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Applications of Socially Aware Design in Education: a systematic mapping of the literature

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Abstract Information and Communication Technologies (ICTs) affect the daily lives of people who use them and knowing the social context, values, culture, and rules, among other characteristics inherent to a society is fundamental to building inclusive, safe, and sustainable technologies. To include the social context in the design of a system and transform it into sociotechnical requirements, Socially Aware Design (SAwD) emerges. Likewise, teaching computing professionals to obtain a more human view of technology, in addition to enabling Software Engineering (SE) practices, which is extremely important for the training of these professionals, teaching SE is a great challenge. This research presents the execution of a systematic mapping of the literature that sought to discover studies that apply SAwD in Education, the techniques, methods, processes, and artifacts associated with SAwD, and the levels and areas of education that use it. It also presents other areas and application domains that consider SAwD in the design and construction process of interactive systems, whose objective is to find and implement socio-technical requirements collaboratively for an inclusive and sustainable design. The results point to the growing use of the SAwD over the years, the importance of including the social context in the development of information and communication technologies, as well as gaps for further research on the application of the SAwD in Education, to propose guidelines for developing games aimed at teaching SE.

Keywords: Socially Aware Design, Education

1 Introduction

The presence of Information and Communication Technology (ICT) in people's daily lives has become something natural. ICTs are present in industry, commerce, health, education, on the streets, in homes, etc. Human beings started to interact most of their time with machines, or with other human beings through machines, and the question is, how are the interactive systems produced by ICTs being built? Are the social, cultural, environmental, legal aspects, among others inherent to the humanity being considered? Why is it important to consider these aspects in the design of an interactive system?

These questions lead to reflections on the importance of knowing the context in which ICTs will be used, by whom they will be used, if they will effectively meet the needs of users, if they will provide access and understanding to all and what impacts they may have on people's daily lives.

Some time ago, these concerns were signaled by the great educator Paulo Freire who said [...] technology, as a human practice, is political, it is permeated by ideology. It has a well-defined purpose, it serves a group of people and the most diverse interests: technology is not neutral, it is intentional and is not produced or used without a vision of the world, of man and of society that underlies it [Freire, 1977].

Therefore, technological artifacts must be created in a contextualized way, considering benefits and limitations of use, identifying the local and global context, since what is developed and used in one place can also reflect in distant places, addressing the implications in the lives of users. and how to use them for the good of the group in that context, from the elucidation of sociotechnical requirements, collaborating in the construction of interactive systems whose technical efficiency does not contradict the social context in which the application will be inserted [Carvalho *et al*., 2022].

One way to discover elements that make up the social context, besides human, cultural, legal and technical aspects in the fabrication of interactive systems is to include techniques and artifacts proposed by Socially Aware Design (SAwD) in the design process. The SAwD proposes the participation of interested parties from different layers of society which may be interested in the project, may be future users or which may contribute in some way to the conception of a design for all [Baranauskas, 2014].

Technological applications built for the benefit of society are countless, which usually arise from the need to solve problems such as improving productivity, communication, expanding the dissemination of knowledge, providing greater social interaction, helping in the teaching and learning process, etc, and in all of them care must be taken to know

the social context in which they will be inserted, especially critical activities such as those involving health, safety and education [Ferrari *et al*., 2019].

Given the importance of social contextualization in the construction of ICTs, the question arises, how is it possible to exercise social and interpersonal skills, in addition to technical skills, in students on courses that teach Software Engineering (SE)? Can SAwd collaborate in this important mission?

The main objective of this research is to systematically investigate and map works that apply the SAwD in education, respective techniques for elucidating the problem and proposing solutions, as well as artifacts generated, considering that education is a critical domain regarding the forms of interaction to promote knowledge through ICTs, and there must be constant concern with inclusion, achieving the objective (learning), not being embarrassed, among other factors that ICTs designed without considering the social context can cause.

To investigate the works that apply the SAwD in education, a Systematic Literature Mapping (SLM) was developed, according to Kitchenham and Charters [2007] whose execution protocol is available in the section 3.

The main contribution of this SLM is to present studies that apply SAwD in education, identify which levels and areas they cover and understand which processes, techniques and artifacts make them up so that SAwD can be applied in research that seeks to address the teaching and learning process. from SE social, cultural, legal issues to the development of inclusive and sustainable ICTs.

As an additional result, other areas and application domains that applied the SAwD in the design process are presented, which can contribute to the dissemination and expansion of the use of the SAwD in the production of interactive systems.

It is important to mention that in preliminary research, no studies were found that gather data on the application of SAwD in information systems, nor educational systems through mapping or systematic reviews.

This article is divided into five sections: the 2 section presents concepts related to the SAwD and the types of systems it supports, the 3 section presents the SML protocol for carrying out this research and related to the execution of the SML. The 4 section presents the results and analysis, and discussion and contributions of the data obtained, in the section 5 the conclusion of this research and as final considerations.

2 Theoretical Framework

This section presents the definition of some concepts cited in this research and mainly addresses the SAwD.

The concept of interaction is broader than interface. Interaction is a communication process between the user and the system through interfaces; it involves everything that happens when the user, through the interface, interacts with the computer system to perform tasks [Barbosa and Silva, 2010].

Design can be characterized by its ability to propose solutions to problems that affect one or more people, modeling a product or service beyond appearance, but also considering strategic aspects of the business, with a main focus on users and their needs [Canedo and Almeida, 2019].

The performance of the SAwD in the design process significantly contributes to clarifying a given problem, exposing the problem and possible solutions using concepts from Organizational Semiotics [Liu, 2000], based on the areas of the Building Blocks of Culture proposed by [Hall, 1959], the Theory of Values from [Watanabe *et al*., 2020] and the holding of participatory design workshops [Camargo and Fazani, 2014]. In this way, it is possible to incorporate elements of everyday life into the design of interactive systems, of the social reality of future users with their respective customs, human, cultural and legal values [Buchdid *et al*., 2019].

The theory of Organizational Semiotics aims to understand how a group of individuals, a company, a city or even a country organizes and communicates, that is, which signs, norms, languages govern that society. Organizational Semiotics directs the SAwD to study and discover requirements at three abstract levels: informal, formal and technical [Buchdid *et al*., 2019]. These levels are graphically represented in an artifact called Semiotic Onion (Figure 1), which illustrates the interaction between the informal, formal and technical levels, society and design [Baranauskas, 2014].

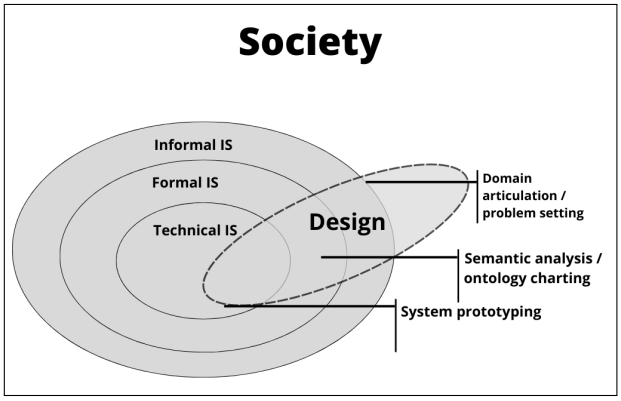

Figure 1. Semiotic Onion. [Baranauskas, 2014].

At the informal level, the aim is to identify the social requirements related to habits, customs, daily life, human and cultural values; at the formal level, the rules, laws, procedures that must be respected within the social context that are being observed and at the technical level, the technological requirements for building the system are recorded considering the requirements identified in the previous levels. In order to obtain the requirements at the three proposed levels, it is extremely important to involve different stakeholders in the design process [Ferrari *et al*., 2019]. In this way, solutions for the construction and use of interactive technologies become more humane, sustainable, inclusive and able to avoid negative impacts on users [Baranauskas, 2014].

The values to be discovered, at the informal, formal and technical levels, can be based on ten areas that make up the culture of a given community or society, according to Hall [1959]. These areas were arranged in a pie format, with each slice representing an area, values at the informal level are elicited at the edge of the pie, values at the formal level are indicated in the middle of the pie, and values at the technical level are described in the core This pie is called Value Pie and can be seen in Figure 2 [Pereira *et al*., 2013].

