Analyzing the Technological Influence on Self-esteem: A Systematic Literature Review under the Socially-Aware Design Perspective

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Abstract Self-esteem is a concept developed from the personal experiences of a person in society, relative to his/her own assessment. It expresses an attitude of approval, or disapproval, and indicates to what extent the person believes to be capable, meaningful, dignified, and successful in relation to his/her abilities, skills, social relationships and physical appearance, for example. Some studies indicate technology has the potential to provide experiences that can affect the users' psychological states, including their self-esteem. This work contributes with a systematic literature review, aiming at investigating technological applications designed to influence self-esteem. Through automatic and manual search, we identified 3,668 papers potentially addressing the subject, and 7 of them were selected for a thorough analysis based on inclusion and exclusion criteria. In this paper we organized and detailed the results we raised through the Semiotic Framework (Semiotic Ladder) perspective. The results highlight what types of systems are used to affect/impact self-esteem, how technology has been used, the strategies for supporting this purpose, and the aspects of self-esteem addressed. Yet, we analyzed what values (personal, social, and technical) these applications considered. This work relates self-esteem, values, technological issues, and strategies to influence self-esteem, and points out limitations and open challenges to further explore.

Keywords: self-esteem, systematic literature review, semiotic framework

1 Introduction

Self-esteem is a positive or negative attitude of people toward themself based on the evaluation of their own thoughts and overall feelings in relation to themself (Rosenberg, 1965). Coopersmith (1965) highlights when this evaluation expresses an attitude of approval, the person believes to be capable, significant, and worthy of success. Self-esteem has also been defined as an emotional response people experience, contemplate, and appraise regarding various aspects of themselves (Heatherton and Wyland, 2003). These aspects are related to self-concept, self-worth, and self-image, indicating the way people see, self-evaluate, and trust themselves.

Although self-esteem is an individual concept, it is based on personal experiences from social interaction throughout the person's life and is related to the way people connect to other people and to the environment (Gunasekare, 2016). In this sense, what the environment affords to an organism will also affect this organism's motivation to act in this environment, in accordance with its purpose and capacities ((Damasio, 2005); Thüring and Mahlke (2007); apud Chen and Lee (2013)). Leary (2012) says self-esteem results from a system that supervises and responds to interpersonal agreement or rejection and argues that when people do something that seems intentional to safeguard or increase their self-esteem, their goal is to protect and enhance their value and thus expand probability of interpersonal

acceptance and social belonging. Social issues such as race, age, academic status, physical attraction, body image, and specific competence (Heatherton and Wyland, 2003; Schrammel *et al.*, 2015) may also affect people's psychological aspects and their self-esteem.

In this context, people have their own needs and subjective motivations, which are regulated by society and the social groups closest to them, also affecting the person's values. Thus, as the environment and the social relationship are coupled to the person's background, intent (motivation), needs, and adaptability may affect self-esteem. Technology, as part of the environment, may also influence the user's psychological state. As technology and social media has been in evolution, human behavior patterns, and social conventions have spread much more quickly inducing some great and others not so good effects on people. The technology usage and its relationship with psychological well-being and self-esteem have been addressed in many studies. Some papers (Boyd and Ellison (2007),Lee and Jang (2010), Pai and Arnott (2013), Apaolaza *et al.* (2013), Hatchel *et al.* (2018), and Marino *et al.* (2018)) were interested in analyzing how the social media technology may positively impact self-esteem. On the other hand, there are some studies that point out these social media have stimulated people to make comparisons, and, as its consequence, people's mental stress level has increased, and their self-esteem decreased. Other studies have investigated the users' addiction to some technologies and how these

technologies have promoted that behavior (Apaolaza *et al.* (2013); Pai and Arnott (2013); Park (2018)). Some studies also address the relationship between users' self-esteem and their affective states through the use of computational technologies (Birk *et al.* (2015), Park (2018), Muriana *et al.* (2019)). These studies, however, analyzed technological systems, applications and devices that were not developed with the primary purpose of affecting self-esteem.

Although social networks can cause great social and psychological impact on their users, (Bittencourt *et al.*, 2016; Shank, 2014; Thüring and Mahlke, 2007) state that technological devices and the systems' interface also play a fundamental role in the interaction and experience of use and provide possibilities for people to change how they feel at the same time enabling them to express their emotions. While these studies indicate technology has the potential to provide experiences that can affect the users' psychological states, including their self-esteem, an analysis of what has been designed and developed in terms of systems and their interfaces regarding affecting people's self-esteem is hardly found in the computing-related fields literature, HCI (Human-Computer Interaction) included. This lack motivated our previous work (Muriana and Baranauskas (2021)), which contributed with a systematic literature review, aiming at investigating technological applications designed to influence self-esteem.

In that previous paper we conducted a Systematic Literature Review (SLR) aiming at evaluating, synthesizing, and presenting studies that designed technological solutions with the intent of positively influence people's self-esteem. Thus, the question we addressed in that systematic literature review was: *have technologies been designed to explicitly (positively) affect/impact self-esteem?* The relevance of this question, especially for the HCI community, is in raising awareness for the ways the products of technology we develop might intentionally (and hopefully) contribute to people's (users) psychological well-being. The Systematic Literature Review (SLR) was based on the PRISMA protocol (Moher *et al.* (2009)). Both automatic and manual searches were used, with specific inclusion and exclusion criteria. The automatic search yielded 3,668 entries, which were narrowed down to 171 studies based on the titles and abstracts. After a thorough review, 41 studies were selected for detailed analysis, focusing on how and why the technology used in these studies could impact self-esteem.

The current article is an extended version of that previous article published in HCII 2021 (Muriana and Baranauskas (2021)). Both papers present the results of a systematic review, research challenges and opportunities in the subject addressed. However, in this current paper the results were analyzed through the Semiotic Ladder (SL) (Stamper (1993)) perspective. The SL, also named Semiotic Framework, is an artifact of Organizational Semiotics (Liu (2000); Stamper (2000)), which allows a view of information systems from six layers of signs (the ladder steps): physical, empirical, syntactical, semantical, pragmatical, and social.

Differently from the previous publication, in this paper we analyze the results of the selected literature based on the *Semiotic Ladder* perspective, to organize answers regarding how technology can affect self-esteem, which technologies

are being used for this purpose, which are the social effects from the applications and devices, and which are the main values these solutions endorse. Besides, we raised what types of support they provide, and what aspects of self-esteem they address. The Semiotic Ladder provides us a view of information in its six steps, from the physical to the social worlds. Moreover, from the results, we raised socio technical values related to the subject of this study. From the Semiotic Ladder perspective, therefore, we could understand the results in a social perspective relating the self-esteem concept found in the studied literature to the informal, formal and technical aspects of technology design. This perspective is related to the Socially-aware Design approach (Baranauskas (2014); Baranauskas *et al.* (2024)), and to values (Pereira *et al.* (2013), Pereira and Baranauskas (2015)). Besides, the Semiotic perspective enables us to go deeper into the limitations and open challenges presented in our previous paper. As so, from the results of this current study, we intend to reach the audience working in the design of computer systems (and their interfaces), who cares about the social impact and well-being of people in their experience of interaction with technology-mediated systems.

The text is organized as follows: first, we present the theoretical referential adopted to organize our results; in the sequence, we describe the SLR methodology; then, we show the general and specific results from the Semiotic Ladder perspective analysis. Last, we discuss the findings, answer all research questions, and point out some research challenges in this issue.

2 A Theoretical Referential for Examining Self-esteem and Technology

Pereira and Baranauskas (2015) argue that designers must understand the social world and see people, organizations, processes, rules, and norms as part of a whole information system. Hall (1959) *apud* Pereira (2011)(2011, p. 238) say "every innovation brings negative and positive impact to the environment in which it is introduced", and "people use technological innovations even without a clear perception of their utility and potential impact". Thus, in considering the self-esteem and technology relation, this study draws on concepts and artefacts coming from the Organizational Semiotics (OS) discipline and the Socially-aware approach to Design (SawD).

The Semiotics of information systems engineering (Liu (2000); Stamper (2000)) reinforces the idea the design of systems reaches the social system in which the technology is built and used (Baranauskas *et al.* (2009)). For (Stamper *et al.*, 1988), Organizational Semiotics (OS) balances technological and social aspects, in terms of information resources, products, and functions. Stamper (1993) characterized an organization as a nested structure of the informal, formal, and technical layers of information, he named "organizational onion" (p.14). The *informal layer* describes the organizational culture, customs, and values expressed as beliefs, habits, and individual behavior
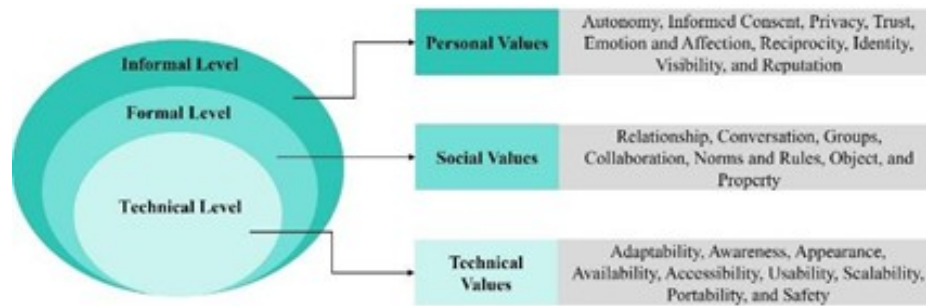
Figure 1. Values' elements in the Semiotic Onion Perspective. Based on Pereira and Baranauskas (2013).

patterns of members of an organization. The *formal layer* illustrates the organized way the society replaces meanings and intentions to aspects that are well established and accepted such as laws, formal methods, behavioral patterns. The *technical layer* represents aspects that are so formalized that they can be technically supported; most of the time, computer systems can be used for this and are used to mediate actions on the preview layers.

In this context, a set of methods was developed in the OS to support the understanding, development, management, and use of information systems (Stamper (1973)). In this paper, we use the Semiotic Ladder (SL) as a framework to organize and identify requirements according to the six levels that represent various aspects of information. The first three levels are related to technological issues (the Physical, Empirical, and Syntactic), and the other three levels are related to aspects of human information functions (Semantic, Pragmatic and Social World).

In the context of this work, the physical world includes physical devices the system uses such as hardware, toys, or other objects that users can manipulate. The empiric layer is related to necessary services and software for the system to work properly, supporting users in their interaction with the physical devices (e.g., internet services). The syntactic layer is related to the "grammar" of interaction, how the physical devices collect valuable information from the user and structure the dialogue. The semantic layer is related to the ways physical devices use the information and how they support users in their meaning making. The pragmatic layer refers to the system's main goal, and the support for practical and effective use of it. The social world layer describes the impacts and consequences in the daily life of stakeholders through the systems in society. The SL has been used in several contexts to organize requirements of the prospective system (Hayashi *et al.* (2018); Maike *et al.* (2015); Santana and Baranauskas (2008)), and to organize the system evaluation process (Baranauskas *et al.* (2003)). In this work we use the SL for organizing all the specific solutions (systems, applications, and devices) and to figure out some important, eventually missing aspects to address self-esteem.

In the Socially Aware Design perspective, Baranauskas (2014); Baranauskas *et al.* (2009) and Baranauskas *et al.* (2013, 2024), articulate that: i) the design process can be seen transversally to the three layers of the semiotic onion, so it is possible to clarify and build meaning at the informal, formal, and technical levels of knowledge through

participatory practices with interested parties; and ii) the design process within this perspective allows articulating the knowledge of the (social) world towards the (technical) system and vice-versa, in such a way it is possible to figure out the impact of a solution on a society. We also suggest the importance of considering values when designing systems for different usage contexts, because these systems will impact on their users. Therefore, from the Socially Aware Design perspective, social aspects are intertwined with technical and formal aspects.

Acknowledging the fact that the self-esteem is associated with how a person lives in society, it is also necessary to develop applications with social concerns in mind. In this sense, the Socially-aware Design approach (Baranauskas (2014), Baranauskas *et al.* (2024)) is useful as it address the design process of a solution, while considering the technological aspects to develop the system. Related to that approach, the Semiotic Ladder perspective supports the organization and understanding of the requirements of systems considering from social to technical issues. Therefore, the analysis in this work, will encompass how the systems were designed to affect the users' self-esteem from the social to physical aspects.

The elements that compose a system must be understood as values bounded to cultural aspects of people, groups, organizations, and their environments, and vary in meaning, importance, and priority according to the culture being analyzed and across time and space (Pereira and Baranauskas (2015)). Values can be understood as people's internalized guides to ascertain particular actions as socially appropriate and to achieve desired behaviors to escape from constant social control (Schwartz (2012)). Schwartz (2012) also says values are the basis of an individual's attitudes and evaluations: when behavior is evaluated as "positive", it stimulates the achievement of the objectives it values; and when it is considered "negative", there is harm and threat to the achievement of that objective. Self-esteem also follows this perspective of good and bad self-evaluation, based on values "established" by society, and found in it.

In computer systems context, depending on the way the system is designed, it may afford behaviors that are intrinsically related to individuals and the complex cultural context in which they are using it (Pereira and Baranauskas (2015)). These behaviors and cultural aspects have an impact over people and can affect their self-esteem. (Pereira *et al.*, 2013) identified 27 elements that represent critical aspects and could be seen as values in systems design (see Figure
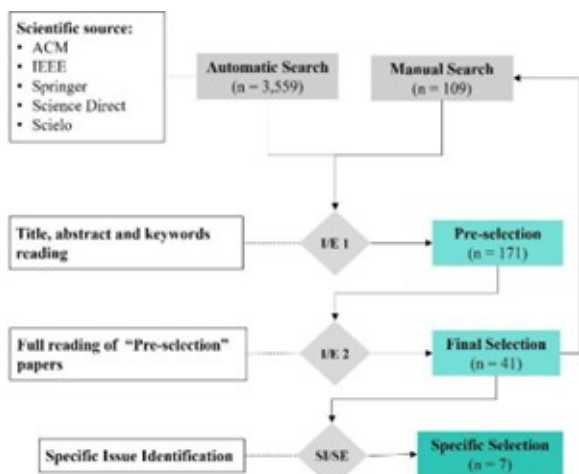
Figure 2. Systematic Literature Review Execution Flow.

1). These elements consider the three layers of the Semiotic Onion: *informal level* values have a personal or ethical nature; *formal level* deals with the collective or social values through the social rules or the system of norms of some organization; and *technical level* values can be figured out as quality attributes or special features of the technology.

Thus, since self-esteem is related to values of the three layers (personal, social, technical) that motivate people to act in specific ways to seek acceptance and social belonging, systems' design should consider these values.

In the systematic literature review conducted in this work, the Semiotic Ladder and the analysis of Values are used to support the examination of the ways technological solutions dealt with the issue of self-esteem.

3   The Systematic Literature Review Protocol

A systematic literature review is a literature study that uses specific and planned, justifiable, and explicit systematic methods to make critical and clear analysis of a research area defined from a question that guides this review (Gough *et al*. (2017)). In our SRL we adopted the PRISMA protocol (*Preferred, Reporting Items for Systematic Reviews and Meta-analyzes*) (Moher *et al*. (2009)) to support us to identify, interpret, and evaluate the studies' data to answer our research questions. In Figure 2 we show the SLR execution flow we followed and the number (*n*) of papers we got in each step. In the coming subsections we describe each step we carried out.

3.1   Research Questions

Based on the key question of this study (*Have technologies been designed to explicitly (positively) affect/impact self-esteem?*) we raised five other specific questions. In Table 1 we present these questions and our motivations to each one.

