Communicability Inspection: Which version of the Semiotic Inspection Method should I use?

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Abstract. Introduction*: The Semiotic Inspection Method (SIM) is widely used to evaluate the communicability of interactive systems, and over the years, researchers have proposed adaptations to SIM.* ***Objective:*** *This paper aims to identify and analyze proposals in the literature that generate a new version of the method.* ***Methodology or Steps****: A literature review was conducted to collect the intended studies. The new versions were then analyzed to understand their motivations and modifications proposed.* ***Results:*** *Five new versions of SIM were identified. The analysis reveals that different aspects of the method were altered according to the intended application context, reflecting the method's flexibility and the evolving needs of its users.*
Keywords *Semiotic Inspection Method, SIM, SIM versions, Semiotic Engineering, Communicability, Systematic Literature Review*

1. Introduction

The accelerated advancement of digital technologies in recent decades has triggered profound social and technical transformations, driven by continuous innovations in Information and Communication Technologies (ICTs). This process, known as Digital Transformation [Weiss 2019], is reshaping the ways people interact, collaborate, and participate socially, as technology takes on a central role in organizing contemporary life.

In this context, the evolution of interaction paradigms, with increasingly distributed, context-aware environments mediated by multiple devices, has intensified the challenges in Human-Computer Interaction (HCI). As highlighted by the II GranDIHC-BR initiative, which identified seven critical societal and technological challenges from 2025 to 2035 in Brazil [Pereira et al. 2024], these innovations demand new theoretical and methodological approaches to address the complexities introduced by emerging technologies [Zaina et al. 2024], as well as to include new visions of the world, technology, human practices, and relationships [da Silva Junior et al. 2024].

Furthermore, the rapid adoption of these technologies and the resulting symbiosis among individuals, technologies, and contexts underscore the importance of adapting evaluation methods and fostering HCI research that considers both local and global perspectives, as discussed in the analysis of the Grand Challenge on Emerging Technologies [Pereira et al. 2024, Zaina et al. 2024]. Although these challenges have been identified in the Grand Challenges in HCI in Brazil, we can argue that the needs and challenges to adapt consolidated evaluation methods or even new frameworks or methods capable of addressing the specificities of these evolving interaction dynamics are an international goal [Barbosa 2022, Stephanidis et al. 2025].

Among the existing qualitative evaluation methods is the Semiotic Inspection Method (SIM) [de Souza et al. 2006], grounded in Semiotic Engineering Theory (SemEng) [de Souza 2005]. SIM was originally proposed to analyze the communicability of interactive systems, *i.e.*, how the system conveys to its users their underlying design intent and interactive principles. As SIM examines the communicative aspects of interactive systems, the authors argued that it could be applied to different contexts and technologies [de Souza et al. 2006]. Later, [Reis e Prates 2011] investigated this claim and as a result showed that SIM could be applied to multiple contexts and technologies without the need for structural modifications to the method.

However, with technological advances and the growing complexity of digital environments, more recently adapted versions that propose modifications to SIM to meet new evaluation challenges have been published. Thus, in this work, we have investigated these new versions that have adapted the original SIM method [de Souza et al. 2006] to allow its application in specific scenarios. Our goal was to analyze the proposed methods, identifying the contexts that motivated the adaptation, the changes proposed in the method, and the initial application and assessment of these methods.

To identify the proposed versions of the method, we conducted a systematic literature review, categorizing all SIM related publications and then conducting an in-depth analysis of the proposal of new versions that adapt SIM. Our findings indicate the existence of five distinct methods derived from SIM, which, when combined with the original version, amount to six different variants of the method. Each one addresses specific evaluation challenges while preserving the overall proposal of the Semiotic Inspection Method. In short, the methods either propose a new step to the method, or they include an inspection of more than one version or components of the system, and different strategies on how to generate and contrast their results.

This paper is organized into the following sections: *Theoretical Framework*, which presents the *Semiotic Engineering Theory* and the *Semiotic Inspection Method*; *Methodology*, describing how the systematic literature review was conducted; *Results* which presents a brief overview of the *overall results*, followed by the *Descriptions of the New Versions of SIM*, highlighting their differences to the original method; followed by the *Discussion* of our results, and finally, our *Conclusions* and future work.

2. Theoretical Framework

This section presents an overview of the Semiotic Engineering Theory and the main concepts necessary to understand SIM, as well as the Semiotic Inspection Method itself.

2.1. Semiotic Engineering Theory

Semiotic Engineering Theory (SemEng) is an explanatory theory within the field of Human-Computer Interaction that views the interface as a form of communication sent by the designer of an interactive system to its users [de Souza 2005]. SemEng aims to explain the phenomena that occur during the design, use, and evaluation of interactive systems, seeking to clarify the nature of these activities and the aspects involved in them.

SemEng perceives a system's interface as a meta-communication in which the designer, holding technical knowledge and an understanding of the users, delivers a one-way message to users through the system. This message, in turn, is received (and interpreted) by users as they interact with the interface. The content of the meta-message can be paraphrased by the template defined as:

> *"Here is my [the designer's] understanding of who you [users] 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 in it in order to fulfill a range of purposes that fall within this vision."* [de Souza 2005, p. 25].

The designer's message to the user is composed of signs (*i.e.* anything that means something to someone in some aspect or capacity [Peirce 1992]). SemEng proposes a specific classification of signs for the interface language of an interactive system, divided into three types: static, dynamic and metalinguistic signs [de Souza et al. 2006, de Souza e Leitão 2009].

Static signs are those that express the state of the system and can be interpreted independently of causal or temporal relationships. The interpretation context is limited to the elements present on the interface at a given moment. Examples include button states, interaction elements, and selected options.

Dynamic signs represent the system's behavior. They are related to the temporal and causal aspects of the interface and can only be perceived through interaction with the system. Unlike static signs, these extend over a sequence of moments, such as actions triggered by a button or the effect of selecting a specific attribute value.

Metalinguistic signs refer to other signs in the interface. They are used by designers to explicitly communicate to users the encoded meanings in the system and how they can be used. Typical examples include help systems, tooltips, error messages, and usage instructions.

In this context, the quality of an interactive system can be defined by its **communicability**, that is, the system's ability to communicate its logic, intent, and design principles in an organized and consistent manner, thereby fulfilling its intended purpose for the user [de Souza 2005, de Souza e Leitão 2009, Leitão et al. 2013]. In other words, SemEng considers designers of interactive systems as active participants in the communication process that takes place during users' interaction with the systems they have developed. Through the interface, designers convey their understanding of who the users are, what they need to do, how they are likely to do it, and why. Users, in turn, unfold and interpret this message as they interact with the system.

There are two main evaluation methods for assessing communicability [de Souza e Leitão 2009]: the Semiotic Inspection Method (SIM) and the Communicability Evaluation Method (CEM).

The key difference between them is that SIM is based on an expert's inspection, whereas CEM is an empirical method based on observing real users interacting with the system. Thus, SIM focuses on evaluating the emission of the meta-communication message by the designer, while CEM aims to evaluate how that message is received by users [de Souza e Leitão 2009] This work focuses on SIM, which will be described in greater detail in the following section.

2.2. The Semiotic Inspection Method (SIM)

SIM is an evaluation method that allows the evaluator to examine the communicability of a system by analyzing how effectively it conveys the designer's intentions and design decisions to its users [de Souza et al. 2006]. The method requires the evaluator to conduct a thorough analysis of what is being conveyed in by each type of sign (metalinguistic, static and dynamic) reconstructing the desigers' meta-message and identifying potential communicative breakdowns. The method is organized in the following steps (Figure 1):

- **Preparation (Step 0):** The evaluator must conduct an informal inspection and define the focus of the analysis, identifying who are the system's intended users and the main goals and activities the system supports. Inspection scenarios should also be elaborated to define the context of the analysis to be conducted
- **Steps 1, 2, 3:** In the first three steps, the metalinguistic, static, and dynamic signs are inspected, respectively. As a result, the evaluator reconstructs the meta-message being conveyed and identifies potential breakdowns, considering only the signs of the type being analyzed.
- **Step 4** In this step, the meta-communication messages generated in the previous steps are compared, as the three types of signs have different expressive power. The evaluator explores whether users might assign contradictory or ambiguous meanings to the signs composing the three messages.
- **Step 5** The final step involves assessing the overall communicability of the system. The evaluator produces a report with their final appreciation of the reconstructed meta-communication message.

The first three steps of the method provide a segmented analysis of the interface, as in each step the evaluator conducts an in-depth analysis of a specific type of sign, and what is being conveyed to users through them. In steps 4 and 5, the focus shifts to reconstructing and analyzing the complete meta-communication message through the contrast, integration, and interpretation of the previously generated versions [de Souza e Leitão 2009, Leitão e Prates 2017].

During the inspection, evaluators act as user representatives, interpreting users' interests and applying their own technical knowledge to optimize the experience and meet users' needs. Evaluators should be specialists in HCI and knowledgeable in Semiotic Engineering Theory. Moreover, the greater their expertise in EngSem, the better the final results of the inspection tend to be [de Souza et al. 2006].

3. Methodology

To identify and analyze the proposed adaptations of SIM for new contexts, we conducted a systematic literature review. In this section, we describe the steps of our methodology, including our research question, inclusion and exclusion criteria, selected databases, search strategies, the limitations of our approach, and the steps for analyzing the identified studies.

According to Kitchenham (2004), a systematic literature review (SLR) is a structured approach to identifying, evaluating, and comprehensively interpreting all

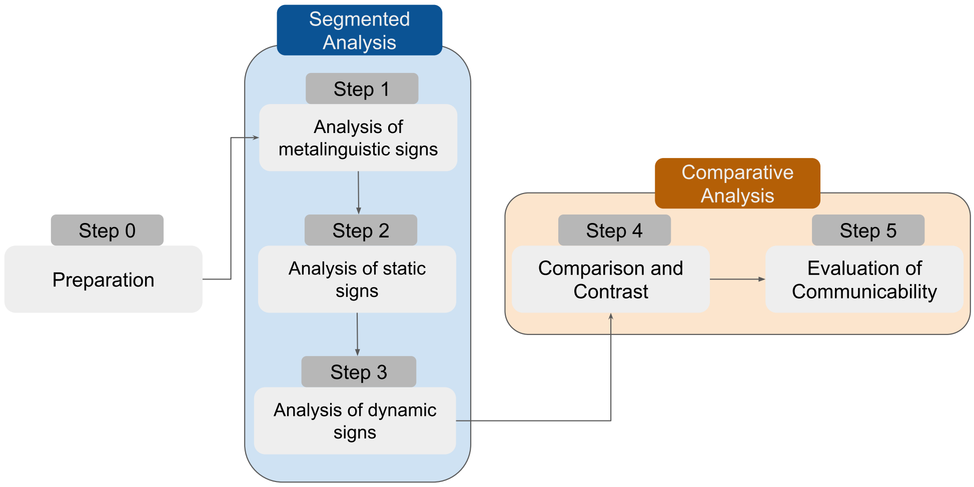

Figure 1. Steps of the Semiotic Inspection Method

Source: Elaborated by the author, adapted from [Leitão e Prates 2017].

relevant evidence related to a research question, topic area, or specific phenomenon. It is a suitable methodology for consolidating existing knowledge about a given technology, enabling the identification of gaps in current investigations and providing a solid foundation for shaping and guiding future research efforts.

In this regard, the objective of this study is to investigate proposed modifications to the Semiotic Inspection Method (SIM) aimed at generating a new version of the method. Accordingly, the following research question was posed: *"What modifications have been introduced to the Semiotic Inspection Method (SIM), and in which contexts have these adaptations been applied?"* To address this research question, the methodology is divided into the following stages: Data collection; Processing and classification of results and Focus on the analysis.

3.1. Data Collection

To map the various scenarios of SIM application in the scientific literature, we chose to use *Google Scholar* as the database for searching academic articles. The platform functions as a metasearch engine, aggregating content from various academic sources, such as scientific journals, institutional repositories, books, theses, and conference proceedings. Thus, Google Scholar results include a broad and diverse set of works such as journal and conference articles, theses, dissertations, and workshop papers, that are often not covered by structured databases like Scopus, Web of Science, or ACM Digital Library. This inclusiveness allowed for a more comprehensive set of works that have focused on SIM.

The search string used was: *"semiotic inspection method" OR "metodo de inspecao semiotica" OR "método de inspeção semiótica"*, including the name of the method in both English and Portuguese, with and without word accentuation.

The search was conducted between March 19 and 25, 2025, resulting in 662 records, including citations and works from any time period. No additional filters were applied, as the tool by default returns any type of work ordered by relevance (as defined by Scholar). The data were exported to a spreadsheet tool in the same order returned in the results and stored containing the following fields: title, authors, publication venue, citation count, and year of publication.

In addition to the initial information provided by Google Scholar, the resulting database also included the following items: database source, type of work (e.g., article, thesis, dissertation, journal), language of the text, country of publication, and authors' affiliations. The records were manually exported in CSV format with the aid of web scraping, organized in a spreadsheet, and then imported into a relational database to support classification and filtering.

To support the systematic review and classification process, we developed a web-based tool that centralizes and visualizes publications included in the database created relative to the Semiotic Inspection Method (SIM). The platform is denominated "SIM Studies" [1] and a detailed description of its architecture, relational database schema, user interface, and usage instructions is provided in [Costa et al. 2025].

3.2. Processing and Classification of Results

After all data were entered into the database, they were individually processed using the "SIM Studies" system to determine the final set of papers, according to the following steps:

- **Duplicate removal**: entries that appeared more than once in the search results;
- **Analysis of citation results**: Google Scholar typically returns "citation-only" results when the original article is not indexed but is cited by other documents. Thus, results that were only citations (e.g., *[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*) were individually reviewed to verify whether their full versions were already present among the other retrieved records. In all such cases, the full documents were already included in the dataset.
- **Removal of full conference proceedings**: Some results included full conference proceedings where at least one paper contained the search string. In this case, the papers were maintained and the Proceedings (as a whole) excluded.

After the aforementioned processing, 85 works were excluded, and the database consisted of a total of 577 individual records, including conference papers, journal articles, doctoral, master and undergraduate dissertations, short papers, extended abstracts, educational materials, books, and book chapters.

In our next step, our goal was to identify the works that presented new versions of SIM, describing the modifications proposed. Thus, we defined a set of categories regarding the purpose of the paper regarding SIM. The initial set was based on our previous knowledge of existing papers, but it was an open set, and if other categories were identified, they were included in the initial set. The classification of the paper was initially based on the analysis of the title and abstract. In case it was not possible to determine how it approached SIM in this step, a diagonal reading of the paper was conducted.

[1] SIM Studies is available at: `http://bit.ly/3GQHGaI`

To ensure greater reliability in the process, two reviewers independently performed the categorization and then compared their results, resolving disagreements through discussion with a third and more experienced researcher. Although no statistical measure of inter-rater reliability (e.g., Cohen's Kappa) was calculated, the consensus-building process involving a third reviewer ensured consistency and methodological rigor in the classification of the records.

The categories were defined as follows:

- **Discussion on SIM:** The method is presented and discussed in greater depth, as in books and/or critical analyses;
- **Semiotic Engineering Discussion:** The focus is on the theory of Semiotic Engineering as a whole, including references to the SIM;
- **Application:** SIM is used to evaluate a system or interface in a specific context;
- **Tools:** The work presents a tool to support the application of the method;
- **Applicability:** SIM is used to evaluate interfaces in a specific context;
- **Application adaptation:** The method is adapted to be applied in specific contexts without modifying its original structure, but potentially reframing components;
- **Method modification:** Modifications to the original structure of the SIM are proposed, such as the creation of a new step or phase;
- **New method:** The work proposes a new method based on the SIM, but does not follow its original structure, for example, the Intermediated SIM [Oliveira et al. 2008, Oliveira e Prates 2018];
- **Citation:** The work only mentions SIM, either in the theoretical framework or in some specific citation.

In this paper, our focus was on papers that were classified as "Method modification". Thus, any papers that were initially classified as "Application adaptation" or "Applicability" were fully read to confirm their classification. The final classification results are presented in Table 1, listing the number of records obtained for each category, considering the removal of duplicate entries and citations.

Table 1. Classification of studies and their respective quantities

Classification	Number
Citation	284
Application	212
New method	19
Application adaptation	15
Semiotic Engineering Discussion	12
Discussion on SIM	11
Applicability	9
Method modification	9
Tools	6
Total	577

3.3. Focus on the Analysis

After completing our classification, 9 works were categorized as *"Method Modification"*, which were then analyzed in full. The registration form was created using spreadsheet software and included the following columns: Title, Author(s), Publication Year, Application Context, Name of the new method, Summary of its motivation, Description of the proposal, Goal of the new method, Summary of the changes to the original method. This structure allowed for the grouping of studies that shared the same method and the identification of differences among them, as well as the historical progression of the proposed method. It is important to note that multiple papers may refer to the same version of SIM, either by proposing it, refining its description, or applying it in new contexts.

3.4. Limitations

While this study generated a large set of publications regarding SIM it has some limitations. First, we only searched Google Scholar, and although it includes a large number of different repositories, there may be publications that have not been identified. Thus, we encourage future studies to replicate or expand this review using complementary academic databases to cross-validate and potentially broaden the findings.

Another limitation is that our search string only contained the full name of the method. We did not analyze other possibilities and terms that might point to other interesting papers, such as searching for "SIM" and "Semiotic Engineering". Although we would expect that papers proposing new versions of the method would include the full name of the method, it would be interesting to investigate more carefully whether other related terms could find other publications.

In addition, the classification of the publications was performed mainly based on title and abstract, and only if necessary the paper went through a diagonal or complete reading. Although this initial classification was conducted by 2 researchers and discussed with a third, there may be some papers that have been misclassified. Finally, only one researcher read in full all of the 'method modification' publications, and although any issues were read and discussed with the other researchers, there might have been aspects that could have been better explored.

4. Ethical Considerations

This research did not involve human participants or the collection of sensitive personal data and therefore did not require approval from a research ethics committee, per the Resolution 510/2016 of the Brazilian National Health Council[2]. All data analyzed were obtained from publicly available scientific publications and are duly referenced in accordance with academic standards. The study was carried out according to the principles of research integrity, methodological transparency, and respect for intellectual property. The authors declare no conflicts of interest related to this work.

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.

[2]Available at: `https://www.gov.br/conselho-nacional-de-saude/pt-br/atos-normativos/resolucoes/2016/resolucao-no-510.pdf/view` (Last visit August 2025)

5.1. Overview

The first publication introducing SIM dates back to 2006 [de Souza et al. 2006]. Entitled *The Semiotic Inspection Method*, this work formally proposes the method based on the theory of Semiotic Engineering. It is the third most cited publication among the collected works, with a total of 278 citations, only behind two widely referenced books: *Semiotic Engineering Methods for Scientific Research in HCI* [de Souza e Leitão 2009] (1200 citations) and *Interação Humano-Computador* [Barbosa e Silva 2010] (339 citations).

Relevant additional information can be observed through data visualization, such as the distribution of publications by year presented in Figure 2. A gradual increase in the number of studies is observed starting in 2006, peaking in 2017, with 53 publications related to the SIM recorded that year.

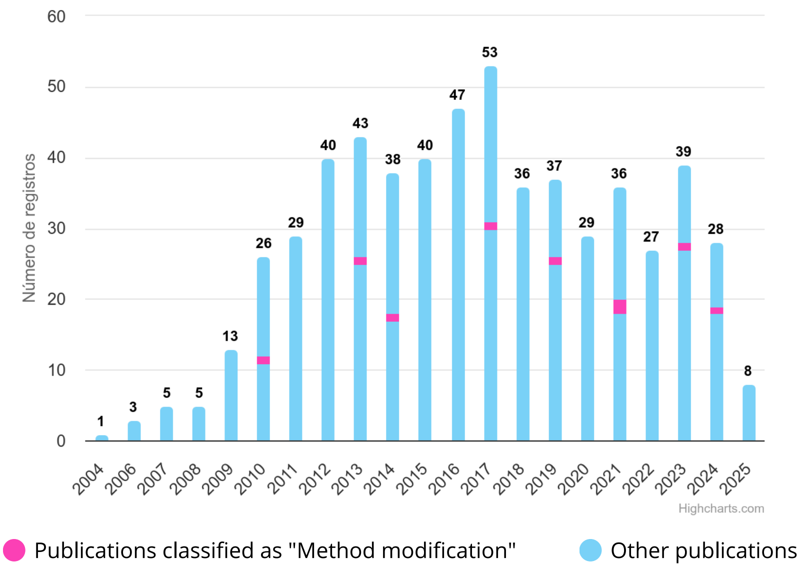

Figure 2. Publications per year with highlight on studies classified as "Method modification"

Source: Created by the author through the SIM Studies platform.

As mentioned, our focus on this paper is on works that proposed a modification to the original SIM method, creating a new version of SIM. In total, we identified 9 works, that described 5 new versions of the method, namely: *Scientific Semiotic Inspection Method (Scientific SIM)*, *Cross-Platform Semiotic Inspection Method (CP-SIM)*, *Semiotic Inspection Method with the addition of Deictic Signs (SIM with Deictic Signs)*, *Semiotic Inspection Method mediated by Screen Reader (SIM-SR)*, and *Semiotic Inspection Method for Human-Computer Integration (SIM-Hint)*.

The nature of the changes proposed by each method varied according to the goal of the adaptation, including a proposal of a new sign class, new steps, or inspecting different versions (complete or partial) of the meta-communication message being conveyed, and different strategies to contrast them. Next we briefly describe each of the new versions.

5.2. Description of New Versions of SIM

In this section, we present each proposed version of SIM. The methods will be presented in chronological order, based on when they were first introduced in the literature. We briefly describe the motivation for the adaptation, the proposed method, describing its steps and modifications introduced. We highlight in blue the changes from the original SIM version to facilitate the identification of modifications.

5.2.1. Scientific SIM (2010)

Scientific SIM [de Souza et al. 2010] was proposed mainly by the same authors who proposed the original SIM, and its goal is to generate results that go beyond the *technical* application of the method, which focuses on the quality of the system's interaction. Scientific SIM aims to allow the evaluator or researcher to conduct a systematic analysis of the system with the goal of generating *scientific knowledge* related to the technical solution encoded in the system. The method allows for the generation of insights regarding communicative phenomena in interactive systems, thus contributing to the theoretical advancement of the field.

The main differences between the Scientific SIM and the original method are posing an initial research question, and the inclusion of a triangulation step. The main steps of SIM are the same for the inspection of the system. However, the inspector's focus is not on identifying communicative breakdowns in the meta-communication message, but rather identifying challenges and relevant aspects of the solution regarding the research question. In the triangulation step, the inspector will check the validity of their findings against evidence obtained with other methods or procedures. These methods may be of endogenous sources (comparisons with other systems from the same domain) or exogenous sources (systems from different domains but with similar characteristics).

Next, we describe the steps for the application of Scientific SIM (text in blue and italic highlights steps that are different from or added to the original method):

- **Step 0**: **Preparation** *with a clear definition of the scientific problem to be investigated and analysis criteria linked to theoretical advancement in HCI*;
- **Step 1**: **Inspection of metalinguistic signs**, reconstructing meta-message 1 based on these signs and identified communicability issues;
- **Step 2**: **Inspection of static signs**, reconstructing meta-message 2 based on these signs and identified communicability issues;
- **Step 3**: **Inspection of dynamic signs**, reconstructing meta-message 3 based on these signs and identified communicability issues;
- **Step 4**: **Comparison and contrast** of the three meta-messages and the communicability breakdowns identified;
- **Step 5**: **Communicability appreciation** *in an epistemological dimension, seeking to relate the findings to theoretical questions, raise new research inquiries, or revise known interpretations in HCI*;
- ***Step 6: - Triangulation**: Triangulation of results obtained in the inspection with findings obtained with other methods or proceedings of endogenous (similar artifacts or analyses by other evaluators of the same system) or exogenous (artifacts from different domains with relevant comparative features) sources.*

In the article [de Souza et al. 2010], authors illustrate the application of the Scientific SIM in a case study aimed at investigating *"how a system's feedback is* *communicated to users, what kinds of signs are used, what interpretations they trigger, how these interpretations relate to the system's semantics"*. The primary object of study was Simple CSS (SCSS), a freely distributed Cascading Style Sheet. The authors conducted a detailed analysis of the feedback signs offered by the interface and demonstrated how, through this inspection, it was possible to generate new insights into design practices in authoring tools and on the communicability limits of systems aimed at non-expert users. The results were then triangulated with empirical evidence provided by endogenous and exogenous sources. The endogenous source was web material content about SCSS itself and other freely distributed CSS editors (for example, users' opinions, FAQ's, publicity, and the like). The exogenous source was the result of a semiotic inspection of a portion of Google Groups.

As a result of the inspection, authors present a formulation of the semiotic commonalities of signification and interpretation processes between these and feedback issues involved in general configuration tasks and their consequences. Regarding Scientific SIM, authors argued that it can be effectively used as an epistemological tool for scientific investigation in HCI. Thus, the Scientific SIM becomes a valuable tool for identifying communication patterns in interfaces, understanding designer intentions, and contributing to the development of new knowledge in the field.

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

Traditional evaluation methods are not entirely suitable for assessing the quality of cross-platform systems, as evaluating each part in isolation may not reflect the overall usability across different devices [Denis e Karsenty 2004]. This limitation poses a challenge for evaluating the system's use in different computing devices such as PCs, smartphones, and tablets, which have distinct capabilities and constraints. In this context, the work by [Maués e Barbosa 2013] aims to address this gap, given the scarcity of studies in this area at the time.

The Cross-Platform Semiotic Inspection Method (CP-SIM) is an extension of the Semiotic Inspection Method (SIM) aimed at evaluating cross-platform systems. It was developed to address communicability breakdowns that may occur when users switch between versions of the same system across different platforms (like web, mobile, etc.).

The method was proposed by [Maués e Barbosa 2013], based on the assumption that the communicability of a system should not be assessed solely in isolation on each platform, but also in terms of communicative coherence and continuity between its different versions, a concept referred to as **cross-communicability**. The method incorporates concepts such as sign impermeability, which refers to signs whose meanings remain unchanged across platforms, and significant manipulations, which involve alterations to signs that can affect their meaning, form, or structure across platforms. These concepts, previously applied in the context of end-user development, enhance the method's diagnostic capability by allowing precise identification of communicative breakdowns.

The application of CP-SIM to the case study of the online radio and music streaming platform 8 tracks [Maués e Barbosa 2014] demonstrated its ability to identify both internal communication problems within each platform's version and semiotic inconsistencies across platforms, which could compromise the users' experience in continuous and alternating usage contexts. Thus, the method allows one to assess whether the different versions of the same system (*e.g.* desktop, mobile, and tablet) can consistently and effectively communicate the design principles and the functionality of the system as a whole, and not only as an isolated version for each platform.

CP-SIM combines: A vertical analysis, which applies the traditional SIM steps individually on each platform; and a horizontal analysis, which contrasts the messages communicated across platforms to identify inconsistencies, ambiguities, and breakdowns in the user experience. This approach seeks to ensure that signs (icons, texts, behaviors, etc.) maintain coherent meanings and support cross-platform usability.

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 meta-message 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 meta-message 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 meta-message 3 and identified communicability issues;
  - **Step 4**: Comparison and contrast of the meta-messages 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.*

The study revealed that, when contrasting the meta-messages of different versions of a system, new ambiguities and communication failures may emerge. Furthermore, individual failures can propagate, intensify, or even be mitigated by elements present in other platforms. The horizontal analysis enables inspectors to identify issues related to composition, continuity, and consistency across platforms, thus contributing to the improvement of cross-platform design and development, including approaches such as graceful degradation.

5.2.3. SIM with Deictic Signs (2017)

[Lopes et al. 2017] propose an extension of the Semiotic Inspection Method (SIM) with the aim of adapting it to more complex interactive contexts, especially digital games, collaborative systems, and geolocation systems (in terms of space and time).

Due to immersive experience, one of the main factors in game interaction, the authors chose to place greater emphasis on communication breakdowns, which represent only a small subset of all the insights that the SIM can provide to experts about the analyzed system interface. In this context, the method was applied to the games *Ingress*, *Kinectimals*, and *Just Dance Now*.

Based on the results obtained through the SIM, the authors observed that many of the messages conveyed by the interfaces referred to elements external to the system, such as the user's physical space, the moment of interaction, and the player's identity. These elements could not be adequately assessed using the original SIM categories: metalinguistic, static, and dynamic signs. Therefore, the authors proposed the inclusion of a new class of signs: **deictic signs**, inspired by the linguistic concept of deixis, to address the personal, spatial, and temporal references present in the interface. Deictic signs are organized into three categories: personal (referring to the player), spatial (related to the place of interaction), and temporal (associated with specific moments in time).

To incorporate this new perspective, the authors modified SIM by proposing an expanded model, explicitly introducing the inspection of deictic signs as an independent step (part of the segmented analysis of the system). This modification enables SIM with Deictic Signs to address context-aware systems, such as augmented reality games or pervasive computing environments, making the method more robust and better suited for evaluating communicability in settings where the system heavily relies on data that is external to the interface.

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 meta-message 1 and identified communicability issues;
- **Step 2**: **Inspection of static signs**, resulting in meta-message 2 and identified communicability issues;
- **Step 3**: **Inspection of dynamic signs**, resulting in meta-message 3 and identified communicability issues;
- ***Step 4**: **Inspection of deictic signs** (personal, spatial, and temporal), resulting in meta-message 4 and the identification of communicability breakdowns;*
- **Step 4**: **Comparison and contrast** of the *four* meta-messages and communicability breakdowns found;
- **Step 5**: **Communicability appreciation**.

The proposal was consolidated through the application of the adapted SIM to the three aforementioned games. The inspection revealed that deictic signs, previously not considered by the original SIM method, play a fundamental role in the immersive experience and in the communicability of the systems. For example, in Ingress, failures were identified in the alignment between the virtual map and the physical space; in Kinectimals, the game presented inconsistencies between the player's movements and their on-screen representation; and in Just Dance Now, visual and auditory elements varied according to time and the player's profile (paying or not), directly affecting the intended communication. Thus, by identifying communicability breakdowns specifically related to deictic signs, the authors demonstrated that the proposed adaptation enables a more accurate evaluation, particularly in systems involving context-sensitive interaction.

5.2.4. SIM-SR: Screen Reader (2019)

The Semiotic Inspection Method Mediated by Screen Reader (SIM-SR) was developed to evaluate the communicability of interactive systems accessed by visually impaired users who rely on screen readers [Carvalho et al. 2019]. The proposal is motivated by the understanding that the screen reader acts not only as an accessibility tool but also as a mediator of the meta-communication originally designed by the system's designer. In this mediation process, the screen reader may introduce noise, omissions, or distortions, compromising message clarity, and, consequently, the user's communicative experience. Thus, SIM-SR adapts SIM to address the specificities of this mediated interaction, expanding its ability to identify communication barriers that are invisible to traditional inspection.

SIM-SR adapts the original SIM by including, at each stage of sign type analysis, a horizontal analysis, contrasting how those signs are presented to users by the screen reader, and a comparison of the meta-message reconstructed with and without it. During step 4 of the method, in which the inspector compares and contrasts the *meta-messages*, these new *meta-messages* — generated through the mediation of screen readers — must also be considered, allowing the inspector to account for and document the impacts of system usage when mediated by a screen reader.

Thus, the method enables the identification and analysis of both communicability and accessibility issues in interactive systems, specifically addressing the unique aspects of interaction for users with visual impairments. The evaluation considers how the message designed by the system's designer is reinterpreted and conveyed by the screen reader. For the interface to be truly understandable and usable by these users, it is not enough for the reader to simply vocalize visible texts; it must also communicate structural, hierarchical, and organizational aspects of the content. This focus allows the method to be more attentive to the nuances of screen reader interaction, uncovering cases where, despite following accessibility guidelines, the system still fails to communicate effectively.

The detailed steps of the method are presented 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 inspection scenarios;
- **Step 1**: **Inspection of metalinguistic signs**: analysis of metalinguistic signs and reconstruction of resulting meta-message in the system, *and the same signs mediated by the screen reader, and contrast of the two meta-messages*;
- **Step 2**: **Inspection of static signs**: analysis of static signs and reconstruction of resulting meta-message in the system, *and the same signs mediated by the screen reader, and contrast of the two meta-messages*;

- **Step 3**: **Inspection of dynamic signs**: analysis of dynamic signs and reconstruction of resulting meta-message in the system, *and the same signs mediated by the screen reader, and contrast of the two meta-messages*;
- **Step 4**: **Comparison and contrast** of the meta-messages and communicability breakdowns found, *first independently for the original system, then mediated by the screen reader, and finally between the two, identifying both communicability and accessibility breakdowns;*
- **Step 5**: **Communicability** *and accessibility* **appreciation**.

Since its proposal, SIM-SR has been applied in several case studies by the authors, including the evaluation of the Tudo Gostoso website [Carvalho et al. 2021], Trello and Todoist [Carvalho et al. 2023] , as well as by other researchers, e.g. federal academic systems [de Barros et al. 2024], and the BioPortal tool [Cardoso et al. 2023]. These studies demonstrate its usefulness both in identifying communicability barriers and in reflecting on digital accessibility. The findings indicate that SIM-SR enables an integrated analysis of accessibility and communicability aspects, highlighting different levels of communicative breakdowns experienced by visually impaired users.

Finally, SIM-SR stands out by producing results that complement those of the WCAG 2.1 guidelines [(W3C) 2018], providing a deeper insight into how these guidelines are applied in practice and how technical shortcomings impact the transmission of the *meta-message* [Carvalho et al. 2023].

5.2.5. SIM-HInt: Human-Computer Integration (2022)

With the evolution of Human-Computer Interaction (HCI) toward the emerging paradigm of Human-Computer Integration (HInt), in which digital technologies begin to act as proactive partners of users, it becomes necessary to adapt traditional evaluation methods to the new communicative dynamics [Barbosa 2022]. In this context, [Barbosa et al. 2024] proposed SIM-HInt (Semiotic Inspection Method for Human-Computer Integration), aimed at analyzing the integrated meta-communication across multiple components of autonomous and distributed technological solutions. In the case of HInt, when there are multiple components in the system, each component presents part of the meta-message being conveyed by the designer.

As part of this proposal, the author introduced the concept of **integrated meta-communication**, which refers to the predefined, distributed communicative act performed by designers through multiple system components to convey a unified message to the user. The **integrated communicability** then emerges as a new quality attribute, reflecting how consistently and coherently these distributed fragments can convey the designers' intentions and principles in full [Barbosa 2022]. It includes not only the clarity of each individual component's message but also the user's ability to reconstruct the designer's overall communicative intent across the system as a whole. These concepts are central to understanding and evaluating how effectively partner technologies in Hint paradigms support mutual understating and cooperation between users and systems.

SIM-HInt proposes changes to the original SIM, in order to allow inspectors to conduct a systematic analysis of the *integrated communicability* of a meta-communication message being conveyed through multiple components of a HInt system. To do so, SIM-HInt defines that the first phase is a horizontal analysis of the metalinguistic signs of all components. The goal is for the inspector to generate an overall view of the intended integrated meta-communication and how it is partitioned through the components. Then, it has a vertical analysis per component that is aligned with the original SIM, and finally, one more horizontal analysis to generate the integrated meta-message. Next we present the steps of the method (text in blue and italic highlights steps that are different from or added to the original method):

- **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 meta-messages generated by each component and reconstruct the integrated meta-message, 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 meta-message 2 and identified communicability problems;
  - **Step 2**: **Inspection of dynamic signs**, resulting in meta-message 3 and identified communicability problems;
  - **Step 3**: **Contrast** and generation of the meta-message *for each component, including the metalinguistic analysis for the component conducted in Step 1 of Phase 2*;
  - **Step 4**: **Appreciation of the communicability** *for each component*.
- ***Phase 4: Horizontal Analysis of Integrated Meta-communication***
  - ***Step 1****: Contrast and consolidate the meta-message of each component generating an integrated meta-message for the system;*
  - ***Step 2****: Explore gaps, inconsistencies, overlaps, and communication breakdowns in the overall meta-message;*
  - ***Step 3****: Generate the final appreciation of integrated communicability of the HInt system.*

To evaluate the method, it was applied in a case study involving the Samsung Galaxy Fit2 solution, composed of a smart band, mobile applications, and support materials. The application of SIM-HInt demonstrated its ability to reveal communicative inconsistencies among components, as well as to assess the effectiveness of the solution as a partner technology to users in a Human-Computer integration scenario.

Thus, SIM-HInt enables the identification of meta-communication breakdowns that would not be captured by the original SIM, such as continuity breakdowns, inconsistencies between interfaces, and conflicting signs among components. Moreover, the method directly contributes to the (re)design of partner technologies by offering conceptual and practical support to improve the communicative quality of the solution as a whole.

6. Discussion

The analysis of the different adaptations derived from the Semiotic Inspection Method (SIM) highlights the evolution of the method into a "family" of methods in response to new challenges in the field of HCI and digital transformation. All of the new versions, except Scientific SIM, focused on the analysis of the communicability of an interactive system in a specific context. Scientific SIM changes the focus of the analysis from the system's communicability to analyzing the designer's discourse (through the system) and solution as a means to generate knowledge about HCI. In other words, instead of focusing on the quality of the system's interaction represented by its communicability, defined as a technical application of the method, it adapts it to be used as a scientific research tool [de Souza et al. 2010].

The other methods (*i.e.* CP-SIM, SIM with Deictic Signs, SIM-SR, SIM-HInt) aim at assessing the system's communicability, identifying potential communicative breakdowns that may take place in the user-system interaction, and reconstructing and analyzing the designer's meta-communication message. SIM with Deictic Signs and SIM-SR take into consideration the original definition of communicability, whereas CP-SIM and SIM-HInt extend the concept of communicability to their specific contexts of interest. Although SIM-SR is based on the original concept of communicability, by contrasting the communication conveyed by the original system and its "translated" version generated by the screen reader, it also identifies accessibility barriers and problems of the system.

CP-SIM analyzes the *cross-communicability* of the system, *i.e.* the communicability of a system across the multiple platforms available to users in which they can interact with the system [Maués e Barbosa 2013]. SIM-HInt focuses on the analysis of the *integrated communicability* of the system, *i.e.* how can parts of the designers' meta-message being conveyed through different components be integrated to present the overall meta-communication to users [Barbosa e Prates 2022]. Notice that even though both concepts consider the use of multiple devices, in the cross-communicability concept, the system's meta-message is presented by each platform, and thus, the platforms need to be consistent regarding what they present and how. In integrated communicability, each component is responsible for presenting part of the whole meta-message, and users need to understand (all) the parts to grasp the overall meta-message being conveyed.

Our analysis show that the different extended versions adopt different strategies to extend the method. Figure 3 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 add one or more extra steps to the original SIM. Scientific SIM includes the definition of the research question in the preparation step and the triangulation step at the end of the inspection. The research for SIM with Deictic Signs proposes a new class of signs (*deictic*) and adds a step to the segmented analysis per sign class, to include the analysis of the deictic signs, which will then also be considered in the other two steps (contrast and communicability appreciation).

The other 3 methods – CP-SIM, SIM-SR and SIM-HInt – have similar approaches in their extensions. First of all, all of them include the inspection of more than one (complete or partial) version of the meta-message – in CP-SIM, each platform's version; in SIM-SR, the original system and the screen reader versions; and in SIM-Hint, the partial version presented by each component. They all propose vertical and horizontal analysis of the steps, albeit in different moments. A vertical inspection refers to the inspection of one version being examined, considering (some of) the original steps of the method. A horizontal inspection refers to contrasting results of one or more steps across the inspections of the different versions.

CP-SIM proposes a vertical inspection of each version and then includes three new steps to conduct a horizontal inspection of the results of each vertical inspection and generate the overall results. SIM-SR proposes a horizontal inspection for each step of the method (vertical inspection) to contrast the analysis of the original version with the screen reader mediated version. Finally, SIM-Hint proposes a horizontal inspection of the metalinguistic signs of all components, followed by a vertical inspection of each component and a final horizontal inspection to contrast and integrate the results for each component, generating the integrated meta-communication and overall appreciation. The horizontal/vertical traversing proposed by each of the methods is intentional and well justified in each proposal and is a relevant part of the extended method.

It is worth pointing out that none of the new extensions aim to replace the original SIM method. As mentioned they are proposed as alternatives to be applied with a specific focus or in a specific context, in which the original SIM would not fully apply. Table 2 summarizes the main differences among the methods discussed.

Table 2. 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 *cross-communicability*, 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 meta-messages 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 *integrated communicability* across multiple components, evaluating the solution as partner technology

The different extended versions of SIM discussed in this section can be taken as an indicator of the possibility or even flexibility to extend SIM to specific contexts. The adoption of the vertical and horizontal traversing of SIM steps seems to be a successful strategy to propose a broader method, that can take into account how different versions (complete or partial) of the designers' intended meta-communication being conveyed by one or more channels can be systematically analyzed and assessed. All the

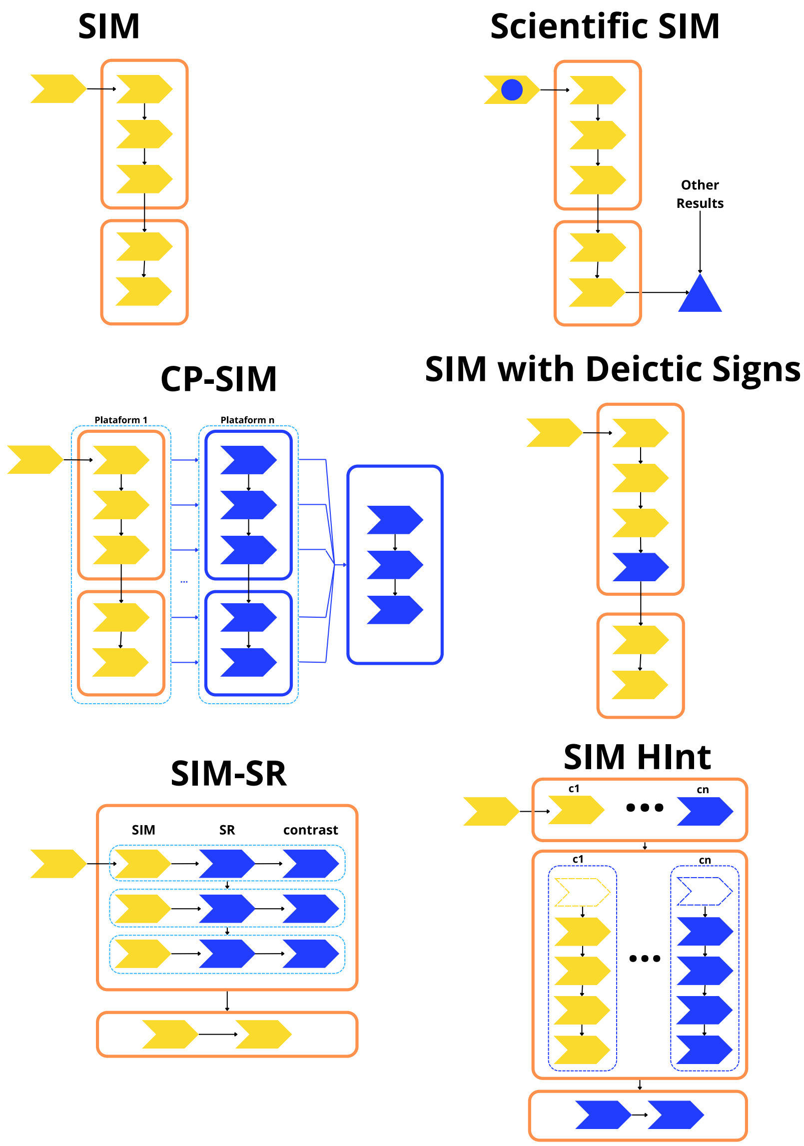

Figure 3. Diagram of each method highlighting its modification
Source: Elaborated by the author.

extended methods are based on Semiotic Engineering Theory and require the inspector to understand the theory and its concepts in order to apply the method. Furthermore, the extended versions of the method, include one or several new steps, which increase the cost of the method's application, in terms of the time required and even the interpretative complexity involved in requiring additional comparative analysis and a more complex integration to take place in the process to generate the overall reconstructed meta-communication and communicabilty assessment.

While each version of SIM was analyzed individually, we recognize that future studies could explore whether multiple versions can be combined or applied sequentially to the same system. For instance, one could consider using CP-SIM to address cross-platform consistency, followed by SIM-SR to evaluate accessibility for visually impaired users. However, such combinations would require careful methodological planning to avoid overlapping efforts or conflicting criteria. Investigating the complementarity and interoperability among SIM variants may provide valuable practical guidance for complex evaluation scenarios and represents a promising direction for future research.

7. Conclusion

Through a systematic review of the adaptations and derivations of the Semiotic Inspection Method (SIM), it was possible to trace its theoretical and methodological evolution since its original formulation. Of the five new versions of SIM identified, the Scientific SIM changed the focus of the application from a technical evaluation of communicability to that of a scientific tool to generate new knowledge of HCI. The other 4 proposed changes in the method so they could applied to specific contexts, in which they had identified potential limitations in applying the original SIM.

The diversity of methods identified in the literature demonstrates that SIM is a conceptually robust and methodologically flexible approach that can be adapted to evaluate different interface modalities and emerging technological contexts. This adaptability also reflects the maturity of Semiotic Engineering as a scientific theory, whose tools can be continuously revisited, expanded, and refined while maintaining conceptual coherence.

Moreover, this study highlights that SIM remains widely applicable and effective. The derived methods should be understood as complementary rather than substitutive, offering additional resources for more specific or complex situations. Although all versions of SIM, including the original, require evaluators to have knowledge of semiotic engineering theory, the new versions also introduce new challenges, such as greater application complexity and scalability limitations.

This research contributes to researchers interested in the Semiotic Inspection Method, as it organizes the existing versions of the methods, contrasting their focus, and adaptations. It is also relevant for those interested in communicability, as it identifies new concepts related to communicability in specific situations (namely, cross-communicability and integrated communicability), and communicability evaluation methods. Clearly, it brings contributions to Semiotic Engineering Theory, as it organizes the SIM versions, discussing theoretical aspects considered in the versions proposed. Finally, it contributes to the Grand Research Challenges in Human-Computer Interaction in Brazil for 2025-2035 [Pereira et al. 2024], in special *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 they all present new methodological approaches regarding new contexts or emerging technologies. They could also inspire researchers to investigate whether SIM could be adapted to other challenges, which also call for the need for new methods.

As a practical contribution, this research not only mapped and organized the accumulated knowledge on SIM-derived methods, but also developed SIM Studies – a public digital platform that serves as a repository of the analyzed studies. This tool enables dynamic queries, temporal visualizations, and quantitative analyses, allowing researchers to explore the publications according to different aspects, such as their purpose regarding SIM, publication type, year and forum, among others. Thus, the tool can be interesting for anyone interested in researching, teaching or learning about SIM.

This work contributes both to the consolidation of existing knowledge about SIM and to 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 choices about the most appropriate variation of the method for their contexts. The results also encourage the investigation of new proposals aligned with the technological, social, and communicational transformations of contemporary interaction.

The results of this study open avenues for future research. In continuing the investigation of the new versions proposed of SIM, it would be interesting to assess how consolidated each of them is. To do so, it would be relevant to collect reports on the use of these versions, analyzing the context in which they have been applied, by whom (the proponents themselves or other researchers), and any mentions of the costs and benefits of their application.

In our research, we classified all publications according to their purpose related to SIM. Nevertheless, we focused our analysis on those that proposed modifications to SIM (classified as 'Method modification'). It would also be interesting to further investigate publications classified as *'Application adaptation'* and *'New Method'*, to understand how SIM has influenced evaluation practices beyond its original structure.

Additionally, it would be interesting to learn more about *'tools'* that have been proposed to support the application of the method, verifying if they are still available for use, and if so assess how they could support the application of the new versions, or whether they could be reviewed to do so. The platform developed in this study could also be expanded to allow moderated contributions from other researchers, keeping the database of studies continuously up to date. Finally, the classification used could be refined by introducing subcategories that consider, for instance, the application context or the technologies involved.

8. Acknowledgments

Authors acknowledge that they have use AI technology to improve spelling, grammar, ponctuation and clarity of text, and to support the translation of the original text to English.

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