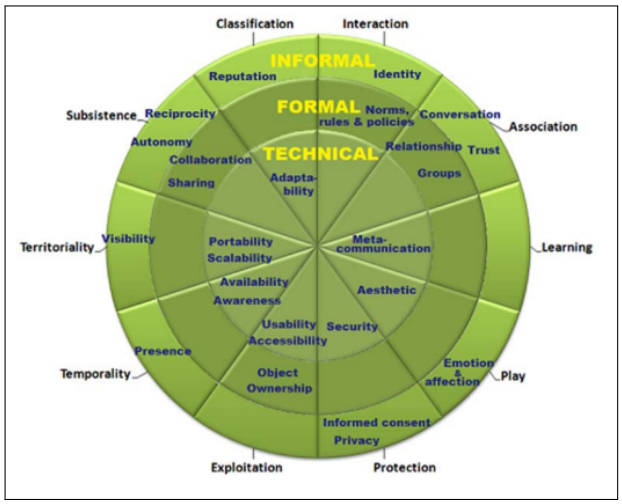

Figure 2. The Value Pie [Pereira *et al*., 2013].

Finding and understanding these values, as well as better understanding the problem and finding the most appropriate solution, depends on a joint effort by the interested parties. To collaborate in this purpose, participatory design techniques can be applied that aim to properly understand the interests and preferences of users [Malinverni *et al*., 2016].

Therefore, the SAwD suggests participatory design that is based on the effective participation of stakeholders in design decisions for new technologies or improvements in existing ones. All people involved can contribute, regardless of their position in the organization or society, being important the representative participation of heterogeneous stakeholders in semi-participatory design workshops, which involve participatory design practices with elements that make up Organizational Semiotics [Buchdid *et al*., 2019].

The artifacts proposed by the SAwD involve the discovery of interested parties from different layers of society, represented in the Diagram of Interested Parties, the discussion of problems related to the topic in question, with suggestion of ideas for the solution registered in the Evaluation Frame, the definition of central stakeholders who are responsible for clarifying the real needs, represented in the Value Prospect Table, the transformation of this information into requirements are arranged in the Semiotic Frame, which contains six steps (social, pragmatic, semantic, syntactic, empirical and physical world) represented in Figure 3, which also presents the Collaborative Brainwriting technique to help discover these requirements.

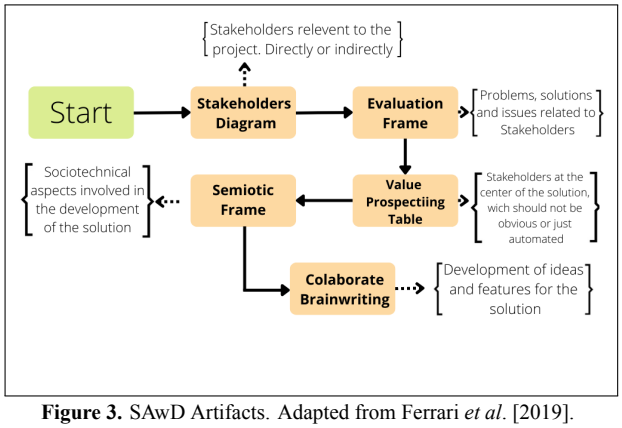

Figure 3. SAwD Artifacts. Adapted from Ferrari *et al*. [2019].

A platform called OpenDesign [da Silva *et al*., 2018a] was developed to enable the creation of artifacts proposed by the SAwD, the application of techniques to discover problems, solutions, social and technical requirements, such as brainstorming, brainwriting and braindrawing, collaboratively. During the execution of the workshops, it is also possible to carry out braindrawing sessions, remotely, from the Online Braindraw functionality.

It is important to highlight some concepts that are addressed in related studies reported in section 4.1. The studies found in this research refer to SAwD applications in interactive systems. Concepts:

- Interactive systems - transmit, display, store or transform information through physical devices (cell phones, computers, etc.) and systems that dynamically respond to people's actions for various purposes. The use of interactive systems has a great impact on the world and influence on people's daily lives, and design must be thought of in a sustainable way and centered on human values [Benyon, 2011];
- Socioenactive systems - add computational technology to a social space, causing interference in the social relations contained in the environment in which they are installed, but for these interventions to have the intended effect, it is necessary to understand the participating computational system, the people and all the things present in the environment [da Silva and Baranauskas, 2020]. It must establish and maintain interactions that occur in three dimensions Social (people), Physical (environment, objects) and Digital (computer technologies);
- Persuasive systems - aim to persuade, influence and motivate people to change behavior in relation to a given situation, without using coercion or lying. A very characteristic example is related to changing eating habits or including physical activities in the daily lives of people who are looking for a healthier life [Espinoza and Baranauskas, 2020a]. Researchers point out that social and behavioral characteristics of stakeholders are fundamental for the success of persuasive systems, and in this case SAwD can collaborate to raise and understand the social context in which the system will be used [Espinoza and Baranauskas, 2020a]. In Espinoza and Baranauskas [2020b] a socially aware framework for building persuasive systems is proposed;
- Tangible User Interface (TUI) - attach digital information to objects or environments in the physical world that are part of people's daily lives, serving as an interface between the physical and digital world, favoring interaction and understanding of the context in which it is inserted. In an educational environment, for example, it increases the engagement and motivation of students in the teaching and learning process [Gutiérrez Posada *et al*., 2015];
- Internet of Things (IoT) - embed information technology in "things" that are part of people's daily lives through a communication network, realizing the concept of ubiquitous and pervasive computing that allows the use of technology without the user noticing its pres-

Table 1. Research objective.

Analyze	scientific papers.
With the purpose of	identify studies that apply SAwD in Education
With regard to	processes, methods, techniques, tools and areas
From the point of view of	researchers in the area
In the context of	interactive systems

ence [Silva *et al*., 2019]. A classic example is smart homes that, through sensors, can turn on the air conditioning when the homeowner is returning home.

Articles related to the topic addressed in this research are cited in the section 4.1. It should be noted that SAwD is a relatively new design process and therefore related research regarding Systematic Literature Mapping reviews that could guide the objectives and questions of this research were not found.

3 Systematic Literature Mapping (SLM)

Systematic Literature Mapping (SLM) is a research method that aims to answer a research question through evidence reported in scientific papers. To develop a SML, it is important to define the protocol that covers the research objective, main question and sub-questions, search strategies, definition of search string, selection of databases, criteria for inclusion and exclusion of studies, inheritance of data and analysis of results ([Kitchenham and Charters, 2007]).

3.1 Objective

This research aims to investigate studies that apply SAwD in Education, which techniques, methods, processes and tools are associated with it, which areas of Education use it and the types of learning objects produced.

The main objective was elaborated according to the paradigm GQM *(Goal-Question-Metric)* [Basili and Rombach, 1988] arranged in the Table 1.

3.2 Research Questions

To achieve the objective defined in this research, a main research question (MQ) and sub-questions (SQ) were formulated to guide the extraction of data from the selected articles.

MQ: Are there studies that apply the SAwD in Education?

The sub-questions and respective objectives are registered in Table 2.

3.3 Search Strategy

The search strategy was divided into three stages. The first stage consists of performing database searches using a search string. In the second stage, the forward snowballing technique was applied.Wohlin [2014] of the study that presents the highest number of citations among the findings, as a way of identifying more studies that may contribute to this research. In the third step, a manual search was developed in a scientific journal that presents research on interactive systems.

Table 2. Sub-questions of Research.

Sub-questions	Objective
SQ1 - How many studies report the use of SAwD in educational projects?	Identify if the use of the SAwDis incipient in the educational context.
SQ2 - Which educational stages use SAwD?	Identify at which educational stage the SAwD was applied (elementary school, middle school, high school or postsecondary).
SQ3 - Which educational stages are explored by SAwD?	Identify which areas of education use SAwD approach.
SQ4 - Are there studies reporting the use of CSD in Software Engineering (SE) education?	Identify if there are works that apply the SAwD in SE education.
SQ5 - What learning objects are produced?	Identify the purpose of using the SAwD in education.
SQ6 - Are there works that apply the SAwD in the construction of educational games?	Identify the use of SAwD in the design of educational games.
SQ7 - Is there a formal process or method for applying the SAwD in the educational context?	Identify the process or method used for development.
SQ8 - What techniques and tools are used in the application of the SAwD?	Identify the tools used in development and deployment.
SQ9 - Does it present forms of validation and results?	Identify advantages in using the SAwD application to education.
SQ10 - What areas is the SAwD acting in?	Identify areas of activity and future possibilities.

In all stages, inclusion and exclusion criteria and filters for selection of studies were applied. In the Figure 4 the scheme with the three steps to develop this SLM is represented.

3.3.1 Databases

Four databases were defined to execute the first stage of the research: IEEExplorer, ACM Digital Library, Scopus and Wiley. These databases were chosen because they encom-

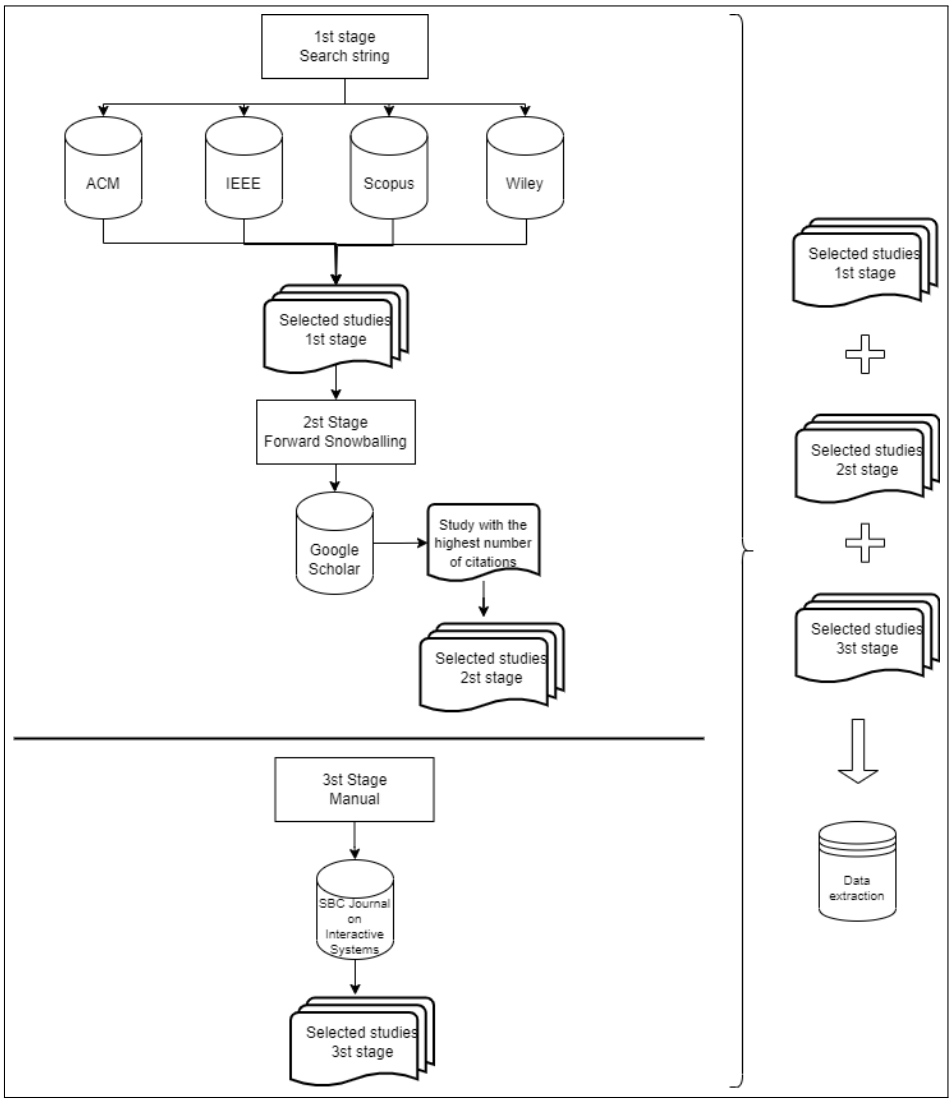

Figure 4. Search strategies.

pass the research area and to expand the diversity of findings.

For the execution of the forward snowballing, of the second stage, the Google Scholar platform was chosen, as suggested by Wohlin *et al*. [2022].

For the third stage, manual search, a journal was selected that presents research on interactive systems, SBC Journal on Interactive Systems, of the published volumes from 2014 to 2022.

3.3.2 Search String

Initially it was used PICOC (Population, Intervention, Comparison, Outcome, Context) [Kitchenham and Charters, 2007] to build a search string, as can be seen on Table 3, but the returned studies did not contain the SAwD, many of them were only about education, others only about software engineering, not returning studies with the three elements Population + Intervention + Context.

Thus, the search string used was based on keywords extracted from related research (control group) plus synonymous words, generated in the string: (“Social awareness design” OR “Designing Socially-Aware” OR “socially conscious design” OR “socially conscious design”), excluding words that mention education or SE, in order to obtain the return of the largest number of studies on SAwD during the first stage of this MSL. The string search was tested in the selected databases, satisfactorily returning 97 studies.

Table 3. Search String.

Population	((“Social awareness design” OR “social awareness” OR “Designing Socially-Aware” OR “socially conscious design” OR “socially aware design”) AND (“learning OR teaching” OR “learning objects”))	AND
Intervention	(“software engineering” OR “computer engineering”)	AND
Context	(learning OR teaching OR “learning objects”)	

3.4 Selection of articles

For the selection of articles, inclusion and exclusion criteria were defined and applied through the execution of two filters. The criteria and filters are the same for all steps defined in this research.

Table 4. Inclusion and exclusion criteria.

CE	CI
It is not in English or Portuguese language	Mentions the use of SAwD.
It has not been peer reviewed	Mentions process, methods or tools applied in the SAwD
It is not aligned with the purpose of this research	-
SML ou SRL	-
Duplicate articles	-
Articles not available for free	-

3.4.1 Inclusion and exclusion criteria

The inclusion and exclusion criteria applied during the preliminary analysis of the articles, carried out through two filters, are presented in the Table 4, and in the left column are defined the exclusion criteria (EC) and the right column defines the inclusion criteria (CI). These criteria were applied in the three execution stages of this MSL: databases, forward snowballing and manual.

When defining the inclusion criteria, it was considered that all studies that mentioned SAwD or that studies involving processes, methods, and tools used by SAwD should be selected for analysis independent of the area of activity with the aim of expanding the findings, while for Exclusion of studies was limited to English and Portuguese languages, peer-reviewed studies, also excluding books and gray literature.

3.4.2 Filters

Two filters were used to select articles:

- 1^{st} filter - title reading e abstract
- 2^{nd} filter - reading the introduction and conclusion.

3.5 Data extraction strategy

For data extraction, articles that pass through filters 1 and 2 were analyzed through a complete reading in order to extract the following data:

- Year of publication,
- Publication vehicle,
- Search location,
- objective,
- Technological area,
- Application domain,
- Process,
- Artifacts,
- Prototypes,
- Techniques,
- Tools,
- Validation.

For studies that show the SAwD applied to education, the following data will also be extracted:

- Level,
- Area,
- Artifact.

Table 5. Results of steps 2 and 3.

Step	1st step			2nd step	
Forward snowballing 72	Exclud. 40	Duplic. 21	Includ. 10	Exclud. 0	Includ. 10
Manual 137	Exclud. 130	Duplic. 0	Includ. 7	Exclud. 4	Includ. 3

3.6 Execution

This SML started in February 2022 with the search in selected databases according to the planning for the execution of the first stage. The application of the selection criteria took place in February and March 2022. The quantitative result of the searches and selection of articles by database after applying the criteria can be seen in Figure 5. It was observed that the ACM and Scopus databases returned the largest number of studies and also the largest number of studies selected according to the acceptance criteria of this SML.

A despite the IEEE and Wiley databases having returned some studies, only one study from each database was selected, but the study from Wiley portrays the creation of social constructionist learning environments [Gonçalves and Baranauskas, 2021], of relevance for the purpose of this research and the IEEE selection, despite not being applied in the field of education, generates interest in the process and artifacts used in the SAwD [Hayashi and Baranauskas, 2009].

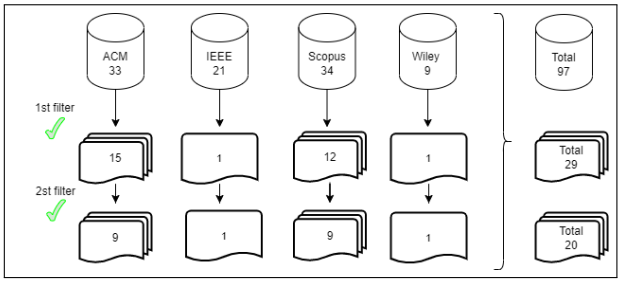

Figure 5. Result of 1^st stage.

From the 20 studies selected in the first stage, forward snowballing began by checking the number of citations of each selected study on the Google Scholar platform. With the exception of study 5, which presented 72 citations, the citation average of the other studies was 4 citations, thus, study 5 [Baranauskas, 2014] was used for the execution of forward snowballing, also considering its year of publication (2014) and the relevance of this study for research on SAwD. In these 72 studies, the selection criteria were applied according to filters 1 and 2, and 10 studies were selected, in which 5 of these studies applied the SAwD in education.

Next, the titles and abstracts of the studies published in the 2014 to 2022 editions of the SBC Journal on Interactive System were read. A total of 137 studies were found, of which only 3 passed the inclusion and exclusion criteria, one of which was applied to build a therapeutic game [Ferrari *et al.*, 2020].

Table 5 presents the detailed result of steps 2 and 3, considering the execution of the 1^st and 2^nd filters, returned, excluded, duplicated and included studies.

In Figure 6 it is possible to observe the results by stage and the total number of studies selected for data extraction, noting that in the 1st stage are the studies selected from the search in 4 databases, by through a search string, that in the 2nd stage a forward snowballing was performed on the Google Scholar platform of the most cited study of the previous stage and in the 3rd stage a manual search was performed in a journal dedicated to studies on interactive systems.

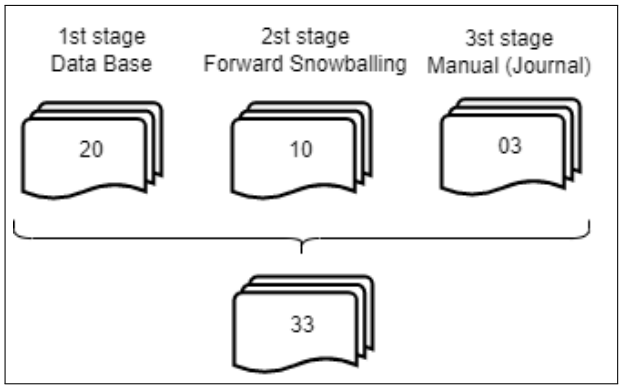

Figure 6. Total of selected studies.

After selecting the studies, the complete reading of the 33 studies was carried out to extract and analyze the data according to the items proposed in the protocol. Data is presented in the next section.

4 Results and Analysis

In this section the selected studies and the respective data extraction are presented, with an analysis and discussion from the extracted data in order to answer the research questions. For data extraction, the items defined in the protocol of this research were considered.

4.1 Articles

In Tables 6, 7, 8 are shown the unique identifiers and titles of the selected studies. The table 6 contains the studies from the first stage of the research returned from the databases used.

The articles identified with ID 01 and 03 address, respectively, design for the construction of ubiquitous and pervasive integration scenarios, based on SAwD, starting from the understanding of the problem with the involvement of interested parties to evolve a project solution (SOBRAPET) and understanding the societal dimensions: social, physical and digital (Hospital Sobrapar) - Sobrapet. ID 02 aims to describe the co-design process for creating interactive public spaces. Students on an HCI course. ID 04 presents a framework for designing socially conscious persuasive systems, while 05 and 20 bring a semi-participatory model to the e-Citizenship system. Articles 09 and 10 cover the development of learning environments.

Articles 06, 07 and 08 are works that developed solutions focused on inclusion and diversity: the first on telephony for the deaf and rural telehealth, the second on a chatbox to help children deal with online threats and the third on combating prejudice against LGBT individuals.

Article 13 addresses collective awareness about energy consumption and conservation, in addition to mediating the socialization of educational practices related to students with special needs. Article 19 establishes a framework that aggregates social opinion in the context of developing an e-learning course and describes two phases of the design refinement process where social opinion can be incorporated

These are some examples of articles that were found and met the previously described inclusion criteria.

The titles selected from the execution of forward snowballing are described in Table 7, the abbreviation SN was added to the unique identifier and the numbering was restarted at 1.

In table 8 the unique identifiers and titles of the three studies selected from a manual search in the SBC Journal on Interactive Systems are described. The acronym JM was used to differentiate these studies from the others selected in the previous steps.

Article SN01 introduces a values-driven and culturally informed design approach that offers artifacts and methods for addressing values and culture in a theoretically grounded and explicit way. Article SN02 presents design and evaluation of

Table 6. Studies selected in the first stage.

ID	TITLE
01	*Reclaiming Human Space at IoT: Contributions of the Socially Aware Design* [Silva *et al*., 2019]
02	*InstInt: Enacting a Small-scale Interactive Installation Through Co-design* [Duarte *et al*., 2018]
03	*Interaction Spaces and Socioenactive Dimensions: Exploring Perturbations of IoHT* [da Silva and Baranauskas, 2020]
04	*Motivation, Persuasion and Healthy Eating: a Case Study on a Socially-Aware Persuasive System Design* [Espinoza and Baranauskas, 2020a]
05	*Social Awareness in Human-Computer Interaction (HCI)* [Baranauskas, 2014]
06	*Abstractions for designing and evaluating communication bridges for people in developing regions* [Tucker and Blake, 2010]
07	*Chatbots to Support Children in Coping with Online Threats: Socio-technical Requirements* [Piccolo *et al*., 2021]
08	*Supporting people on fighting lesbian, gay, bisexual, and transgender (LGBT) prejudice: a critical codesign process* [Pereira and Baranauskas, 2017]
09	*Tangible and Shared Storytelling: Searching for the Social Dimension of Constructionism* [Baranauskas and Posada, 2017]
10	*Embodied-based environment for kindergarten children: Revisiting constructionist ideas* [Gonçalves and Baranauskas, 2021]
11	*OpenDesign of Scientific Research in Pandemic Context* [Gonçalves and Baranauskas, 2021]
12	*Socially-Conscious Service System Design in the Digital Era: Research Agenda* [Watanabe *et al*., 2020]
13	*Culture-based artefacts to inform ICT design: foundations and practice* [Piccolo and Pereira, 2019]
14	*InterArt: Learning Human-Computer Interaction Through the Making of Interactive Art* [Duarte and Baranauskas, 2018]
15	*Design Practices and the SAwD Tool: Towards the Opendesign Concept* [da Silva *et al*., 2018b]
16	*Preliminary Reflections on Affective Affordance in HCI: A Semiotic-Informed Perspective* [Hayashi *et al*., 2016]
17	*SAwD - Socially Aware Design: An parties Semiotics-Based CASE Tool to Support Early Design Activities* [da Silva *et al*., 2016]
18	*Creating an iDTV Application from Inside a TV Company: A Situated and Participatory Approach* [Buchdid *et al*., 2014]
19	*An opinion-based framework for designing socially aware e-learning systems* [Sharma *et al*., 2012]
20	*Communication and Expression in Social Networks: Getting the "making common" from people* [Hayashi and Baranauskas, 2009]

Table 7. Studies selected in the second stage.

ID	TITLE
SN01	*A value-oriented and culturally informed approach to the design of interactive systems* [Pereira and Baranauskas, 2015]
SN02	*A socially inspired energy feedback technology: challenges in a developing scenario* [Piccolo *et al*., 2017]
SN03	*The Social Nature of Programming: Children and Fluency* [Baranauskas and Luque Carbajal, 2017]
SN04	*A TUI-Based Storytelling for Promoting Inclusion in the Preschool Classroom* [Gutiérrez Posada *et al*., 2015]
SN05	*Articulating Socially Aware Design Artifacts and User Stories in the Conception of the OpenDesign Platform* [Reis *et al*., 2020]
SN06	*Computational Thinking for Youth and Adults Education: Towards a Socially Aware Model* [Ortiz and Pereira, 2020]
SN07	*Designing Socially-Aware Persuasive Systems: a Proposed Framework* [Espinoza and Baranauskas, 2020b]
SN08	Diminuindo a distância entre o envelhecer e a tecnologia móvel: uma proposta de curso [**?**]
SN09	*A Framework for Socio-enactive Educational Systems: linking learning, design, and technology* [Imamura and Baranauskas, 2019]
SN10	*Building a Socio-Technical Perspective of Community Resilience with a Semiotic Approach* [Piccolo *et al*., 2018]

Table 8. Studies selected in the third stage.

ID	TITLE
JM01	*Constructing meanings for formal use of mobile communication applications in educational contexts* [Menezes *et al*., 2018]
JM02	*Understanding and designing sociotechnical scenarios: a multi-theoretical approach* [Prado and Baranauskas, 2018]
JM03	*Socially Aware Design of Games: an early workshop for game designers* [Ferrari *et al*., 2020]

a Socially Inspired Energy Eco-Feedback Technology, consisting of an interactive system to trigger and mediate collective savings and a tangible device as public feedback, while article SN03 presents a case study that addresses the design of constructionist environments based on low-cost tangible technologies. SN06 proposes a Socially Aware Model for the practice of computational thinking with youth and adult education students; carry out studies in real scenarios to investigate the effectiveness of the model (if it meets to the objectives for which it was proposed); document the model, the activities developed to its application and observed results; analyze and document lessons learned; It is share the results obtained throughout this research to support other initiatives for the public youth and adult education. The article identified as JM01 investigates the use of WhatsApp and its potential to promote interaction in formal teaching environments, the article JM02 compares theories for sociotechnical understanding and design and, finally, the objective of the article JM03 is to develop a game for support speech therapy exercises

4.2 Temporality

Initially, the number of studies published per year was observed. In Figure 7 there is a period of twelve years counting from the execution of a project that aimed to create an interactive social network, called *Vila na Rede*, which included social issues in the design process [Hayashi and Baranauskas, 2009]. In the following seven years, research in the area continued and between 2017 and 2018, the number of publications tripled. It is noticed that the SAwD is an object of study that remains present in the field of science.

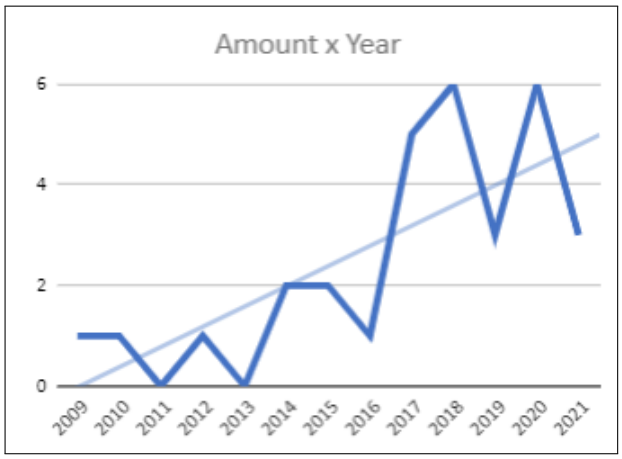

Figure 7. Number of studies published per year.

4.3 Location of research

The place where the research was carried out points out that Brazil is the largest producer of studies on the SAwD, but that other countries are adhering to the inclusion of social issues in the design of development of information technology systems, as shown in Figure 8. It is noteworthy that some countries use studies carried out in Brazil as a subsidy for their research, but that other countries have created their own mechanisms for surveying social requirements. Brazil carried out studies in partnership with other countries, such as Colombia and United Kingdom. Although this information is not in Figure 8, most of the research carried out in Brazil is concentrated in Campinas-SP.

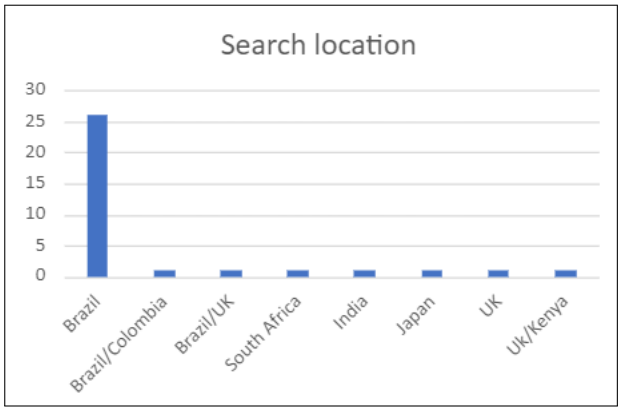

Figure 8. Country where the studies were carried out.

4.4 Place of publication of research

Regarding the publicity of the studies, it was verified that the majority is disclosed through conferences, congresses, symposia and related events, but that there is space to publish on the subject in journals, as shown by the data shown in Figure 9.

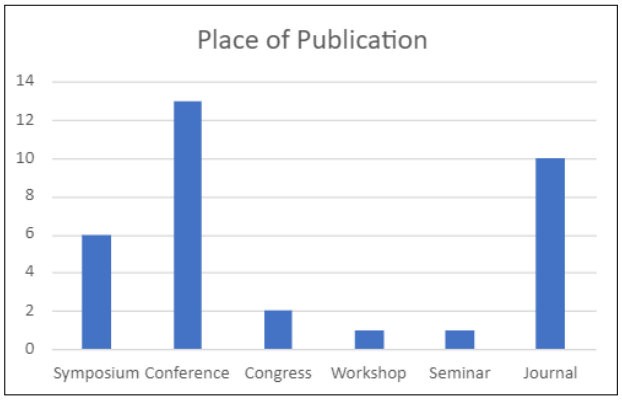

Figure 9. Location: where the studies were published.

4.5 Technological areas covered by SAwD

The data presented in Figure 10 reflect the technological areas in which the SAwD has been applied. These areas data were extracted by the researchers from the data reported in the studies, but in five studies it was not possible to identify a specific technological area, thus these studies are allocated in the "other" category.

It is possible to observe that the most active area of the SAwD is in the construction of social networks. These social networks involve: interactive computational systems for communities to disseminate products, services and other useful information [Baranauskas, 2014], for special education teachers to socialize educational practices forming a network of information that can benefit students with special

needs [Piccolo and Pereira, 2019], for disaster management through information shared in real time by anyone [Piccolo *et al*., 2018], for example.

Collaborative systems and IoT systems (Internet of Things) also appear on the graph in terms of number of studies. One of these studies was applied in a hospital environment in which tangible objects, in this project stuffed animals were used that interacted with children, showing affection when being hugged, presenting a rich work on the perception and relationship of the three dimensions that affect and disturb the space : the Social, the Physics and the Digital [da Silva and Baranauskas, 2020]. As an example of a collaborative system, Baranauskas and Posada [2017] propose the construction of a learning environment based on a Collaborative Programmable Environment for Storytelling with participation and for kindergarten children.

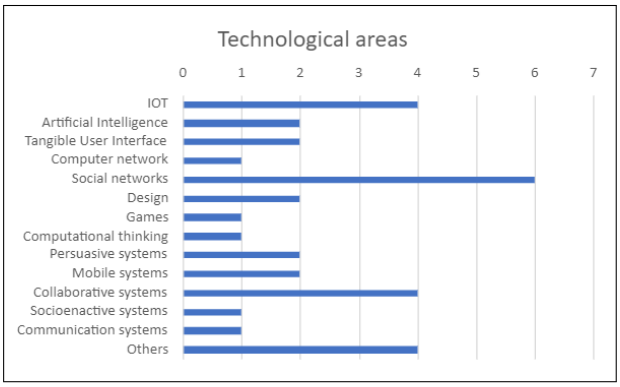

Figure 10. Areas where SAwD has been applied.

There are studies that have characteristics of more than one area, for example in IoT systems, the presence of TUI elements (Tangible User Interface), tangible user interface, is also visualized. Some collaborative systems studied also fit into mobile systems, but in all cases, the predominance of one or the other was chosen in order to be able to quantitatively measure the areas involved in the studies. Another example is one of the systems that portrays the use of AI (Artificial Intelligence) in a chatbot whose objective is to help children deal with online threats, this system also uses mobile technology [Piccolo *et al*., 2021].

Persuasive systems and AI are also a good combination for application in the development of intelligent systems, such as the study that presents the design of a system to influence the consumption of healthy foods using a framework to design socially aware persuasive systems [Espinoza and Baranauskas, 2020a].

Studies that mention education are distributed in the technological areas of communication systems, mobile systems, TUI, computational thinking, design, social networks, socioenactive systems, collaborative systems and others (others include interactive systems without specific definition of another area by the authors of the studies).

4.6 SAwD application domains

Fourteen categories were also defined for the application domain, whose objective is to point out in which branch of society the systems created through the SAwD are being executed. The application domain was extracted from the respective studies, in the same way as the technological areas, based on the definition of the authors themselves.

In Figure 11 the domains and the number of studies per domain are shown. Studies applied to education and social issues had the highest application rate, but it is worth noting that education is subdivided into early childhood education, higher education, Youth and Adult Education, education for the elderly (use of applications) and studies that can be applied at any level and for any educational audience. Likewise, the domain dealing with social issues has a variety of problem situations that are addressed.

The study that represents the application domain "sociotechnical theory" compares theories for sociotechnical understanding and design in such a way as to collaborate with the execution of other projects in this area [Prado and Baranauskas, 2018]. The "tools" application domain reports the construction of an online tool to assist in the application of the SAwD [da Silva *et al*., 2016], as well as the studies allocated in the *framework* application domain that contribute to the activities execution process proposed by SAwD [Espinoza and Baranauskas, 2020b; Imamura and Baranauskas, 2019].

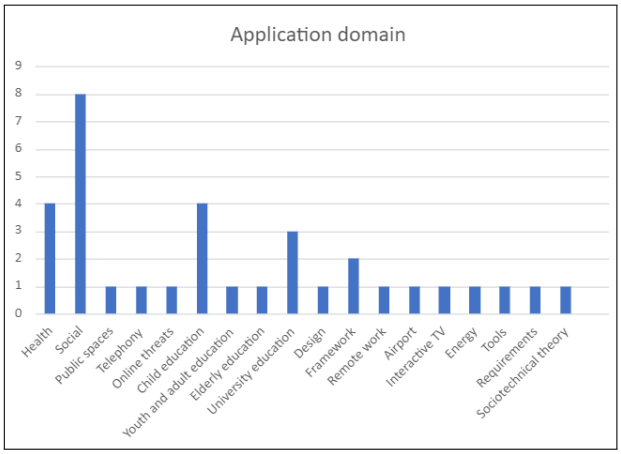

Figure 11. SAwD application domain.

It is also observed in the data presented in Figure 11 that the SAwD can be applied in the construction of information systems in different domains, since the systems are made for people and knowing the context in which they live, including them in the design process leads to the production of inclusive and sustainable systems.

4.7 SAwD in Education

As the main objective of this SML is to find studies that apply the SAwD in education, a deeper analysis of these studies was carried out. In Figure 12 the number of studies that apply the SAwD in education compared to other domain areas are presented, pointing to the receptivity to the SAwD for building educational systems. While in Figure 13 it is shown at what levels of education or for which public there is the contribution of the SAwD in the design process.

Ten studies that apply the SAwD in the educational context were found. Of these, four are applied in early childhood education (13) that propose the construction of social

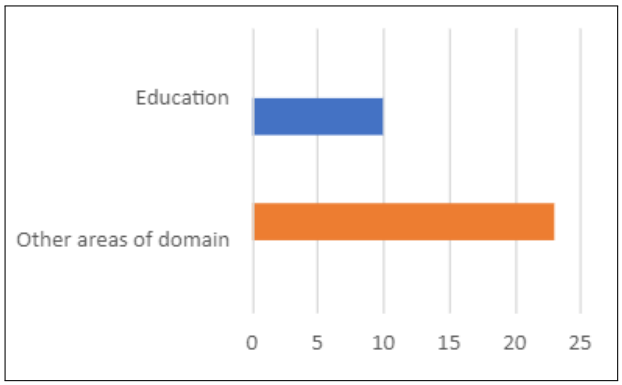

Figure 12. Number of studies applied in education.

constructionist learning environments, through storytelling, use of TUIs and robots, aiming at low-cost learning environments [Baranauskas and Posada, 2017; Gonçalves and Baranauskas, 2021; Baranauskas and Luque Carbajal, 2017], and the construction of a storytelling system using RFID cards (radio frequency identifier) [Gutiérrez Posada *et al*., 2015].

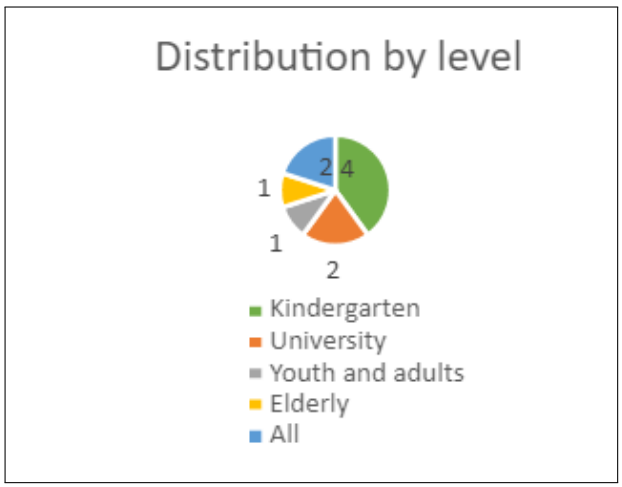

Figure 13. SAWD education level indicated in studies.

The study that applies the SAwD in education for Adult Education aims to teach computational thinking to this public by creating real scenarios, investigating the effectiveness of the model and stimulating other initiatives for the Adult Education public [Ortiz and Pereira, 2020].

SAwD applications in higher education are pointed out in two studies. The first works with the discipline of HCI through projects for the creation of interactive works of art [Duarte and Baranauskas, 2018]. The SAwD plays an important role in the construction of interactive systems, as knowing the social, cultural and legal context is essential for building a system that satisfactorily serves users, even avoiding negative impacts that can occur in the use of interactive technologies. The second study applied at the higher level investigates the use of WhatsApp and its potential to promote interaction in formal teaching environments using in this study the techniques and tools proposed by the SAwD [Menezes *et al*., 2018].

The last two studies that apply the SAwD in education do not specify a level of education, and these studies are therefore considered appropriate for any level. Both studies propose the creation of frameworks aimed at teaching. One of them proposes a social framework for the design of a course in the e-learning [Sharma *et al*., 2012] modality. The other proposes a framework to support the design and development of socio-enactive learning systems considering technical, pedagogical and social aspects in design [Imamura and Baranauskas, 2019].

The areas of education presented by the studies that applied the SAwD in education are represented in Figure 14. The area of storytelling, focused on early childhood education, was mentioned in two studies [Gutiérrez Posada *et al*., 2015; **?**], in addition to the area of Computing Technologies and Programming also for early childhood education [Gonçalves and Baranauskas, 2021; Baranauskas and Luque Carbajal, 2017], respectively. While Computational Thinking was intended for Adult Education, IHC for higher education, Digital Technologies for the elderly and 3 (three) generic studies that can be applied in any area.

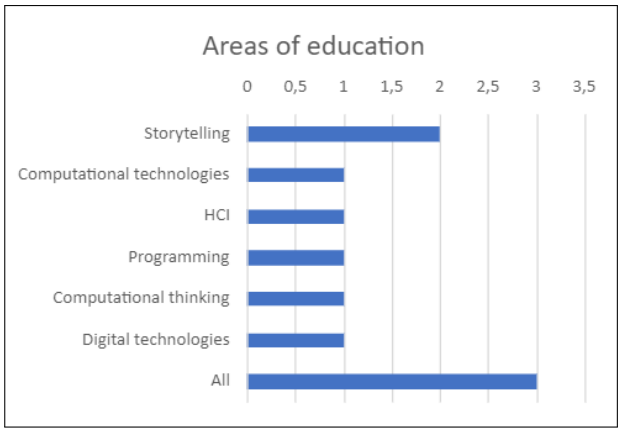

Figure 14. Areas of education in which the SAwD was active.

4.8 Processes, techniques and artifacts mentioned by SAwD

Other data of importance for future SAwD applications in interactive systems are related to "how to do it, what to use, which artifacts to generate?". Thus, these data were also extracted from the studies of this SML according to the attribution given by the respective authors.

It was searched in the studies the mention of the development process, design process or simply process. A study may have mentioned one or more processes or no processes at all. Fourteen forms of attribution to the process were identified in 30 studies and 03 studies did not report the process used.

In Figure 15 it is possible to observe that SAwD is mentioned as a process in 23 studies, followed by Organizational Semiotics (11 studies) and Participatory Design (5 studies). It is noteworthy that the SAwD uses the precepts of Organizational Semiotics and has Participatory Design as one of its practices, which indicates the importance of these elements in the SAwD process. Co-design as a way to build interactive systems in a collaborative way and universal design that aims to enable the use of the system by everyone are also inserted in the context of the SAwD.

Still observing the data displayed in Figure 15 it is possible to highlight prototyping area (2 studies), which starts with the primary representation of an idea that evolves with

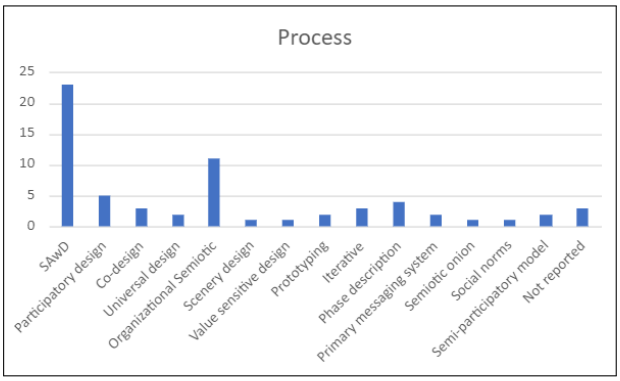

Figure 15. Processes mentioned in the studies.

each iteration (iterative process, reported in 3 studies) until the final prototype, avoiding the construction of a system that does not meet the needs of users. Other elements mentioned as a process by the authors include the Primary Messaging System proposed by Hall [1959], the application of the Semiotic Onion, the inclusion of social norms, the use of a semi-participatory model, the scenario-based design and the design sensitive to value, important allies of the SAwD and 4 studies mentioned the process divided into stages.

Twenty-four techniques used in the execution of the 16 studies were identified. Design workshops (DW) stand out, which, together with their variants participatory DW and semi-participative DW, were mentioned in 18 studies, suggesting that they are the main technique for executing projects that include the SAwD in their process. The brainstorming, brainwriting and braindraw techniques are highlighted as techniques applied during the DW.

Participant observation techniques, ethnography, case studies, interviews and questionnaires are also possible ways to obtain knowledge of the social, legal and technical context for building socially aware systems, totaling the citation for 16 (sixteen) studies as shown in Figure 16.

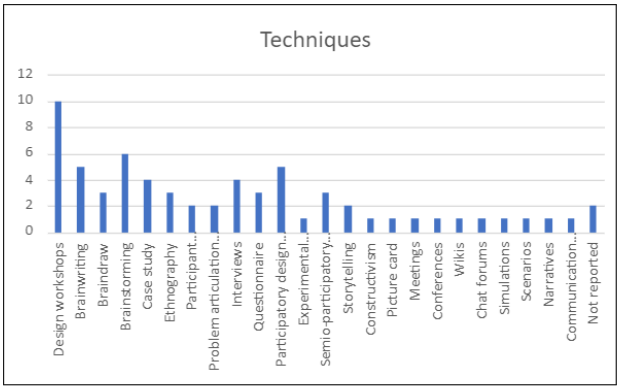

Figure 16. Techniques used in the application of SAwD.

The techniques used mainly in studies that apply the CSD in education seek the construction of knowledge through constructivism, provided by shared narratives, *storytelling*, creation of scenarios and simulations, mentioned by 6 studies among the 10 of education.

Other techniques were mentioned to a lesser extent, such as meetings, conferences, creating wikis, communication prototypes and the Problem Articulation Method (PAM). In two studies, the techniques used were not reported.

The design process that includes the SAwD produces artifacts that support the data for understanding the problem, and the solution from conception to execution and presentation of the final version of the system. In Figure 17 the Diagram of Interested Parties (DIP), the Evaluation Framework (EF) and the Semiotic Ladder (conception) and prototypes (conception and execution) are highlighted, cited by half of the analyzed studies. List of requirements and the semiotic onion were mentioned by 7 and 6 studies, respectively.

There were 26 types of artifacts generated in 29 of the analyzed studies, 4 did not report the artifacts produced.

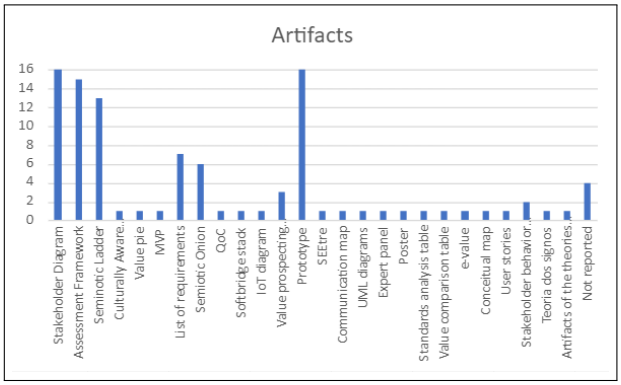

Figure 17. SAwD artifacts presented in the studies.

An analysis of the data referring to the processes and techniques was carried out to identify the combination between them. Thus, in Figure 18 a bubble chart is presented that shows these combinations, with the processes on the vertical axis and the techniques on the horizontal axis. The point of intersection is the bubbles and the bigger the bubble, the greater the number of studies that use that combination.

A possible of analyzing the data in this graph (18) is the use of the techniques brainstorming, brainwriting and braindraw in the SAwD, OS (Organizational Semiotics) processes, Participatory Design and Prototyping or even that Prototyping conducts design workshops to create prototypes.

It can be seen in Figure 18 that prototyping cites up to 15 techniques that contribute to the development of prototypes, that participatory design mainly uses workshops, branidraw and brainwriting to conceive the design, that organizational semiotics is applied mostly in design workshops, including participatory design workshops, curiously not being mentioned explicitly in semi-participatory design workshops.

SAwD mentions the holding of participatory design workshops in eight studies, however if we consider studies that mention experimental workshops, semi-participatory design workshops and design workshops, this number rises to 16, thus, it is clear that holding workshops design is the most common technique for applying SAwD. Brainstorming, brainwriting and braindraw techniques are the techniques most cited by SAwD for applying SAwD during design workshops.

There are countless combination possibilities presented that can contribute to choices in future projects.

4.9 Discussion and contributions

After presenting and analyzing the data found in this research, it is possible to answer the main question of this SML as well

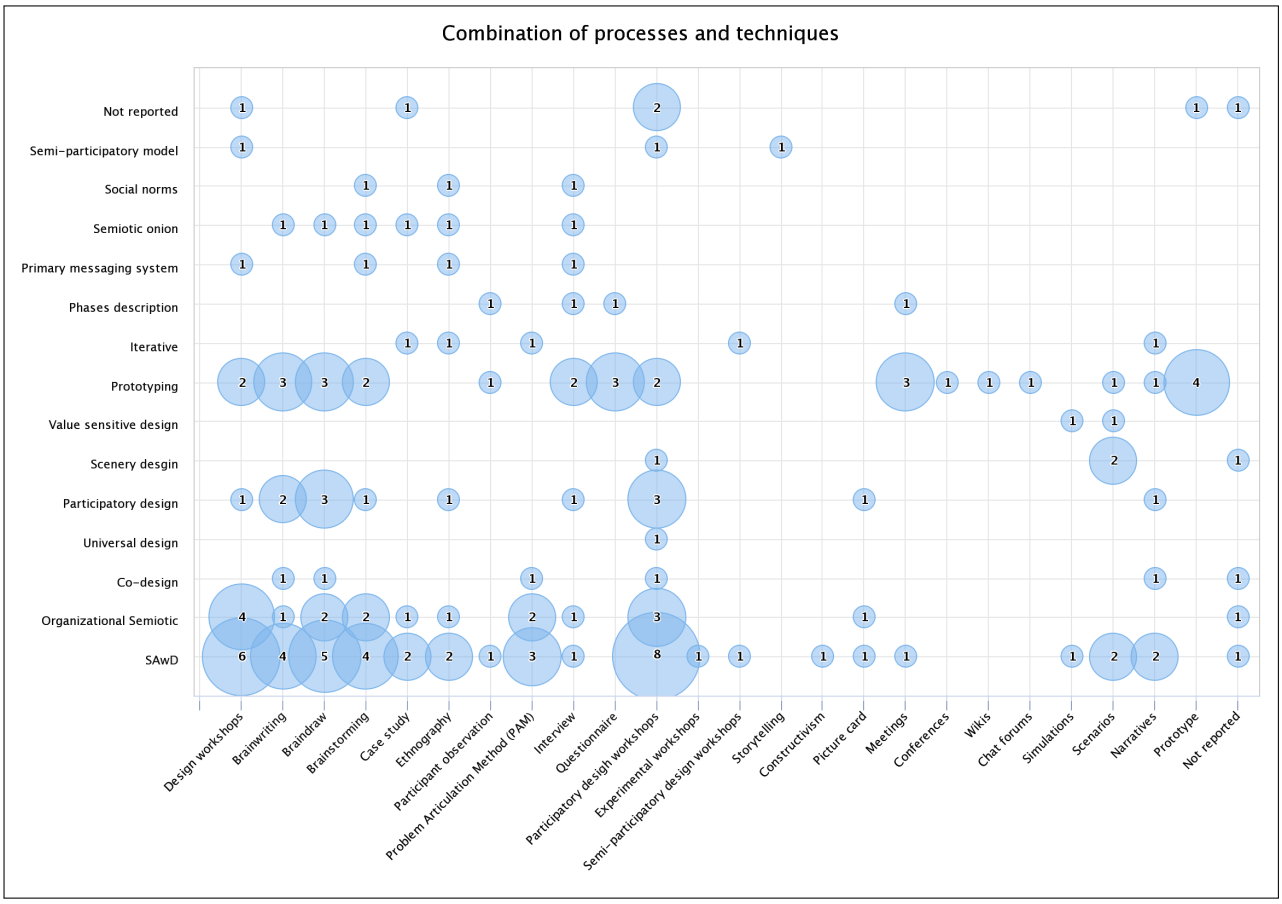

Figure 18. Combination of processes and techniques using a bubbles chart.

as the sub-questions.

The answers referring to the sub-questions of the research can be viewed in the (Table 9). The sub-questions collaborated in the extraction and detailing of data to better understand SAWD and its components (processes, techniques, and artifacts).

The first question answers the number of studies that apply SAwD in education, the main objective of the research, totaling 10 studies out of the 33 selected. The second question answers which levels of education SAwD covers, pointing out that SAwD can be applied at any level of education. The third question reports that no studies were found that apply SAwD in teaching SE, considering that HCI is a discipline not directly linked to SE.

The fifth question sought to verify which learning objects were used or created from SAwD resulting in TUIs, interactive works of art, storytelling and RFID cards. These objects can serve as inspiration for future work involving education and SAwD.

The sixth question aimed to find studies that applied SAwD in the construction of educational games to serve as a basis in the construction of educational games for SE using SAwD, and although only one game focused on health was found, this and the other studies present the techniques and artifacts necessary for the application of SAwD in information systems, be they games, commercial systems, etc.

Sub-questions 7 and 8 sought to discover the processes, techniques, tools and artifacts used by SAwD, which despite not having anything specific to education, it was clear that the application of SAwD can and should be carried out in systems that involve interaction human health, especially the most sensitive ones that cover education, health and security. The existence of an online tool for the collaborative construction of design, called OpenDesign, was even discovered.

The ninth question reports that the studies did not conduct formal validation processes, but as they presented and discussed the generated artifacts, it was possible to understand their importance in the construction of inclusive and sustainable interactive systems.

The tenth and final sub-question presents the technological areas in which SAwD was applied. In total, 13 areas were identified plus four studies that only mention interactive systems in general. These areas range from IoT and AI, to social networks, demonstrating versatility in the application of SAwD.

The main question sought to verify whether there are studies that apply the SAwD in education. The answer is yes, there are studies that apply the SAwD in education. 10 studies were found that apply SAwD in education, distributed across early childhood education, education for young people and adults, higher education, education for digital inclusion of the elderly and four of them cover education in general without reporting a specific level.

Studies that apply SAwD in early childhood education mainly mention the socio-constructionist learning theory that aims at the collaborative construction of knowledge, with participatory and collaborative design being a differentiator of SAwD, and that this way of teaching can be replicated in

Table 9. Answers to Research sub-questions.

Sub-questions	Answers
SQ1 - How many studies report the use of SAwD in educational projects?	10 studies.
SQ2 - What levels of education use the SAwD?	Children's, higher education, Adult Education, digital education for the elderly and studies that can be applied at any level of education.
SQ3 - What areas of education are explored by the SAwD?	Storytelling, Computational Technologies, HCI, Programming, Computational Thinking, Digital Technologies and studies that can be applied in any area.
SQ4 - Are there studies that report the use of SAwD in SE teaching?	No studies were found concerning SAwd in education in the databases searched.
SQ5 - What learning objects are produced?	Social constructionist learning environments through the use of tangible user interfaces, interactive works of art, storytelling system through RFID cards.
SQ6 - Are there works that apply the SAwD in the construction of educational games?	No, but there is a study that applies the SAwD in the construction of a therapeutic game.
SQ7 - Is there a formal process or method for applying the SAwD in the educational context?	The process for implementing the SAwD can be applied in the same way, regardless of the area, therefore there is no specific one for education.
SQ8 - What techniques and tools are used in the application of the SAwD?	The techniques can be seen in Figure 16 and the tools cited by some studies are: SAwD artifacts such as tools, RFID cards, post-its, pens, whiteboard, Card Game, OpenDesign, Raspberry Pi, picture cards, LEGO figures.
SQ9 - Does it present forms of validation and results?	No forms of validation were found, but some studies presented the generated artifacts.
SQ10 - Which areas is the SAwD working?	The SAwD areas of action presented in the analyzed studies can be seen in Figure 10.

higher education, allowing the exercise of communication, collaboration and teamwork skills, for example.

Computational thinking is addressed in the study aimed at young people and adults through the creation of real scenarios, fitting SAwD into the understanding of the social context of these scenarios, pointing out the importance of knowing this context in the computing environment.

Studies that apply SAwD in higher education cover HCI content, an important discipline for the analysis and design (SE) of information systems. SAwD techniques are applied and artifacts are generated in projects developed by students to create interactive works of art. A success story in terms of student involvement and learning how to discover the elements that make up the social context for inclusion in the design of an interactive system.

Although few studies were found that apply SAwD in education, it was demonstrated that the techniques and artifacts used by SAwD contribute to the inclusion of social elements in information systems, and that it is possible to introduce this concept in an educational environment, either through workshops, prototyping, shared narratives or other activities that allow students to exercise social skills.

4.10 Threats to validity

The following were identified as the main threats to the validity of this SML:

1. Bias caused by database selection: number of databases selected for this research;
2. Bias caused by manual procedures: selection and extraction of data performed manually by a single researcher;
3. Bias caused by exclusion criteria: selection of primary studies only and articles not freely available.

The threats to the validity of this research were carefully analyzed in the planning and during the execution, an attempt was made to overcome these possible biases. Thus, we selected 4 databases to obtain a greater number of studies, in addition to carrying out the forward snowballing technique and manual search in a journal specialized in interactive systems; the work of data selection and extraction, although carried out by only one of the researchers, it was done with care and the inclusion and exclusion criteria were carefully defined to avoid not including important studies in the area. The use of the National Education and Research Network (RNP) allowed access to non-free studies through the Federated Academic Community (CAFe) in which the (Federal Technological University of Paraná (UTFPR) participates, in the CAPES Periodicals Portal.

5 Conclusion

The results of this research indicate that the SAwD can be applied in several technological areas whose objective is the construction of interactive systems, regardless of the application domain, and this includes education as an area that can benefit from the construction of sustainable interactive

systems that meet the needs of users inserted in the social context that surrounds them.

It was demonstrated that the studies and applications of the SAwD in the construction of interactive systems is relatively new, whose initial work was carried out in 2009 and in all the following years studies on the SAwD were found, with a greater number of studies between 2017 and 2020, moment in which the SAwD became better known and applied, which suggests a tendency for its use in the coming years.

In the search phase for studies that apply SAwD in interactive systems, no other mappings or systematic reviews on the topic were found, which increases the importance of this research for the academic, scientific, and industrial community.

It can also be said that the SAwD was born and raised in Brazil, so research in Brazil in this area can count on the close support of their parents.

The processes, techniques and artifacts proposed and used by the SAwD that were recorded in this research and can serve as a guide for carrying out future projects.

5.1 Final considerations

Carrying out this SML provided researchers with knowledge of the areas, application domains, processes, techniques, tools and artifacts used and generated when the SAwD was included in the design process for building interactive systems.

It is expected that this work can further contribute to the dissemination of the SAwD, which seeks to build socially aware interactive systems.

For the purposes of future research in the area of education in higher education, there was a gap for the application of the SAwD in educational interactive systems to support the teaching of Software Engineering, however other areas mentioned in this research can be explored as there are indications of effectiveness of the SAwD to build ever more inclusive systems and venture into other areas not yet studied.

Declarations

Acknowledgements

Authors' Contributions

FBBH and WARF developed the searches, exploration and selection of articles. LMP and CGC provided support for data analysis. All authors worked on writing and reviewing the article, in addition to creating graphs, charts and tables to facilitate understanding of the scientific process.

Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

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