3.2   Search Bases and Search String

In this SRL we adopted the automatic searching complemented with manual method to raise relevant

papers. In conformity to our research questions, we defined two main keywords: **technology and self-esteem**. The term 'technology' was chosen to not restrict the types of technologies in search; in this work, as 'technology' we understand and consider everything that has some type of computational processing. The terms *self-image, self-worth, and self-concept* are often used as synonymous of self-esteem (Pereira Santos *et al*. (2017)). Therefore, based on the that, to perform the automatic search, we defined the following search string:

technology AND ("self-esteem" OR "self-concept" OR "self-image" OR "self-worth")

The automatic search was carried out on the main scientific bases used by the computer academic community: ACM, Digital Library, IEEE Xplore, SpringerLink, and ScienceDirect. We also considered Scielo because it indexes Brazilian journals. In the SpringerLink we considered papers in the computer science area, classified as HCI (*Human-Computer Interaction*) subject. In the Science Direct we only examined papers from the "Computers in Human Behavior" and "Computers & Education" Journals, because the first addresses the use of computers from a psychological perspective and self-esteem affects the human behavior, and the latter because digital technology can enhance education and self-esteem is an important factor in this context.

Although the scientific sources cover this SLR multi-disciplinarity, we still considered manual search. After reading the papers selected from automatic search (see "Final selection" on Figure 2), we raised some references of those papers that could be relevant to the scope of this work. We analyzed these new papers and considered all the inclusion and exclusion criteria and the established steps to decide whether to incorporate the paper in the final selection or not.

3.3   Inclusion and Exclusion Criteria

To support us to identify studies that provide evidence related to our research questions, we defined some inclusion and exclusion criteria. In this SLR, we held a paper eligible to be included if it presented a relation between technology and self-esteem. All inclusion and exclusion criteria are listed in Table 2.

To select the papers, we took the inclusion and exclusion criteria in two distinct moments (I/E 1, and I/E 2) (see Figure 2); we adopted this strategy to support us to refine the selection at each new screening step. In each step, all the inclusion criteria were supposed to be reached, and if any of the exclusion criteria were considered at any moment, the paper would not be selected. Besides criteria from Table 3, in each step (I/E 1, and I/E 2) we defined some questions to lead us in the process of selecting papers.

- **Step I/E 1:** in this step our main goal was to identify whether the paper addresses the self-esteem issue. In this sense, we raised the following question: *By the title, abstract and keywords, does the paper address the self-esteem issue in any way?* At this step, we considered the I1 inclusion and E1 exclusion criteria. The selected papers are the "pre-selection" set (see Figure 1).

Question	Motivation
RQ1. What types of technologies have been used to affect/impact self-esteem?	By raising the types of technologies that have been used to affect/impact user's self-esteem we can better understand their limitations and prospect new ones to achieve this purpose.
RQ2. How technology has been used to positively affect/impact self-esteem?	This question is essential to understand the role of the proposed technology in affecting/impacting self-esteem positively, as well as ascertain its limitations.
RQ3. Which values do the solutions take into account to affect/impact self-esteem?	This question is important to identify the (human and technical) values considered or inhibited potentially affecting the experiences.
RQ4. What aspects of self-esteem are affected through technology usage?	This question raises the aspects of self-esteem that have been addressed in the literature. Besides, it helps to relate them to the characteristics of the technologies used.
RQ5. What strategies have been adopted to influence self-esteem through technological support?	This question is relevant to verify which possibilities and challenges exist in the process of influencing self-esteem through technologies usage.

Table 1. Research questions and motivations.

Inclusion criteria	
I1	Study that addresses the self-esteem issue
I1	Study published since 2009
I1	Study from primary sources
I1	Full paper (conference articles), journal or book chapters
I2	Study that focuses on the relationship between technology and self-esteem
I2	Study that focuses on how technology affects/impacts self-esteem
Exclusion Criteria	
E1	Study not related to the research context
E1	Study that does not address the use of technology and correlated areas
E1	Study from secondary source
E1	Study published before 2009
E1	Study that is not in English or Portuguese
E1	Duplicated Study
E1	Short paper (work with up to three pages)
E2	Study that does not discuss "how" and/or "why" technology affect/impact self-esteem

Table 2. Inclusion and Exclusion Criteria.

- **Step I/E 2:** after getting the "pre-selection" papers, we read each one and analyzed whether we could answer the following questions (yes or no): *Does the paper address the correlation between technology and self-esteem?* Does the paper address how and why technology affects self-esteem? At this step, we considered I2 inclusion and E2 exclusion criteria and got the "final selection" (see Figure 1).

From the "final selection" of papers, we expected they could support us to answer the questions presented in Table 1. However, as we discuss in section 4.1, after an in depth reading of the "final selection" of studies, aiming at refining the analysis, we raised two other questions to identify relevant papers from those first selected: *Does the paper describe the design of some technological solution to specifically affect self-esteem? Does the paper describe any supporting strategy used to this purpose?* Therefore, we defined more specific inclusion and exclusion criteria (Table 3). After this stage, we got "specific selection" studies (see Figure 2).

3.4 Data Extraction

After a thorough reading of all "final selection" studies, we extracted some papers' data such as year, source type (journal or conference), authors list and their affiliation and nationality, and the paper' title and context (industry or academia) to obtain metadata of the papers. Also, we raised the papers' type of research (e.g., qualitative, quantitative, systematic literature review), and other technical aspects, such as the solutions' user interface category (e.g., Graphical User Interface (GUI), Natural User Interface (NUI), Tangible User Interface (TUI)), the solutions' device category (e.g., PC, TV, Mobile), and the solutions' interface design approach (e.g., participatory design, user-centered design, semio-participatory design, scenario-based).

	Specific Inclusion Criteria
SI	Study that supports in answering the research questions
SI	Study that explains the strategy used to influence self-esteem
SI	Study that focuses on technology design approaches to affect/impact self-esteem
	Specific Exclusion Criteria
SE	Study that does not present the design of an application, system, or device to affect self-esteem

Table 3. Specific Inclusion and Exclusion Criteria.

For the "specific final selection" papers, we also collected other information related to the tools addressed in the papers, such as the name of the tool, target audience, users' location, and domain application. Also, we raised how the tools were evaluated. Besides, we analyzed some issues related to self-esteem, such as the type of self-esteem addressed by the tool, which aspects of self-esteem the tool directly or indirectly addresses (e.g., self-confidence, self-image, social relationships), and how the studies assess the users' self-esteem. Moreover, we analyzed how the tools deal with the underlying values listed in Table 1. The summarized results can be seen in Figure 3.

4   Results

The SRL was conducted by two researchers. One researcher was responsible for the automatic and manual searches, and for applying the inclusion and exclusion criteria 1 and 2. From the searches, we got a total of 3,668 papers; 3,559 from the automatic process. First, 171 studies were selected, taking into account the papers' titles and their abstracts. Next, it was conducted a full reading of them to find out if they explicitly addressed the relation between technology usage and self-esteem. Then, 41 papers were select for in-depth analysis, regarding ways they could potentially support us to answer our research questions. At this moment, the specific inclusion and exclusion criteria for the specific final selection (final SLR step) were applied also by the second researcher. The reading and analyses to the final specific selection were performed in one iteration. Next, we present the main findings of the SLR.

4.1   Overview of Findings

The automatic and manual searches was conducted from September 2019 to April 2020, and considered a period of ten years of published papers. In Table 4 we show the number of papers we obtained in each of the chosen scientific bases and how many studies were selected.

From the 41 selected studies, only two of them have an author coming from the industry. Thus, studies of this nature seem to be mainly a concern of academic contexts.

From a temporal point of view, the number of papers has increased considerably over the years: in 2009 there were 166 publications, and in 2019, 514. However, most of them, identified automatically, addressed self-esteem from

	Total	Pre-selection	Final Selection
ACM	1314	26	8
IEEE	133	30	1
Springer	1160	13	8
Science Direct	940	57	8
Scielo	12	3	0
Manual	109	42	16
Total	3668	171	41

Table 4. Total amount of selected papers.

America	Europe	Asia
United States (13)	United Kingdom (5)	South Korean (2)
Canada (4)	Netherlands (3)	Thailand (1)
Brazil (2)	Turk (3)	China (1)
	Spain (2)	Taiwan (1)
Africa	France (2)	Singapore (1)
South Africa (1)	Portugal (2)	
	Denmark (1)	
Oceania	Germany (1)	
Australia (1)	Belgium (1)	
New Zealand (1)	Sweden (1)	
	Austria (1)	

Table 5. Authors' Institutions Countries.

perspectives which were not the focus of this work. Most of the papers were concerned about self-esteem in existing social media context; they analyzed, for instance, how mechanisms such as Facebook 'like' can affect self-esteem, or how the user's self-esteem influences social media usage. Some papers also analyzed how self-esteem influences social relationships through technological means, (e.g., chat), or analyzed, yet, how self-esteem may influence technology addiction or vice versa. Those approaches are not the focus of this SLR.

Although 2019 was the year with more publications, considering "pre-selection" and the final selected papers, 2018 was the year with the greatest number of studies correlating technology and self-esteem (26); whereas in 2019 there were 12 publications.

From the demographic point of view, Table 5 shows the contributions distributed from 22 countries located across five continents (North and South Americas, Europe, Asia, Africa, and Oceania); the numbers refer to the researchers' country of affiliation. Overall, the results suggest that North America seem to be more concerned with the theme (impact of technology on people's self-esteem).

Regarding the type of research, 61% (25 studies) carried out quantitative research through surveys and controlled experiments (S2, S3, S4, S5, S7, S8, S11, S12, S13, S14, S15, S16, S17, S18, S19, S22, S23, S25, S26, S30, S31, S35, S38, S39, S41), 29,3% (12 studies) conducted qualitative research (S1, S6, S20, S24, S27, S28, S29, S32, S33, S36, S37, S40) and used prototyping, interviews, video analysis, and other HCI techniques, and 4 studies (9,7%) reported both qualitative and quantitative research (S9, S10, S21, S34).

One paper ran a literature review, but its focus was on psychological well-being, having self-esteem as one of the study aspects.

As we described in section 3.3, we were interested in

papers that present the design of technological solutions to impact/affect the users' self-esteem. Therefore, from the 41 select papers, seven studies ("specific selection") developed some application with this purpose; Paay *et al.* (2018) designed two tools (P01). Table 6 presents these seven papers, and the next section deepens analysis on them.

Next, we depict the specific results related to these seven papers.

4.2 Results through the Semiotic Ladder and Values Perspective

The seven studies offer different types of applications and tools. We briefly describe each of them, as follows.

- **P01 - Happy Frog (Paay *et al.* (2018))**: it is a technological ubiquitous and pervasive device for the users to avoid negative thoughts and get motivated. It comprises a frog stuffed with an LCD screen in its belly. When the users feel sad, they may raise the frog, which will say a motivational and encouraging message. The messages are editable through the internet by the users themselves. After the frog's message is sent, the users must evaluate how they felt when listening to the audio. To do it, they must choose an emoji on the LCD screen (mobile) in the frogs' belly that represents her/his affective state.

- **P01 - Sun of Fortune (Paay *et al.* (2018))**: it is also a technological ubiquitous and pervasive device for the users to avoid negative thoughts, feel themselves confident and motivated, affecting their self-esteem. The object is a sun-shaped technological device composed of LEDs and a microcontroller. To use the device, the user has to write activities on a piece of paper and place them on the end of each sunbeam; at each end of the sunbeam there is a led. When feeling sad, the user presses the button in the center of the sun and one LED will light up randomly, showing which activity the user should perform.

- **P02 – MindBook (Schrammel *et al.* (2015))**: It is an online web page whose interface looks like a social network system. This application aims at behavioral training focused on social interactions and strengthening the self-esteem of children with depression. The system comprises videos, images, games, and a planner for children to plan their activities during the week. Through simulations of real situations they may face in their daily life, children learn how to deal with them, and that positive self-expression is important and influences their self-esteem.

- **P03 Tutoring System (Jraidi and Frasson, 2010)**: It is a system of a multiple-choice questionnaire related to logic with five questions in each of the three available contexts (geometric figures, numbers, and letters). The system aims to improve the users' self-esteem while they answer the questions through positive reflexive association (positive words) in a way it may change the users' states affecting their sense of competence, satisfaction, and motivation.

- **P04 – Batcave (Birk *et al.* (2015))**: A shooting game in which the players move a car in a mine while they need to dodge obstacles and shoot enemies to reach a treasure at the end of the cave. The game was developed to verify how self-esteem influences the players' motivation and their experience, and to verify their post-game psychological state, checking, above all, their affective states, sense of competence, satisfaction, and motivation.

- **P05 – ReacTickles (Keay-Bright and Howarth, I., 2012)**: It is a software used by means of a computer (mouse, keyboard, and display) as a resource to support the relaxation and social encouragement of children with autistic spectrum disorder. The tool intends to promote the child's curiosity through visual effects: the user interacts with the system through the keyboard and mouse and affects the interface depending on frequency of interaction and pressure used to manipulate the objects. The child can also use the voice to control the system. Influencing the social interaction, trustfulness, engagement/motivation, self-reflection, and self-confidence, the system influences the user's self-esteem.

- **P06–Dancing Game (Gerling et al., 2014)** : It is a game that involves the user performing synchronous steps with the beat of the music being played by a specific software. For this, the user must follow the indications of the steps represented by arrows that move on the screen (TV). Through a Kinect connected to a notebook, the system recognizes the user's movements. As this game is designed to aim at social inclusion and not noting physical differences, the system can also recognize the movements of a wheelchair user. So, the game allows three types of interaction: by a carpet that detects the movements on the floor; by movements performed with a wheelchair; and by a control that has four buttons to be pressed with the hand.

- **P07 – eTutoring (Roux and Loock, 2015)**: consists in a platform for cross-age e-tutoring based on social networking tools, in which teenagers are tutors of other younger people through a video call and the functionalities made available. The application aims to promote social relationships so that it can affect the user's motivation and satisfaction.

Acknowledging that technological applications, systems and devices affect life in society, the Socially-aware Design argues for the importance of making explicit their design process. Related to that, only P01 explained the (participatory) design process adopted, and the techniques used (cultural study probe, interviews, prototyping, brainstorming and focus group) to develop the tool they propose. Although P02 reports they adopted user-centered design, considering aspects of autism to design their final application, they do not detail the design process. The other papers do not mention the design approaches and techniques used.

Regarding the evaluation of the proposed tools, usually the papers report that end-users used the designed systems. In P01, the tools were used by the participants for four

	Reference	Scientific Source	Year	Country	Type of Research
P01	Jeni Paay, Heidi Nielsen, Helle Larsen, and Jesper Kjeldskov. 2018. Happy bits: interactive technologies helping young adults with low self-esteem. In Proceedings of the 10th Nordic Conference on Human-Computer Interaction, 584–596.(Paay *et al*. (2018))	ACM	2018	Australia & Denmark	Qualitative
P02	Andreas Schrammel, Helmut Hlavacs, Manuel Sprung, Isabelle Müller, Marlies Mersits, Christopher Eicher, and Nina Schmitz. 2014. Mind Book–A Social Network Trainer for Children with Depression. In International Conference on Games and Learning Alliance, Springer, 152–162. Schrammel *et al*. (2015)	Springer	2015	Austria	Quantitative
P03	Imène Jraidi and Claude Frasson. 2010. Subliminally enhancing self-esteem: impact on learner performance and affective state. In International Conference on Intelligent Tutoring Systems, Springer, 11–20.	Springer	2010	Canada	Quantitative
P04	Max V Birk, Regan L Mandryk, Matthew K Miller, and Kathrin M Gerling. 2015. How self-esteem shapes our interactions with play technologies. In Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play, 35–45. (Birk *et al*. (2015)).	ACM	2015	Canada & United Kingdom	Quantitative
P05	Wendy Keay-Bright and Imogen Howarth. 2012. Is simplicity the key to engagement for children on the autism spectrum? Personal and Ubiquitous Computing 16, 2 (2012), 129–141.	Springer	2011	United Kingdom	Qualitative
P06	Kathrin Maria Gerling, Matthew Miller, Regan L Mandryk, Max Valentin Birk, and Jan David Smeddinck. 2014. Effects of balancing for physical abilities on player performance, experience and self-esteem in exergames. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 2201–2210.	ACM	2014	Canada & Germany	Qualitative & Quantitative
P07	Petra le Roux, and Marianne Loock. "The impact and opportunities of e-tutoring in a challenged socio-economic environment." 2015 International Conference on Computing, Communication and Security (ICCCS). IEEE, 2015.	IEEE	2015	South Africa	Qualitative & Quantitative

Table 6. Specific Final Selected Papers.

weeks in their homes, and the evaluation took place through usage logs, daily notes, emojis, and interviews. In P02 participants used the system for a few days at school to self-assess their emotional state; the paper also reports usability evaluation of the tool the researchers carried out after users' execution of some tasks in the system. In P03 the students were randomly assigned either to the experimental condition or to the control condition to use the system and some physiological measures of all users were recorded. P05 performed three experiments with children, but in the last one, only one child used the system for a few days, and his teachers, through observation, noted his self-esteem had improved. To assess the users' self-esteem, P01, P03, P04, and P07 used specific questionnaires such as *Rosenberg Self-esteem Scale* (Rosenberg (1965)), after the users used the tools; P07 also applied the questionnaire before the users utilized the system. Finally, P06 carried out two controlled experiments, and at the end of each one, some questionnaires related to the user's psychological state and to the game interface were applied.

Related to the solutions' target audience, P01 and P03 focused on young adults; P02 and P05 considered children and adolescents. The remaining tools (P04, P06, and P07) do not mention the target audience, although they conducted experiments with young adults.

As the solutions present distinct strategies and technologies to address the theme, we used the *Semiotic Ladder* (SL) adapted by Hayashi *et al*. (2018) to have a big picture of them. Table 7 shows each solution's main characteristics within each layer of the SL.

In the *physical layer*, we raised the technologies used to affect/impact self-esteem. Regarding the device categories, most of the works (83.3%) made use of traditional computer devices (mouse, display, keyboard, and CPU), or notebook, or television (TV) for user interfaces. From those studies, P01 and P06 used an interactive device that is not keyboard and mouse-based interaction: it considers the body movements on a carpet with sensors, or on a mobile controller to be adopted like a video game joystick (P06); and P01 uses micro-controller, actuators, and button on a device placed on the wall, and a cell phone, its audio output, and its sensors, and a plush frog for the prototype of a second tool. In the empiric layer, we show access to the services for these solutions to work properly. As we can see, all of them demand internet access and some specific services related to it, except P05 and P06, which both require specific software on the user's computer.

The *syntactic layer* handles the information the devices such as sensors and keyboards collect, to provide a "sentence" for communication (interaction). Related to that, three interface categories were identified in the studies: GUI (P02, P03, P04, P07), TUI (P01), NUI (P06), and NUI+TUI (P05). GUI usage as the most frequent interface category was expected as it is yet the most common means by which people interact with the digital world. However, some studies such as those that adopted TUI and NUI seem to be aware of novel ways to interact with technology (e.g., ubiquitous, pervasive), their relevance, and the diverse possibilities they enable. For instance, in P05 the tool considers the pressure and time the users type on the keyboard to give them feedback, and in P06 the accuracy of the user's movement under a sensor with the information that is shown in the display is more important.

The *semantic layer* refers to elements provided regarding users' sense making of these data (e.g., through metaphors, through body movement, etc.); the meaning depends mostly on the content the tools present to the users. In the selected papers we note the information is shown through conventional elements, such as list of options (P1), a leaderboard (P4), and interface elements changing (P5).

The *pragmatic layer* describes the intention reflected in each solution and the effectiveness of its perception by users. In this sense, tools have different domains and purposes. Concerning their domain, three studies are in the psychology field (P01, P02, P03), two are in the educational area (P03, P07), and the other two are entertaining games (P04, P06). Related to the type of solution, both tools P01 and P06 are motivational-based, P02 and P05 are therapeutic-based, and P03 and P07 are teaching/learning-based. P04 and P06, are leisure games, and there are some informational aspects in P02. Still regarding the pragmatic layer, we can also note that the users do not seem to be aware of the fact these applications should affect their self-esteem; just in P01 users were aware about this goal of the system.

The solutions adopted two types of strategies to affect the users' self-esteem: action-based supporting strategy, i.e., the user's psychological state is affected indirectly (P04, P05, P06, P07); cognitive training-based supporting strategy, i.e., when the focus is on explicitly reaching the user's psychological state through its cognitive aspect (P01, P02, P03). These strategies can also be implicit, i.e., when the user is not aware of the strategies and objectives of the tool; or explicit, i.e., when the user is aware of what is happening and its pragmatic aspect.

The social world layer, the upper layer of the Semiotic Ladder, identifies the impact in the user's daily life, and the social consequences on it. From this perspective, four works (P02, P05, P06, P07) considered a social approach. P02 and P05 aim to motivate interaction with technology so that children can feel more confident to interact socially and to express themselves positively. P06 uses a strategy that makes the game more egalitarian, so it favors social inclusion, influencing the self-confidence of users, which can affect self-esteem. P07 seeks to promote positive social experiences by teaching and learning, so it increases self-esteem, especially of those in the role of tutor.

Regarding the values present in the solution specifications, we identified the personal, social, and technical values they express, or inhibit, or do not yet address. The identification of the values was done considering the values' definitions of Pereira *et al*. (2013). For example: the value *Ownership and property* according to the authors, means "the right to possess a private object or information, and the right over the actions that can be executed over/with/through this object; or yet, the right to momentarily make usage of a public object or information and respect the available action over it." (p. 6). Based on this definition we analyzed whether the solution we identified in the SLR paper express the value (or not) in its design, or have it explicitly addressed in the paper. It should be mentioned that we restricted ourselves to mark

							Semiotic Ladder Layers		
	Physical World	**Empiric**	**Syntactic**	**Semantic**	**Pragmatic**	**Social World**
P01	Plush animal; cellphone; LEDs; actuators; sun-shaped artifact on the wall.	Internet connection/ services; wireless connection;	Affordance of the stuffed animal; affordance of the "sun button"; Emojis for evaluation of affective status; Led flashing to indicate task drawn	Meaning depends on the content of the motivational message (audio); description of the task to be performed; representation of emotion through the evaluation of the expressed motivational messages	avoiding negative thoughts	——-
P02	Computer (monitor, keyboard, mouse); internet infrastructure	Internet connection/ services	Mouse click on interface elements	social media interface elements (e.g., friends, user's activity feed), results of the activities the system proposes	behavioral training focused on social interactions	Design for behavioral training to support children's social interaction and self-confidence
P03	Computer (monitor, keyboard, mouse); internet infrastructure; sensors	Internet connection/ services	Mouse click on the options to answer the questions and on the "next question" button	List of response options that resembles a quiz, with option to answer or to pass the question; indication of the possibilities of answers; self-reflexive and positive affective words	self-reflection with the positive and affective association for improving school performance	——-
P04	Computer (monitor, keyboard, mouse); internet infrastructure	Internet connection/ services	Use of the keyboard to play and move the "car" in the game	Leaderboard, ranking of users according to score; name and photo of users, score achieved in the game; use of colors to indicate placements; move character on screen during the game	affective states changing	——-

			Semiotic Ladder Layers			
	Physical World	**Empiric**	**Syntactic**	**Semantic**	**Pragmatic**	**Social World**
P05	Computer (monitor, keyboard, mouse); microphone	Specific software	Pressure and time manipulation of object; Use of voice to manipulate the tool	Change of interface elements (get bigger, smaller, increase or decrease color intensity)	encouragement——- for interaction	
P06	Dancing carpet; Kinect; game pad control; TV; notebook	Specific software (game)	Speed, direction and precision of movement on the dance carpet (or wheelchair or game pad control)	Graphic element indicating the movement to be executed; Graphic effect indicating the "hit" of the movement; change of the score	social inclusion and not noting physical differences	Design aimed at social inclusion, influencing self-confidence, which affects self-esteem.
P07	computer (monitor, keyboard, mouse); microphone; webcam; cellphone; internet infrastructure	Internet connection/ services; VOIP; SMS	Mouse and keyboard usage, video and audio during the communication	meaning depends on the content of the messages, audios e videos	cross-age e-tutoring to address social needs	Design focused on social experiences for positive learning and self-esteem improvement

Table 7. The selected papers through the Semiotic Framework.

as present the value that is discussed in the paper, even if indirectly. In P06, for instance, users could use some public artifacts (a carpet or a joystick) to interact with the system. In P04, the value visibility was marked as present, because the user can be seen (photo or name) by other users in the leader boarding. The values identification was performed by the two researchers responsible for this SLR. Table 8 summarizes the values addressed by the papers.

As we can observe, personal values are more considered than social values and technical values, demonstrating the applications seemed to be more concerned with individual aspects, although self-esteem is built based on the interaction of the individual with other people and the environment. P02 and P07 were the works that considered personal values the most (9), while P03 is the work that least presents personal values (5 of 10). While P07 focuses on direct interaction between users, P03 is a system in which users answer some multiple-choice questions by themselves. Regarding social values, we note, once again, the work P07 is the one with the most values (7), while P03 considered only the sense of property.

Although P02 is a system focused on social impact and considers 9 of 10 personal values, it does not have mechanisms for social interaction among users (it is just an application based on a social media interface). The strategy used is based on cognitive-behavioral training in which the person is put in imaginary situations to solve some problem.

Finally, the technical values are the ones least discussed by the authors in the papers. Although their technological solutions express concerns about accessibility or aesthetic apparency, for example, these technical values issues were

not discussed or were not as deeply discussed, like personal and social values were. In some cases, it was possible just to infer the solution is accessible, as in P06. Thus, from the analysis organized through the Semiotic Ladder, even in a context in which social experiences are relevant, the solutions still favor the personal, individual action over the social related issues. We can observe this from the social world layer, in Table 8: the works mentioned are those that discussed the social implications of the applications. This does not mean there is a lack of concern with the subject in the other works, but as we presuppose social experiences are relevant factors in the self-esteem issue, we think this aspect should be considered at design time, as the SawD highlights. Also, as five of the seven tools are for individual use, it shows the lack of social concerns in the development of applications to affect/impact self-esteem. We also highlight this from the identification of the lack of social values in the tools such as conversation, collaboration, and relationship, and the lack of some personal values significant for the sense of belonging and social acceptance (e.g., reputation, and presence).

Although the solutions are distinct from each other, their strategies have similar goals to affect self-esteem. In the next section, based on these findings, we answer the five questions of the SLR presented in Table 2.

5   Discussion

From the detailing of the solutions through the Semiotic Ladder perspective, the values identified in them, and other information taken from the papers, in Figure 3 we summarize

how the specific selected studies addressed strategies to influence self-esteem through computational technology. From this information, in the following subsections we answer the five questions and point out some research challenges for further work.

5.1   Technological Influence on Self-esteem

As regards question RQ1 (*What types of technologies have been used to affect/impact self-esteem?*), we observe that most of the technological devices are the traditional ones (e.g., desktop computers, monitor, keyboard, and mouse), in such a way that the user interface is also the conventional one (GUI). Differently, P06 (NUI-based system) uses sensors to detect movements, and P01 moves towards pervasive and ubiquitous scenarios of technology that have been increasingly present in society. Yet, we noticed, most of the applications need internet connection and services, or some standalone specific software installed in the computers. Although nowadays it is easier to get an internet connection than some years ago, it may cause dependence and availability issues, especially in some parts of the world in which this infrastructure is not provided for all yet.

Regarding question RQ2 (*How technology has been used to positively affect/impact self-esteem?*), the studies used technology in several ways:

- *Self-reflection:* motivational messages (P01).
- *Forgetting negative thoughts:* activities suggestions (P01).
- *Simulation:* handle with everyday problem-solving (P02).
- *Leisure:* games (P04, and P06).
- *Learning:* question and answer system (P03).
- *Exploration:* encouraging interaction and discovery (P05).
- *Social relationships:* promoting social experiences through learning (P07).

Overall, the users' interactions with the tools are individual, except for P06 and P07. Also, technologies are being used within contexts of leisure, motivation enforcement, scholar performing, information gathering, therapy.

About the question RQ3 (Which values do the solutions take into account to affect/impact self-esteem?), we observe that the works address more personal values than the social and technical ones. The results related to personal values show all applications seek for raising a sense of autonomy (except P03), trust and reciprocity in the users, concern for their affective states and also awareness of the results of their actions. These values are significant for self-esteem because they directly impact the sensations of satisfaction, motivation, and self-confidence. Reputation and visibility, although not present in P01 and P03, are more effective values for a sense of belonging and social acceptance.

As for social values, we noticed that the studies focusing on social interaction (P05, P06, P07), except P02, are those that have the most present values related to social relations

(conversation, groups, and relationship). Although P05 is for individual use, the system is being used in an environment with other people around, favoring social interactions. We can also point out that the tools do not address values such as: norms, rules, and policies, except for P02. This is important to the users because they must have the sense of freedom and confidence to use the technology. The value related to property is present in all applications since the user takes possession of some object for interaction even if temporarily.

Finally, about technical values, although they have been more present than social values, they are the ones that present less information in the papers. Issues such as scalability, portability, are values that seem not addressed due to this moment of the studies, considering that most are prototypes used in controlled test scenarios. The usability and appearance were the values all the works were careful to consider since they are values that directly affect the user experience, although adaptability, awareness and safety would also be relevant to consider. Concerning accessibility, although it is an essential value for any technological application, only P05, and P06 addressed it through their target audiences: children with autism (P05) and wheelchair users (P06).

Concerning question RQ4 (*What aspects of self-esteem are affected through technology usage?*), and question RQ5 (*What strategies have been adopted to influence self-esteem through technological support?*) we answered them together because they are correlated. Each tool identified has its specific usage purpose (see the pragmatic layer of Table 8). When we analyze their intrinsic motives, we conclude they intended to prevent users from negative self-assessments and feelings of lack of skill. Also, through the users' interaction with them, it was expected to rouse the user's positive sense of capacity and confidence. In this sense, several supporting strategies were adopted to affect the users' self-esteem, for instance: motivation through positive messages (P01) and by using positive and affective words (P03); encouragement, by activating the user's curiosity in exploring technological artifacts (P05); behavioral training simulation of everyday situations to demonstrate how being positive is important to engage positive social relationships (P02); games as a means of affective states changes (P04 e P06); balancing the difficulty level and score system of a game so that a wheelchair user does not feel less capable (P06); system interface similar to social networks so that the user feels part of a social group (P02); suggesting some activity to avoid negative thoughts (P01); older student teaching the youngest (P07); and online community formation (P07).

The strategies adopted in P02, P03, P04, P05, P06, and in P07 promoted the users' competence and ability, favoring their self-confidence. The promotion of self-confidence in P02 and P05 occurs when the design and the strategies of the tools consider real everyday situations and encourage and motivate children to deal with the situations, even in a virtual way. In P01 the user's self-confidence is also promoted and it affects their self-image, because the users can reflect about the content of the messages they listen to.

Avoiding negative thoughts is another strategy used in some tools. In 'sun of fortune' (P01) the activities support users suggesting they perform some tasks. In P03 it is more

|	Personal Values	Social Values	Technical Values
P01	Autonomy, Trust, Informed consent, Emotion and Affection, Identity, Privacy, Reciprocity	Object, Property	Accessibility, Adaptability, Aesthetic Apparency, Availability, Safety, Usability
P02	Autonomy, Trust, Informed consent, Emotion and Affection, Identity, Privacy, Reciprocity, Reputation, Visibility	Norms and Rules, Property	Aesthetic Apparency, Availability, Usability
P03	Trust, Informed consent, Emotion and Affection, Privacy, Reciprocity	Property	Aesthetic Apparency, Usability
P04	Autonomy, Trust, Informed consent, Emotion and Affection, Reciprocity, Reputation, Visibility	Object, Property	Aesthetic Apparency, Awareness, Availability, Usability
P05	Autonomy, Trust, Informed consent, Emotion and Affection, Presence, Reciprocity, Reputation, Visibility	Conversation, Groups, Object, Relationship, Property	Accessibility, Adaptability, Aesthetic Apparency, Usability
P06	Autonomy, Trust, Informed consent, Emotion and Affection, Presence, Reciprocity, Reputation, Visibility	Conversation, Groups, Object, Relationship, Property	Accessibility, Adaptability, Aesthetic Apparency, Usability
P07	Autonomy, Trust, Informed consent, Emotion and Affection, Presence, Privacy, Reciprocity, Reputation, Visibility	Collaboration, Sharing, Conversation, Groups, Object, Relationship, Property	Adaptability, Availability, Portability, Usability

Table 8. Values considered in each paper.
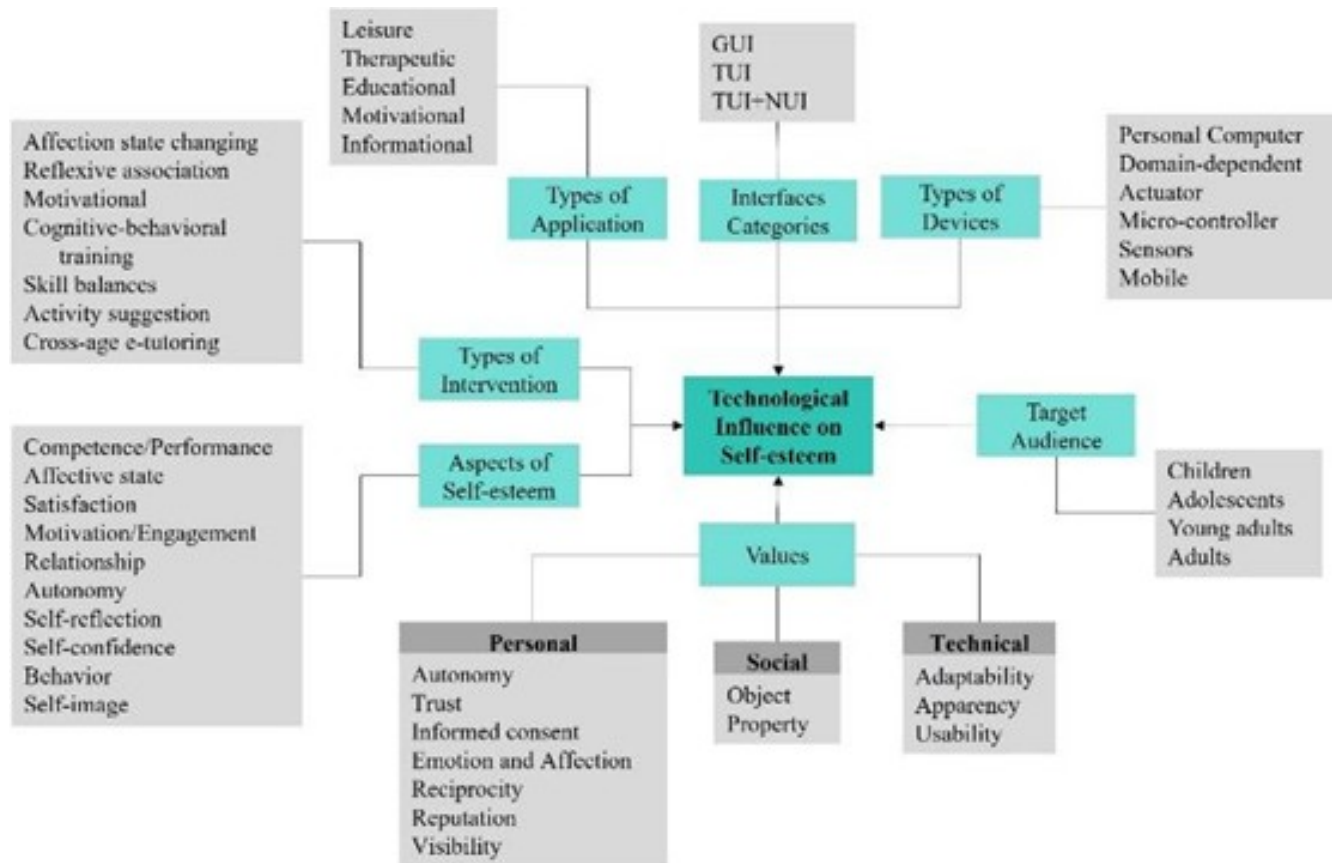
Figure 3. Overall Picture of the Findings Summarized

complex, because it uses positive and affective association with past experiences to support users to face a situation that was not very good. Therefore, we highlight all strategies that are concerned about motivating users to perform tasks and having some experience such as social situations through simulation. Through these strategies, they promoted positive feelings and affective states that are correlated to satisfaction, for good personal experiences.

From the answers to the questions, we highlight whatever the domain, the application, and the technological device, the most important are the strategies enabled by the tools, that will impact the self-esteem' aspects intended to affect. In the next section we discuss some design challenges for considering the personal, social, and technical values to guide design in this context of self-esteem, framed by the three layers of the semiotic onion (informal, formal and technical).

5.2   Research Challenges

In what follows, we present some challenges and open topics to further investigation. The topics are organized through the Semiotic Onion Levels of analysis.

5.2.1   Informal Level

The informal level of the semiotic onion describes the organizational culture, customs, and values expressed as beliefs, habits, and individual behavior patterns. This level involves the informal interactions between people with their

artifacts and among themselves. People behave and express themselves seeking self-acceptance and social belonging, essential elements for self-esteem. As follows, we raise some design challenges related to the informal aspects of the user-tool relation.

Balancing User's Privacy and Exposition: Privacy refers to the quality of what is private, such as personal life and the intimacy of a person. In this sense, privacy refers to the right of users to determine what information about them will be available and who may access it. Technological systems also ought to ponder about this issue throughout its development and design process. In the P01 study, users argued it is important not to expose the user's situation to everyone. Therefore, we also highlight the importance of maintaining the privacy of users and protecting them from situations that could cause them the opposite of the intended psychological effect. Still regarding privacy issues, P02 used a strategy like social networking, to raise social belonging. Nevertheless, it is also important to pay attention to the potentially negative effects on users, especially for those who suffer from depression, if this type of strategy also adopts other social media mechanisms such as "likes" and "comments". In this sense, systems should ponder and balance exposition and privacy. Some users may wish to expose themselves and this attitude may benefit them and their self-esteem, while others can suffer consequences of this exposure. Thus, privacy concerns can affect the trust in the system, self-confidence, and the user's emotion.

Balancing Sense of Social Belonging and Self-identity: Most of the applications we raised do not focus on social

aspects which promote the sense of social belonging; P02 is the only system which clarifies its social intention of providing the user this feeling through its interface. However, as people seek for social belonging and acceptance, systems need to provide users with the feeling they are socially accepted. Mechanisms addressing 'reputation' and 'visibility' can be used for this aim; nevertheless, it is challenging to use them, since such values can evoke comparisons in users, affecting their self-identity, and decreasing their sense of social acceptance, their level of motivation, and satisfaction.

5.2.2 Formal Level

The formal level of the semiotic onion illustrates the organized way society deals with meanings and intentions (e.g., laws, formal methods, models, etc.). Self-esteem is an individual concept, and Paay *et al*. (2018)) state the technology must be used individually if its intention is to affect the user's self-esteem. However, the self-esteem is influenced by how a person lives in society and, in the Paay *et al*. (2018)'s results it is clear, from the user's speeches, the influence of the other people: participants of Paay *et al*. (2018)'s study believe other family members and their friends could write the messages of the "happy frog" so they could feel more self-confident. Also, in sun of fortune (P01), some participants said that doing some activities sometimes involved talking to a family member. These examples indicate that social context is a significant strategy to be considered in the design of technology to affect self-esteem. Next, we point out some challenges relative to the formal level of user-tool relation.

Balancing Individual Experience and Social Support: All the raised solutions in this SLR allow users to have individual interactions with the systems. It is important because they have the opportunities to reach their own goals, and better develop personal aspects and values, which are fundamental for self-esteem. However, although self-esteem is an individual concept, it is built up through social interaction. Thus, social values such as collaboration, conversation, and sharing are essential interactional aspects to emerge from the interaction with the proposed tools. In this sense, balancing between individual and social experiences are challenging because the context, the support, the motivations, values and the users' needs, and goals are diverse.

Balancing Individual Behavior and Social Patterns Behavior: Society is defined by its rules, norms and social patterns and behaviors. Although the formal layer of the semiotic onion indicates and formalizes these conventions of a particular society, in the context of self-esteem it raises issues too. Following such standards can be a problem for those people who do not feel akin to them. In this sense, systems should enable users to find themselves the point of balance among their own behavior patterns and those pre-established by society, avoiding imposed conventions.

Supporting Sense-making: Sense-making, in a pragmatic sense, means to give meaning and purpose to the interaction process with technology and the world. In this way, the interface communication and its syntactic and semantic aspects must be designed to support the users' sense-making. The communication between the user and the system is fundamental in the process of dealing with self-esteem, once the user feels motivated to interact with technology. In P01, for instance, the user knew, since the beginning, the devices' major aim. So, pondering the way the system will communicate (transparently or explicitly) some message to the users is fundamental to avoid the feeling they have a problem, or they are a trouble. Also, there is a semantic level challenge, in which the design needs to ponder about interface elements, audios, images, etc., so the user can make sense of the tool.

5.2.3 Technical Level

The technical level of the semiotic onion represents the computer system and its connected parts, which mediates actions on the previous (informal and formal) layers. At this level there are concerns about ways to make the application available any time and for all. Thus, some research challenges are listed as follows:

Supporting Access for All: people differ not only in their needs, motivations, and values, but also in their different abilities and (physical, psychological, emotional) conditions when using a system and interacting socially. Thus, promoting access for all is also a challenge in this self-esteem context because several aspects must be considered. However, the more universal the access, the more users may interact with the system, and with the others through the system, not feeling left out, which avoids their self-esteem being affected negatively. Solutions need to be adaptable to as many users as possible, such as the studies (P06) show. In this sense, the adaptation of applications and strategies to influence self-esteem for different audiences and contexts is challenging, mainly if the application will be used in a social context and for many users at the same time. Therefore, balancing the pragmatic strategies is fundamental: in P01, for example, the tools could be adapted for children and for parents and friends to collaborate with messages and activities; in P06, if the adjustment strategies for the wheelchair user to play are not "accurate" and "fair" it can have reverse effects on both players; in P03, if the questions that users might answer are not adequate to their knowledge level, self-reflective and affective positive words might not have the intended effect; similarly, if the game P04 is very challenging, the user may feel incapable, especially if other people are playing together. Therefore, this adaptability in the systems to deal with diversity of users is not a simple issue.

Pervasiveness and Ubiquity: Some technological constraints are those that technologies already impose, such as data security and privacy, or usability and accessibility, and those related to the context where the system will be used in. However, in a society that is increasingly connected, pervasiveness and ubiquitous technologies may provide more natural interactions and systems always available, such as the one reported in P01. Thinking about ubiquity and pervasiveness, in P05, for instance, there could be more interactional objects and other social situations simulated in such a way the objects could communicate

and interact among them through ubiquity and pervasiveness (IoT scenarios), for example. Also, the system could consider corporal movements, like those used by the study P06, turning the interaction more natural. New scenarios could be designed to consider social interactions and physical changes in the environment where the application would be used. These brainstorming ideas, for example, could affect aspects of the users' self-esteem, providing them with more realistic and natural experiences, particularly if no specific skill is demanded.

Although pervasiveness and ubiquity may promote more natural interactions, they bring forth internet connection dependence and availability issues. In this self-esteem context, availability is fundamental because users must be "free" to "manage" their moments of psychological discomfort. P01, for instance, introduced two devices for users to use whenever they feel sad and in need of some motivational support; the other studies did not make the applications available to users whenever they wish. Therefore, developing and allowing the applications to be always available to users and/or guarantee they have the necessary conditions to use it is challenging.

Technological tools to affect self-esteem intend to make the user feel good. In this sense, the design of these tools and systems should consider affective issues in real-time, in such a way that the system automatically adapts itself to what the user seems to be feeling and, thus, supports the user to overcome that sensation, which could affect, for example, his self-confidence and motivation.

From these personal, social and technical perspectives brought by the analysis of the informal, formal and technical aspects of the self-esteem-oriented applications, we hope to support, to preserve and promote the well-being of those who are operating or will use the technological solutions. The discussion illustrates the demands on understanding, tolerance, and a sense of social equity in any situation and nature of the use of a system.

Some questions to guide and inform further research on the relation of technology and self-esteem are synthesized as follows:

- How may the solution support the users' privacy while maintaining their visibility and their sense of presence?
- How may reputation and visibility be achieved, not causing a reverse psychological effect on users?
- How may the solution's design allow users to express their real self (identity) to deal with social comparisons?
- How may the solution enable social interactions and relationships without the feeling of having been socially excluded?
- How may solutions affect self-esteem making use of the social context regardless of their domain and type of application?
- How may solutions avoid incorporate norms and behavior patterns that are pre established by society and may cause some discomfort leading the user to negative self-assessments?
- How may the solutions consider social and interactional aspects, individual and social interactions, and at the same time take into account the universal access good

practices?
- How may the pervasiveness and ubiquity of systems and new ways of interaction with technology support technological applications, systems, and devices to affect-self-esteem?
- How to make sure that the devices will always be available for users?
- How may the solutions consider the user's affective and emotional states in real-time, from the way they are feeling or the experience they are going through?

5.3 Towards new Concerns and Challenges

Considering that the results and discussion previously presented are based on searches carried out between 2009 and 2019, we carried out new automatic searches in the scientific bases considered in this SRL using the same search string; in this new search we considered the years from 2020 to 2023. Table 9 shows the total number of papers obtained.

	Total
ACM	1,102
IEEE	134
Springer	806
Science Direct	281
Scielo	3

Table 9. Amount of automatic search papers from 2020 to 2023.

Considering that the numbers in Table 4 are related to a period of 10 years and those in Table 9 to 4 years, we note that the relation between technology and self-esteem has been progressively more discussed. This fact highlights the importance of the theme and the concerns about the effects that technology can have on its users: Muriana and Baranauskas (2021), for example, carried out a study about the relation between the Self-Determination Theory, the design of systems and self-esteem; Marcu and Huh-Yoo (2023) developed an approach to improve the design process to improve users' mental health through self-esteem and social relationships. Ramani and Diwanji (2022) analyzed the impact of users' addiction to social media on self-esteem and recommended methods to reduce this addiction.

Nevertheless, if on the one hand concerns to the issue seems to have increased, on the other hand it is necessary to keep in mind that there may be some data noise as mentioned in Section 3, with subjects that are not of interest to this RSL. For example, the work of Morshed *et al.* (2020) which investigated how to "measure" a person's self-esteem, or the work of Kempf *et al.* (2020) which analyzed the effects of robotics courses on students. In any case, these numbers and works highlight the importance of the topic suggesting new challenges for the area, as far as we know not addressed yet, and research opportunities.

6 Conclusion

Several studies in literature have addressed social media and how technology may impact self-esteem and biases the user experience. In this way, in this paper we extended

our previous systematic literature review (Muriana and Baranauskas (2021)) and raised papers whose approach is the design of technological solutions to affect the self-esteem of people. Our major motivation was to address how technology can support self-esteem, what types of technologies have been used to do it, and the strategies they have relied on for this purpose. Besides, we wondered to find out which aspects of self-esteem these applications impacted and mainly the values they have achieved.

To reach our goal, we selected 3,668 papers and in the final of the process we got 41 ones. However, we noted not all papers addressed self-esteem in a way to show applications designed explicitly to influence self-esteem. Therefore, from those 41 papers, we selected seven which developed tools with this purpose. Differently from our previous paper, in this one result were further analyzed under the Semiotic Ladder and the Values perspective in such a way we could relate self-esteem and technology in a more socially oriented perspective.

From the analysis, we noticed most of the solutions made use of traditional computer devices, such as mouse and keyboard. In this way, we could see the user's interaction with these tools are mostly GUI-based. Therefore, we point out demands on new human-computer interaction approaches such as the use of voice, body movements, and objects embodiment to enable more natural ways of interacting, as illustrated by P01 and P06 studies. Moreover, we show evidence of the need and availability of internet connection for the applications usage. We also point out that most of the papers did not consider social aspects and social values in the design of the applications. In this paper we argued that, especially because self-esteem is mutually dependent on social life, the design solutions should pay attention to this.

The results presented in this paper raise some challenges in this topic. Besides, this paper contributes to give some direction on how other technological scenarios could use the implemented strategies pointed out in this SLR with diverse objectives and how it could affect the users' self-esteem. