expand the method to address these aspects.

In this regard, Lopes *et al.* [2017] introduces the concept of the deictic sign, originating from Linguistics and Semiotics, as a theoretical and methodological element that can be incorporated into adapted versions of SIM. The *deictic sign* establishes an indexical relation with its referents, situating them in terms of person, space, and time, always in relation to the moment of communication mediated by the interface. This perspective proved particularly relevant in the analysis of digital games, in which the user experience strongly depends on the articulation between data from the physical world and its symbolic representation within the system.

Based on the application of SIM to the games *Ingress*, *Kinectimals*, and *Just Dance Now*, the authors observed that a significant portion of the messages conveyed by the interfaces referred directly to elements external to the system, such as the player's identity, physical location, bodily movements, and the specific moment of interaction. These elements could not be adequately analyzed using the traditional SIM categories, as they do not refer exclusively to internal system states or behaviors, but rather to the situated context of interaction.

In light of this scenario, the authors propose an explicit adaptation of the Semiotic Inspection Method through the inclusion of a new formal class of signs, deictic signs, organized into three subcategories: personal deixis, related to who is interacting; spatial deixis, associated with where the interaction takes place; and temporal deixis, linked to when the interaction occurs. This extension allows the method to systematically account for contextual references that are fundamental in context-aware systems.

From a procedural standpoint, the modification of SIM is realized through the introduction of a specific step for inspecting deictic signs, integrated into the segmented analysis of the system. As a result, the method is able to explicitly consider not only the communicability constructed from signs internal to the interface, but also those that emerge from the relationship between the system and the real context of use. This adaptation makes SIM more suitable for evaluating sys-

SIM Deictic Signs

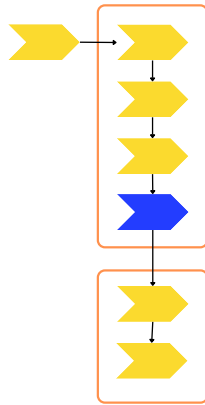


Figure 11. Summarized illustration of the SIM with Deictic Signs

tems such as digital games, augmented reality applications, collaborative environments, and ubiquitous computing systems, in which communicability intrinsically depends on data external to the interface.

5.4.1 Modified Method

The steps of the *SIM with Deictic Signs* can be described as follows (text in blue and italic highlights steps that are different from or added to the original method):

- **Step 0: Preparation**, including the definition of scope and scenarios;
- **Step 1: Inspection of metalinguistic signs**, resulting in metamessage 1 and identified communicability issues;
- **Step 2: Inspection of static signs**, resulting in metamessage 2 and identified communicability issues;
- **Step 3: Inspection of dynamic signs**, resulting in metamessage 3 and identified communicability issues;
- **Step 4: Inspection of deictic signs (personal, spatial, and temporal), resulting in metamessage 4 and the identification of communicability breakdowns;**
- **Step 5: Comparison and contrast** of the *four* metamesages and communicability breakdowns found;
- **Step 6: Communicability appreciation.**

Figure 11 shows the SIM summarized illustration with the specific additions of this modification highlighted in blue, namely the fourth step, which performs the analysis of deictic signs.

In summary, the incorporation of deictic signs does not alter the theoretical foundations of SIM, but rather expands its analytical scope and strengthens its ability to evaluate communicability in complex interactive contexts, in which the interface acts as a mediator between the designer, the user, and the physical world in which the interaction is situated.

5.4.2 Application

The study by Lopes *et al.* [2017] applied the Semiotic Inspection Method, SIM, with the incorporation of deictic signs to the digital games *Ingress*, *Kinectimals*, and *Just Dance Now*, considering tasks representative of real gameplay. Initially, the authors applied SIM in its traditional form, reconstructing the system metamesages based on metalinguistic, static, and

dynamic signs. However, during this phase, recurring interaction elements were identified that could not be adequately analyzed through these categories, particularly those related to the player's physical, temporal, and personal context.

The application of SIM with deictic signs highlighted, across all three games, the central role of external context in interface communicability. In *Ingress*, spatial deictic signs exposed inconsistencies between the in game map representation and the actual urban environment, revealing flawed assumptions regarding the player's spatial orientation and environmental knowledge. In *Kinectimals*, the analysis showed that spatial and personal deictic signs, especially those related to motion capture, did not always accurately correspond to the sensor's real capabilities, resulting in communicability breakdowns during interaction. In *Just Dance Now*, temporal deictic signs were particularly salient, as the availability of songs and challenges varied according to time and account type. Additionally, spatial and temporal deictic signs used in performance feedback did not always clearly indicate which aspects of the player's movements were incorrect.

Overall, the application of SIM to digital games with the inclusion of deictic signs demonstrated that the method becomes more suitable for analyzing strongly situated interactive systems, in which interaction depends on who the user is, where they are, and when the interaction takes place. The inspection showed that many communicability problems identified in the analyzed games did not stem from failures in internal interface signs, but rather from how the system represented, or failed to represent, the external interaction context. Consequently, the adaptation of SIM proved to be essential for a more precise evaluation of communicability in digital games.

5.5 SIM-SR: Screen Reader (2019)

The Semiotic Inspection Method mediated by Screen Reader (SIM-SR) was proposed as an adaptation of the Semiotic Inspection Method aimed at evaluating the communicability of interactive systems when interaction is mediated by screen readers, as typically occurs for users with visual impairments [Carvalho *et al.*, 2019]. The proposal is grounded in the understanding that the screen reader plays an active role in mediating the designer's meta-communication, effectively translating the interface's signs into auditory representations. As a result, the communication process originally established between designer and user becomes indirect and subject to transformations introduced by this mediation.

From a semiotic perspective, this mediation may introduce omissions, distortions, ambiguities, or additional information that were not part of the designer's original communicative intent. Such transformations can compromise the consistency and clarity of the metamessage, generating communicability breakdowns that are specific to users who rely on screen readers and that may remain invisible in traditional applications of SIM. SIM-SR addresses this gap by explicitly incorporating the screen reader as an intermediary in the communicative process, thereby extending SIM's analytical scope to account for accessibility-related phenomena intertwined with communicability issues.

Methodologically, SIM-SR preserves the core structure of the original SIM while introducing systematic adaptations

across its analytical stages. In each step dedicated to the inspection of a specific type of sign (metalinguistic, static, and dynamic), the method incorporates a horizontal analysis that contrasts how the same signs are conveyed in the visual interface and through screen reader mediation. This dual inspection enables the reconstruction of parallel metamessages: one derived from direct interaction with the interface and another derived from the screen reader's auditory translation. The contrast between these reconstructions allows evaluators to identify inconsistencies, meaning losses, or changes that might be introduced by the mediation process.

This comparative logic becomes particularly central in Step 4, in which the evaluator contrasts the reconstructed metamessages. In SIM-SR, this step is expanded to include not only the comparison among metamessages derived from different sign classes, as in the original method, but also the comparison between non-mediated and mediated interactions. This expanded contrast enables the identification of communicability breakdowns that affect all users, as well as those that specifically impact screen reader users due to accessibility limitations or translation issues. Consequently, the method supports a more fine-grained distinction between problems related to the content of the designer's metamessage and those arising from the screen reader's mediation.

By explicitly addressing this mediation, SIM-SR allows for an integrated analysis of communicability and accessibility. The method highlights that making content available to screen readers is not sufficient to ensure effective communication.

5.5.1 Modified Method

The steps of SIM-SR are organized as follows (the steps highlighted in blue and italic correspond to additions or modifications relative to the original method):

- **Step 0: Preparation**, including the definition of scope, user profiles, and inspection scenarios, *explicitly considering users who interact through screen readers*;
- **Step 1: Inspection of metalinguistic signs**: analysis and reconstruction of the metamessage based on metalinguistic signs in the visual interface, *followed by the inspection of the same signs as mediated by the screen reader and the contrast between the two metamessages*;
- **Step 2: Inspection of static signs**: analysis and reconstruction of the metamessage derived from static signs, *including their presentation through the screen reader and the contrast of the resulting metamessages*;
- **Step 3: Inspection of dynamic signs**: analysis of dynamic signs and system behavior, *considering both non-mediated interaction and interaction mediated by the screen reader, followed by a contrast of the reconstructed metamessages*;
- **Step 4: Comparison and contrast of metamessages**: *first conducted independently for non-mediated and mediated interactions, and then between them, enabling the identification of communicability and accessibility breakdowns*;
- **Step 5: Communicability and accessibility appreciation**, consolidating findings and explicitly accounting for the impacts of screen reader mediation on the communicative experience.

Figure 12 shows the SIM summarized illustration with the specific additions of this modification highlighted in blue, namely the repetition of the first three steps using a screen reader and the individual comparison of the steps.

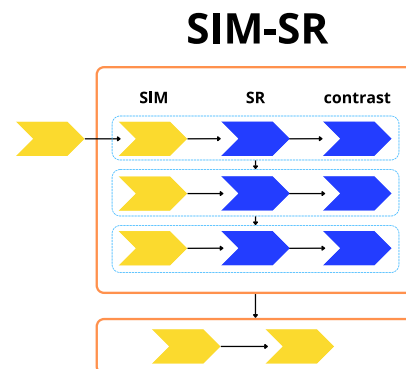


Figure 12. Summarized illustration of the SIM-SR

As part of their investigation authors have shown that SIM-SR stands out as a complementary approach to guideline-based accessibility evaluations, such as those grounded in Web Content Accessibility Guidelines (WCAG)¹⁰ [Carvalho *et al.*, 2023]. Rather than focusing solely on technical compliance, the method provides deeper insights into how accessibility shortcomings affect the transmission and interpretation of the designer's metamessage. In doing so, SIM-SR reinforces the role of communicability as a central quality attribute in accessible interaction design and expands the applicability of Semiotic Engineering to contexts of assistive technology mediation.

5.5.2 Application

The applicability of the Semiotic Inspection Method Mediated by Screen Readers (SIM-SR) was investigated through three qualitative case studies conducted on systems from different domains, namely the *TudoGostoso recipe website* [Carvalho *et al.*, 2021b,a], the *Trello project management tool*, and the *Todoist task management system* [Carvalho *et al.*, 2023]. The selection of these systems aimed to cover diverse contexts of use, levels of interaction complexity, and interface elements, enabling an assessment of the method's ability to identify communicability and accessibility problems in different scenarios of interaction mediated by screen readers.

Despite the differences among the analyzed systems, the three case studies revealed recurring patterns of problems when interaction is mediated by screen readers. In the analysis of metalinguistic signs, communicative breakdowns were identified in the presentation of instructions, help messages, and feedback that referred to exclusively visual elements or were not fully verbalized, compromising the understanding of expected actions by users with visual impairments. In some cases, relevant information was available only visually, while in others it was verbalized in an ambiguous manner or disconnected from the interaction context.

The analysis of static signs revealed difficulties related to

¹⁰See Web Content Accessibility Guidelines (WCAG) at <https://www.w3.org/WAI/standards-guidelines/wcag/> Accessed on 22 September 2026

the identification and comprehension of interface components such as buttons, links, form fields, and icons. Across all systems, elements that were adequately presented visually were not always meaningfully conveyed by the screen reader, due to the absence of appropriate labels, inadequate use of alternative texts, or the verbalization of irrelevant information. These issues resulted in communicative losses that hinder the recognition of available functionalities and the construction of a coherent understanding of the interface.

The most critical problems were observed in the analysis of dynamic signs. In all three case studies, system state changes, outcomes of user actions, and dynamic feedback were often not automatically announced by the screen reader. As a result, users with visual impairments needed to infer the effects of their actions through a new exploration of the static signs of the interface, increasing the cognitive cost of interaction and, in some situations, preventing the completion of essential tasks. This pattern was particularly evident in functionalities associated with rich interactions, such as adding or removing items, changing states, submitting content, and evaluating information.

The contrast of the reconstructed meta messages showed that although the systems convey a relatively consistent metamessage for users who interact visually, this message suffers significant losses when mediated by screen readers. The identified breakdowns were not limited to technical accessibility issues, but directly affected the quality of designer-to-user communication, revealing inconsistencies between the designer's intentions and how these intentions are transmitted to users with visual impairments.

Overall, the three case studies demonstrate that SIM-SR is effective in revealing communicability and accessibility problems that would not be fully captured by evaluations based solely on technical guidelines. The application of the method highlights the importance of explicitly considering screen reader mediation in the evaluation process, reinforcing the notion that accessibility should be understood not only as technical compliance, but as an integral part of the quality of communication established through the interface.

5.6 SIM-HInt: Human-Computer Integration (2024)

The evolution of Human-Computer Interaction (HCI) toward the paradigm of Human-Computer Integration (HInt) introduces new challenges to interaction analysis and evaluation. In HInt, digital technologies are conceived as partner technologies that act proactively and share agency with users, rather than functioning solely as passive tools or interaction mediators [Barbosa, 2022]. This paradigm shift demands adaptations to traditional evaluation methods in order to address new communicative dynamics characterized by autonomy, distribution, and coordination across multiple system components.

Within this context, Barbosa [2024] proposed SIM-HInt (Semiotic Inspection Method for Human-Computer Integration) as an extension of the original Semiotic Inspection Method. SIM-HInt is intended to support the analysis of meta-communication in HInt solutions composed of multiple interactive components, such as combinations of physical devices and digital systems. In these solutions, the designer's

communicative intent is not conveyed by a single interface, but is fragmented across components, with each component expressing only a partial contribution to the overall metamesage.

A key concept introduced by SIM-HInt is that of *integrated meta-communication*, understood as a predefined and distributed communicative act performed by designers through multiple components in order to convey a unified message to users. From this perspective, *integrated communicability* is defined as a quality attribute that reflects how consistently and coherently these distributed fragments convey the designers' intentions when considered together [Barbosa, 2022]. Integrated communicability, therefore, concerns both the clarity of the communicative strategies employed in each component and the user's ability to reconstruct the designers' overall communicative intent across the system as a whole.

To support the analysis of integrated communicability, SIM-HInt introduces methodological changes to the original SIM by explicitly incorporating horizontal and vertical analytical perspectives. The method is structured to first support an overarching understanding of how the designers' intentions are distributed across components, then allow a detailed inspection of each component individually, and finally enable the consolidation of findings into an integrated appreciation of the system's meta-communication.

SIM-HInt begins with a preparation phase, followed by a horizontal analysis of metalinguistic signs across all components. This horizontal analysis aims to generate an initial understanding of the intended integrated meta-communication and how it is partitioned among components. Subsequently, the method proceeds with a vertical analysis per component that is aligned with the original SIM. In the vertical analysis, evaluators should pay special attention to signs that refer to other components. A final horizontal analysis then supports the reconstruction and appreciation of the integrated metamessage conveyed by the system.

5.6.1 Modified Method

The steps of SIM-HInt are presented below, with text highlighted in blue and italic indicating steps that differ from or extend the original SIM:

- **Phase 1: Preparation**, including the definition of scope and scenarios, *identifying and structuring the inspection across multiple components*;
- **Phase 2: Horizontal Metalinguistic Analysis**
 - *Step 1: Inspect the metalinguistic signs of each component individually.*
 - *Step 2: Contrast the metamesages generated by each component and reconstruct the integrated metamessage based on the metalinguistic signs of all components.*
 - *Step 3: Appreciation of the integrated communicability based on metalinguistic signs.*
- **Phase 3: Vertical Analysis per Component**
 - **Step 1: Inspection of static signs**, resulting in metamessage 2 and identified communicability problems;

- **Step 2: Inspection of dynamic signs**, resulting in metamessage 3 and identified communicability problems;
- **Step 3: Contrast** and generation of the metamessage *for each component, including the metalinguistic analysis conducted in Phase 2*;
- **Step 4: Appreciation of communicability for each individual component**.
- **Phase 4: Horizontal Analysis of Integrated Meta-communication**
 - **Step 1: Contrast and consolidate the metames-sages of all components to generate an integrated metamessage for the system**;
 - **Step 2: Identify gaps, inconsistencies, overlaps, and communicative breakdowns in the overall metamessage**;
 - **Step 3: Generate the final appreciation of inte-grated communicability of the HInt system**.

Figure 13 shows the SIM summarized illustration with the specific additions of this modification highlighted in blue.

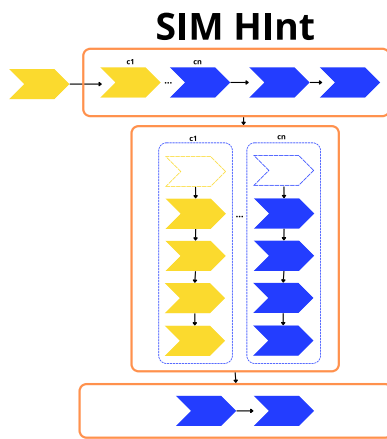


Figure 13. Summarized illustration of the SIM-HInt

By explicitly addressing the distributed nature of meta-communication in HInt solutions, SIM-HInt extends the analytical scope of the original SIM to account for communicative phenomena that emerge only when multiple components operate together. The method emphasizes the reconstruction and examination of integrated meta-communication as a central element for understanding how designers' intentions are conveyed in Human-Computer Integration contexts.

5.6.2 Application

The application of SIM-HInt was presented through a case study involving the Samsung Galaxy Fit2, a Human-Computer Integration solution composed of a smart band and supporting mobile applications [Barbosa, 2024]. The analysis examined how the responsibilities and roles of each component were communicated, including the smart band as the data collection device, the configuration application, and the application responsible for aggregating and presenting performance data.

Following the phases defined by SIM-HInt, the evaluation contrasted the metamesages conveyed by each compo-

nent and analyzed their consistency when considered jointly. The horizontal analyses supported the reconstruction of the integrated metamessage of the solution, while the vertical analyses per component enabled the identification of communicative gaps, ambiguities, and inconsistencies emerging from the distribution of interaction and feedback across components.

The SIM-HInt analysis concluded that, although each component conveys a relatively consistent communicative proposal when inspected individually, the integrated communicability of the solution as a whole is compromised by gaps and ambiguities arising from the fragmentation of meta-communication across components. Essential information about the integrated functioning of the solution is predominantly conveyed through metalinguistic signs external to the interfaces, which limits users' ability to reconstruct the designers' intentions during interaction. Additionally, the fragmentation of responsibilities between the smart band and the supporting applications, combined with the lack of explicit cross-references between interfaces, results in continuity breakdowns that would not be fully captured by applying the original SIM to isolated components.

5.7 Versions of SIM in the literature

Considering all identified applications, the Semiotic Inspection Method is well established in the literature, with more than 200 studies reporting its use, as discussed in Section 3. However, as presented in Section 5, the method has been adapted into five distinct variations designed to address specific contexts: Scientific SIM, CP-SIM, SIM with Deictic Signs, SIM-SR, and SIM-HInt. This section examines if and how these variants have been applied. Our goal is to generate initial indicators on each method's visibility and consolidation. As mentioned in Section 3.3, for each method we performed a forward snowballing search based on the main articles presenting the method – the seed set. Table 2 presents for each method, the articles considered in the analysis.

Table 2. Studies included in the seed set for each SIM variant.

Version of SIM	Seed reference
SIM-SR	Carvalho <i>et al.</i> [2019]
	Carvalho <i>et al.</i> [2021b]
	Carvalho [2021]
	Carvalho <i>et al.</i> [2023]
CP-SIM	Maués and Barbosa [2013] Maués and Barbosa [2014]
Scientific SIM	de Souza <i>et al.</i> [2010]
SIM-HInt	Barbosa [2024]
Deictic Signs	Lopes <i>et al.</i> [2017]

The results, presented in Table 3, show that Scientific SIM is the variant with the highest number of citations and reported applications, followed by SIM-SR. In contrast, although CP-SIM and SIM with Deictic Signs are cited in the literature, there are no reports of their application. Finally, SIM-HInt is the most recently published as part of a doctoral dissertation [Barbosa, 2024] and does not yet have any citations and, consequently, no reported applications.

The earliest modification identified in the literature is

Table 3. Citations and applications of Semiotic Inspection Method variants

Version of SIM	Year	Citations	Applications
Scientific SIM	2010	97	16
CP-SIM	2013	22	0
Deictic Signs	2017	13	0
SIM-SR	2019	18	5
SIM-HInt	2024	0	0

Scientific SIM, introduced in 2010, which has since been applied in both journal articles and academic theses. For Scientific SIM, more than 155 citations of the work by de Souza *et al.* [2010] were identified. Among these, 97 publications explicitly include the terms “scientific” or “científico”, considering both the English and Portuguese denominations of the variant. These 97 articles were therefore subjected to a diagonal analysis aimed at identifying whether they reported on applying the method.

We noticed that the article is often used as a reference to the original Semiotic Inspection Method, or relevant concepts to its applications such as sign classes or the communicability concept. In most cases the Scientific SIM is not mentioned, and consequently, also not applied. In our analysis, we took into account a previous work that conducted a systematic literature review to investigate the applicability of SIM [Reis and Prates, 2011] reported that Scientific SIM had been applied in 3 other studies. Then we identified, 13 studies that applied Scientific SIM from 2011 on (different from the ones considered in Reis and Prates [2011]). Thus, in total we could consider that at least 16 studies have applied Scientific SIM.

It is important to note that in the case of Scientific SIM, the fact that we based our analysis only on the citations of de Souza *et al.* [2010] could be a significant limitation. The book entitled “*Semiotic Engineering Methods for Scientific Research in HCI*” [de Souza and Leitão, 2009] discussed the scientific application of two communicability methods: the Semiotic Inspection Method (SIM) and the Communicability Evaluation Method (CEM). Thus, other publications that might have applied Scientific SIM and cited only this book as reference might not have been identified in our analysis.

Two recent examples illustrate the applications of the Scientific SIM variant in different contexts. In Souza and Prates [2021] the method was used to investigate how game engines communicate, through their interfaces, the strategies and constructs that enable users without prior programming knowledge to create games. On the other hand, Gomes *et al.* [2025] analyzed how generative AI systems communicate ethical considerations to users, using Scientific SIM. They conclude that ChatGPT, Gemini, and Claude do not communicate these aspects clearly or consistently through their interfaces, despite having policies addressing ethics.

Introduced in 2019, **SIM-SR** was cited by 18 other publications, and 5 of them have applied it. Among these works, de Barros *et al.* [2024] investigated communicability problems related to the use of screen readers in academic systems of public higher education institutions, examining whether these problems occur across different institutions. Cardoso *et al.* [2023] used SIM-SR as part of a methodological triangulation, applying it to both the homepage and the ontology visualization page of the sickle cell disease ontology in Bio-

Portal.

The introductory article on the Cross-Platform Semiotic Inspection Method (**CP-SIM**) [Maués and Barbosa, 2013] has 12 citations. However, none of them report applying the method. Similarly, **SIM with Deictic Signs** [Lopes *et al.*, 2017] was cited by 13 other papers without any mentions of applying the method. Finally, for **SIM-HInt**, the most recent modification of SIM [Barbosa, 2024], we did not find any citations or application reports.

6 Discussion

The analysis of the adaptations derived from the Semiotic Inspection Method (SIM) reveals the gradual consolidation of the method into a coherent “family” of SIM methods. It is important to emphasize that none of the proposed variants aims to replace the original SIM. Instead, they are conceived as complementary alternatives, designed to address contexts in which the original method alone may not be sufficient. Table 4 summarizes the main differences among the SIM-derived methods. In this section, we discuss how these variants relate to each other regarding their focus, structure, consolidation, and potential integration.

6.1 Focus

Most of SIM adaptation proposals were motivated by specific issues regarding emerging challenges in HCI and digital transformation. Except for Scientific SIM, the other proposals focus on assessing the communicability of interactive systems within specific contexts of use. Scientific SIM, in contrast, shifts the analytical focus from the system’s communicability to the designer’s discourse and the solution embodied in the system, with the explicit goal of generating scientific knowledge about HCI. Rather than emphasizing communicability as a measure of interaction quality, typically associated with the technical application of the method, Scientific SIM adapts SIM to function as a research-oriented analytical instrument [de Souza *et al.*, 2010].

The remaining variants, namely CP-SIM, SIM with Deictic Signs, SIM-SR, and SIM-HInt, preserve communicability as their core analytical concern. These methods aim to identify communicative breakdowns occurring during user–system interaction, reconstruct the designer’s meta-communication, and analyze how this message is conveyed through different interactional configurations. SIM with Deictic Signs and SIM-SR adhere closely to the original definition of communicability, while CP-SIM and SIM-HInt extend the concept to address more complex technological arrangements.

SIM with Deictic Signs includes a new type of sign in the Semiotic Engineering classification of interactive signs – deictic signs, which refer to elements represented in the interface that are external to the system (e.g. physical location) [Lopes *et al.*, 2015, 2017]. Thus, the method broadens the possible interactions and types of signs considered. Although SIM-SR [Carvalho *et al.*, 2019] is grounded in the original notion of communicability, its comparative analysis of the original system with the screen-reader-mediated interaction also aims at identifying accessibility barriers and interaction problems introduced by assistive technologies.

CP-SIM introduces the concept of *cross-communicability*, defined as the system’s ability to

Table 4. Comparative summary of the methods derived from SIM

Method	Application Context	Modifications	Distinctions
Scientific SIM	Scientific research in HCI	Formulation of a research question, and inclusion of result triangulation	Potential for generating generalizable knowledge and methodological validity
CP-SIM	Multi-platform systems (web, mobile, tablet)	Vertical analysis per version and horizontal analysis across platforms	Focus on <i>cross-communicability</i> , assessing continuity and consistency across different versions of the same system
SIM with Deictic Signs	Context-aware systems	Addition of a new class of signs: deictic (personal, spatial, and temporal)	Inspection of external references like time, space, and user identity
SIM-SR	Accessibility with screen readers	Comparison of metamessages without and with screen reader use	Highlights how the screen reader mediation affects the intended meta-communication
SIM-HInt	Autonomous technology composed of more than one component	Horizontal metalinguistic analysis, vertical inspections per component, and integrated meta-communication	Focus on <i>integrated communicability</i> across multiple components, evaluating the solution as partner technology

communicate consistently across multiple platforms through which users may interact with it [Maués and Barbosa, 2013]. SIM-HInt, in turn, focuses on *integrated communicability*, examining how different components of an autonomous or multi-component solution convey complementary portions of the designer’s metamessage and how these portions can be integrated by users into a coherent understanding of the system [Barbosa and Prates, 2022]. Although both approaches involve multiple devices or components, they differ conceptually. In cross-communicability, each platform conveys a standalone version of the metamessage, requiring consistency across platforms so users can use different versions seamlessly. In integrated communicability, each component conveys only part of the overall metamessage, and users must interact with the different parts and integrate them (i.e. make sense of them as part of a whole) to fully comprehend the intended communication.

6.2 Structure

The analysis also indicates that the extended versions of SIM adopt distinct strategies to modify the original method. Figure 14 depicts an overall summarized view of the steps of each method, highlighting in blue the changes from the original method. Scientific SIM and SIM with Deictic Signs introduce additional steps into the original procedure. In Scientific SIM, the definition of a research question is incorporated into the preparation stage, and a triangulation step is added at the end of the inspection process. SIM with Deictic Signs includes a step to analyze deictic signs (as part of the segmented analysis), which subsequently informs the contrast and communicability appreciation stages (the same as the other types of signs).

In contrast, CP-SIM, SIM-SR, and SIM-HInt adopt a similar structural strategy in their extensions of the original method. All three approaches involve the inspection of multiple versions, either complete or partial, of the designer’s metamessage. In CP-SIM, these versions correspond to different platforms; in SIM-SR, to the original system and its screen-reader-mediated counterpart; and in SIM-HInt, to the partial messages conveyed by each system component. Across these methods, the analytical process is explicitly organized

around the systematic articulation of vertical and horizontal analyses. Vertical analysis refers to the inspection of a single system version or component following some or all of the original SIM steps, whereas horizontal analysis involves contrasting results obtained across different versions or components.

While sharing this common structure, each method operationalizes vertical and horizontal analyses in a distinct manner. CP-SIM applies vertical inspections independently to each platform-specific version and subsequently introduces additional steps dedicated to the horizontal integration and interpretation of the results. SIM-SR embeds horizontal analysis throughout the inspection process by systematically contrasting each step of the original interaction with its screen-reader-mediated counterpart. SIM-HInt, in turn, begins with a horizontal inspection of metalinguistic signs across all components, proceeds with vertical inspections of each component, and concludes with a final horizontal integration aimed at reconstructing the overall meta-communication and producing a global communicability assessment. In all cases, the deliberate coordination of vertical and horizontal traversals is theoretically grounded and represents a central methodological contribution of these extensions.

6.3 Consolidation

In the 20 years since SIM was proposed, we identified five adaptations motivated by emerging interaction contexts that go beyond the original method’s scope. These variants preserve the core principles of Semiotic Engineering, particularly communicability as a relevant quality of the designer-to-user meta-communication, while introducing targeted methodological extensions (e.g., additional analytical stages, new classes of signs, mediated interaction, and cross-platform comparison), thus forming a complementary family of methods that reinforces SIM’s conceptual robustness and methodological flexibility.

We can argue that the proposals are theoretically sound as each one of them explicitly justifies its motivation and changes based on Semiotic Engineering. Furthermore, all authors proposing the adaptations have conducted at least one case study of the new method. These studies demonstrate

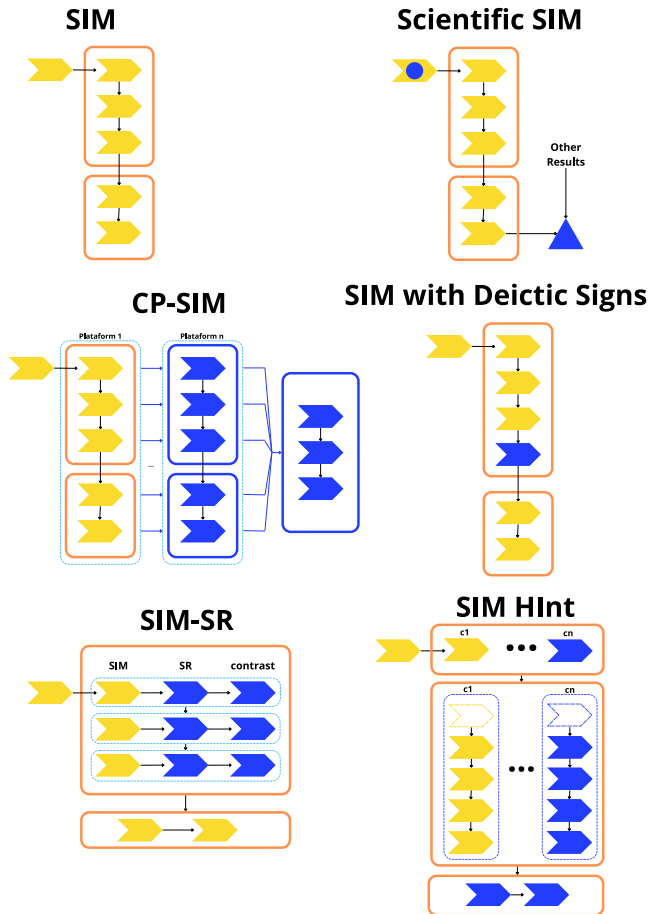


Figure 14. Complete diagram with all versions

the feasibility of the proposed methods and illustrate specific aspects of their application. Rather than seeking comparative validations of effectiveness, these studies show how each variant addresses specific evaluation demands not fully covered by the original SIM. Taken together, the results extend the analytical scope of SIM to emerging contexts, mediating technologies, and integrated technology (i.e. requiring multiple interactive components).

Aiming to generate an initial indicator of each's variant consolidation, we analyzed their application. However, except for Scientific SIM, the others have not yet been (broadly) applied in other contexts, and by other researchers. In the case of Scientific SIM, although its citation record is substantial, most works reference it only as theoretical grounding for communicability and SIM, without explicitly applying the method. Nevertheless, our analysis identified at least 16 empirical studies that applied Scientific SIM in different contexts, suggesting that it is the most consolidated SIM adaptation so far.

In our initial analysis, we identified that CP-SIM (2013) and SIM with Deictic Signs (2017) have been cited, but not applied in other case studies. SIM-HInt (2024) is the most recent adaptation, and has not been cited yet. SIM-SR (2019) has been applied in other works, that do not involve the authors [de Barros *et al.*, 2024; Menezes *et al.*, 2023; Melo *et al.*, 2024, 2026; Cardoso *et al.*, 2023]. This scenario suggests the need for future empirical studies applying the methods that generate reports and indicators (positive or negative) about their applicability.

Even though the literature does not offer a clear explanation for this low adoption rate, we can raise some possible reasons. First of all, the methods focus on communicability, which is not the main property usually assessed of systems - usability, user experience (UX) and accessibility are more broadly used as a quality property¹¹. Considering that SIM and its variants have been proposed by Brazilian researchers, one might wonder whether publication language could have played a role in its adoption. However, the language of the papers presenting the variants do not seem to be related to their adoption. Most of the articles were published in English in international forums - Scientific SIM [de Souza *et al.*, 2010] international HCI journal (English); CP-SIM [Maués and Barbosa, 2013, 2014] international HCI conferences (English); SIM with Deictic Signs [Lopes *et al.*, 2017] international HCI journal (English); SIM-SR [Carvalho *et al.*, 2019, 2021b] Brazilian HCI conference (Portuguese), but in an international HCI journal in 2023 [Carvalho *et al.*, 2023], and SIM Hint [Barbosa, 2024] PhD thesis (Portuguese). Thus, the language does not seem to have a direct affect in the method's consolidation.

One other aspect to consider is that SIM requires evaluators to have (at least a basic) knowledge of Semiotic Engineering theory and is costly in terms of time [Reis and Prates, 2013]. All the variants proposed also require this knowledge, and may combine it with other specific concepts (i.e. deictic signs or accessibility principles) or technologies (i.e. HInt technology). As they all include more steps or more than one traversal, they necessarily require more time to be applied than the original method. Finally, there is not much material about the methods available, besides the articles in which they are proposed and/or initially applied, which tend to focus on the research, rather than teaching how to apply the method.

All these issues point to open avenues for future investigation that can contribute to the visibility and consolidation of the methods.

6.4 Potential Combination

The proposals for each SIM variant justified the need for the new adaptation and cited previous variants, as can be seen in Figure 15. Although they all focus on different contexts, they are not mutually exclusive. For instance, considering a system that could be used on different platforms, one might be interested in assessing the consistency of cross-platform versions to users, including those interacting with the support of Screen Readers. Another scenario would be for one (or more components) of a HInt technology to include deictic signs. These examples indicate that there could be situations in which it would be interesting to combine two (or more) SIM variants.

All the variants, conduct an inspection segmented by sign class, followed by an integrative analysis to synthesize the results. Thus the overall structure of the original SIM, and the inspection of each sign class are maintained in all variants. The main differences are related to how the steps are articulated into the vertical and horizontal analysis and

¹¹In a quick search in Google Scholar for each of these terms we have found: 'usability': 2,880,000 results; 'ux' or "user experience": 136,000 results; 'accessibility': 7,880,000 results; 'communicability': 46,000 results. (Conducted on Feb 13th, 2026).

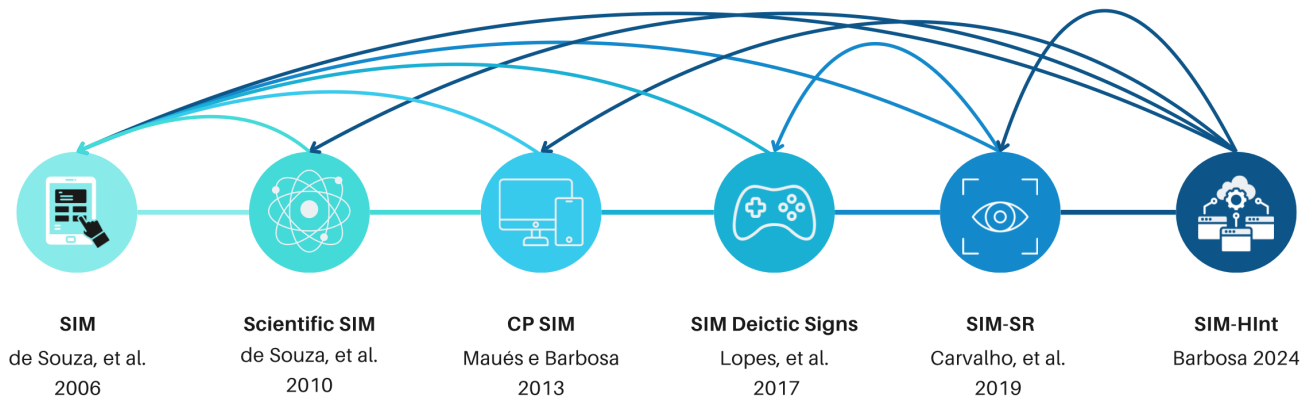


Figure 15. Citations between articles

the inclusion of some extra steps (e.g. in Scientific SIM the research question and triangulation; and in SIM with Deictic Signs the inspection of deictic signs). Thus, methodologically it is possible to combine one or more variants into an overall evaluation process.

In the proposal for Scientific SIM [de Souza *et al.*, 2010], the authors argue that SIM, could be applied technically – with a focus on the communicability of the system, or scientifically – with a focus on generating new knowledge based on the analysis of the designer’s discourse embodied in the system. The scientific application required an initial research question to be defined (at the preparation step), an analysis of each step, including an analysis of what the metamessage conveyed about the research question, and a final triangulation step. All the other variants focus on how to apply SIM to different contexts, and the case studies presented technical applications of each variant. Nevertheless, adding the same changes described (i.e. the research question and triangulation) to a variant, would allow a scientific version of the variant to be applied in its specific context. In other words, it would mean posing the research question in the Preparation step, including in the segmented steps the analysis of the research question, and adding a final triangulation step to any of the variants.

The SIM with Deictic Signs variant included one step (namely the *Inspection of the deictic signs* step) in the segmented analysis of the sign types and its consideration in the contrast and appreciation steps (steps 4 and 5 – integrative analysis). All the other proposed variants include the original 3 steps of the segmented analysis, as can be seen in Figure 14. Thus, if a system in any of the contexts considered by the variants included deictic signs, it would be possible to take them into consideration by adding the ‘*Inspection of the deictic signs*’ step in the segmented analysis of each variant.

SIM-SR proposes that for each type of class in the segmented analysis, the evaluator contrasts what is being conveyed by signs in that class, considering the original interface, and how they are presented to users by the Screen Reader. Thus, for the other variants, for each step of the segmented analysis (of each component) it would be necessary to also include the analysis of how the screen reader presented the signs and the contrast between them (original and screen-reader).

CP-SIM and SIM Hint involve the inspection of more than one component – CP-SIM applies when each component

is a version of the metamessage, whereas SIM HInt when each component presents parts of an overall message. Thus, in both cases, combining them with SIM with Deictic Signs or SIM-SR would require the specific step(s) to be applied to the vertical analysis of each component, as discussed before. However, this still leaves us with the question whether it would be possible to combine the two of them? We can envision the possibility of the two contexts being combined. A HInt technology might have one of its components (the same part of the metamessage) available in more than one platform. That would mean that the vertical traversal in SIM Hint for that platform should be substituted by the CP-SIM variant. We can also conceive a scenario in which a HInt technology could be available through different sets of components, each set presenting the same solution. In other words each set would be considered “a platform”. Thus, the inspection would require each vertical traversal of CP-SIM to be the application of SIM HInt to that “platform”.

In short, the theoretical framework in which SIM and its variants are grounded show that it would be possible to combine different variants to evaluate specific contexts that included two or more of their focus. This combination might even be necessary in some cases, as the individual application of each variant may limit the evaluator’s ability to analyze the metamessage being conveyed as a whole (e.g. if a HInt technology included deictic signs). Nonetheless, the combination itself raises other issues that represent an open research agenda regarding:

- **Combination:** (i) How should the segmented and integrative steps be sequenced when combining two or more variants? (ii) Would this combination depend only on the variants being combined, or could the system and its domain play a role in defining the best combination? (iii) Would it be feasible to define a generalized procedural template for combining any pair (or set) of variants within the SIM family – a “Meta-SIM” method, rather than requiring an ad hoc combination strategy for each new context?
- **Cost and Benefits:** Combinations would likely be more costly to conduct than applying an individual variant, but potentially less costly than applying two different variants independently (which would mean repeating some of the steps that are common in both variants) and

reconciling their results post hoc. Thus, (i) What would be the additional time and effort cost of a combined application relative to applying each variant separately? (ii) Does the cost to apply combined variants scale linearly with the number of variants? (iii) Would the generated results be equivalent to applying each variant separately or could combined applications reveal communicability or accessibility breakdowns that remain invisible to any individual variant applied in isolation?

Future work investigating these issues, empirically evaluating the existing variants and their possible combinations, and contrasting them against the application of individual methods, will contribute to the understanding and adoption of the SIM family.

7 Conclusion

By systematically reviewing the adaptations of the Semiotic Inspection Method (SIM), this study traced the theoretical and methodological evolution of the method since its original formulation. Among the five identified SIM variants, Scientific SIM stands out for shifting the focus of application from a primarily technical evaluation of communicability to the use of SIM as a scientific instrument for generating knowledge in HCI. The remaining four variants were proposed to enable the application of SIM in specific contexts in which limitations of the original method had been identified. Thus, the SIM variants should be understood as complementary rather than substitutive, offering additional analytical resources to address more specialized or complex evaluation scenarios.

One of the costs usually associated to SIM is having to learn the Semiotic Engineering theoretical concepts necessary to understand and apply the method [Reis and Prates, 2013]. Our study shows that this knowledge also has benefits, as the different SIM variant proposals justified the original SIM's limits and articulated their proposed changes in terms of communicative aspects of the Semiotic Engineering theory ontology. Thus, one of the contributions of this study is to strengthen the argument of the usefulness of including theoretical background as part of HCI professionals' education [Carroll, 2003; Rogers, 2012].

Even though the proposed variants of SIM are well grounded in Semiotic Engineering, most of them have only been limitedly applied, based on our initial review of the literature. All of the methods have been applied in at least one or more case studies by the authors as a proof of concept, demonstrating their applicability and usefulness. Only two of the methods have been applied by other researchers: Scientific SIM (at least 16 application reports) and SIM-SR (5 application reports identified). Thus, except for Scientific SIM, further studies applying the proposed versions are needed in order to allow for the consolidation of these variants, as well as to generate indicators of their costs and benefits. Furthermore, comparative studies discussing strengths, limitations, and complementarities between different methods that could be applied in the contexts for which the variants have been proposed would be relevant.

This study has organized and contrasted the existing variants of the method, clarifying their analytical focus and methodological adaptations. Thus, it contributes to the re-

search on Semiotic Engineering theory by articulating how different SIM variants incorporate and operationalize distinct theoretical considerations. It also provides an overall view of communicability, including the proposals to extend the concept, particularly *cross-communicability* and *integrated communicability*, along with their corresponding evaluation SIM variant – CP-SIM and SIM HInt, respectively.

In addition, the findings contribute to the Brazilian Grand Research Challenges in Human-Computer Interaction for 2025–2035 [Pereira *et al.*, 2024], especially *Grand Challenge 1 – New Theoretical and Methodological Approaches* [da Silva Junior *et al.*, 2024] and *Grand Challenge 7 – Interaction with Emerging Technologies* [Zaina *et al.*, 2024], as the analyzed variants propose methodological responses to new interaction contexts and emerging technologies. These results may also motivate further investigations into how SIM could be adapted to address other challenges that demand novel evaluation approaches.

The findings also relate to international research agendas in HCI, such as the Seven HCI Grand Challenges [Stephandidis *et al.*, 2019, 2025]. In this context, our study contributes by systematizing how SIM has been adapted to address such emerging contexts, offering a consolidated view of methodological extensions that support communicability inspection in increasingly distributed, mediated, and integrated interaction scenarios.

As a practical contribution, as part of this research *SIM Studies* was developed. As SIM Studies is a public platform, our goal is to maintain and update its repository so that it can be useful to others interested in researching or finding material regarding SIM.

Overall, this work contributes both to consolidating existing knowledge about SIM and to fostering critical reflection on the evolution of evaluation methods in HCI. By systematizing the uses, adaptations, and application contexts of SIM, the results are expected to support evaluators in making informed decisions regarding the most appropriate variant of the method for their specific contexts. Moreover, the findings encourage the exploration of new proposals aligned with the technological, social, and communicational transformations shaping contemporary interaction.

The findings of this study also point to several directions for future research. We conducted an initial analysis of the consolidation of each SIM variant. However, it would be relevant to investigate further, with a more thorough search of articles that may have applied the methods and generating indicators of their consolidation thus far. We have also theoretically discussed the possibility of combining two or more of the variants. As discussed in section 6.4, it would be interesting to investigate possible ways to combine the different variants and their cost. It would also be relevant to conduct case studies to analyze practical aspects of these combinations. Furthermore, it could be relevant to investigate a meta-method that could support the proposal of new SIM variants, if necessary.

Additionally, future research could investigate tools that have been proposed to support the application of SIM, assessing their current availability and their potential to support existing or future SIM variants. The increase use of LLMs in different aspects of HCI research [Pang *et al.*, 2025] and its

use in evaluation methods [Guerino *et al.*, 2025; Meira *et al.*, 2026], also motivates a research regarding how LLMs can support in the application of the SIM family variants. The *SIM Studies* platform itself could be expanded to enable moderated contributions from the research community, ensuring that the database remains up to date. Finally, the classification scheme adopted in this study could be refined through the introduction of subcategories that account for application contexts or technological characteristics, further enhancing analytical precision.

Declarations

Authors' Contributions

CF and RP contributed to the conceptualization of the study and developed the methodology. CF, RC, and RP contributed to the data curation. RC e CF contributed to software development and formal analysis. CF, RC, and RP conducted the investigation. RC contributed to the visualization and preparation of the figures. CF, RP, and RC were responsible for project administration. RP led the validation process. All authors contributed to the writing and review of the manuscript, and have read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests

Availability of data and materials

The software generated and analysed during the current study are available in <https://ricardo.bib.br/mis/>. To ensure access to the data, a CSV dataset extracted on September 26, 2026, is provided as part of this study.

Further relevant information

Citation Diversity Statement: The authors acknowledge that citation practices are not neutral and may reflect structural biases in scientific production. In compiling the reference list for this study, efforts were made to include contributions from researchers of different genders, geographic regions, and institutional contexts, within the constraints imposed by the scope of the topic and the availability of relevant literature. Although no formal quantification of citation diversity was conducted, the authors adopted a reflective and conscientious approach to citation choices, aiming to contribute to more equitable and inclusive scholarly practices.

Generative AI Usage Statement: The authors declare that generative AI tools were used to support improvements in language quality, grammar, punctuation, and textual clarity, as well as to assist with translation into English, which is not the authors' first language.

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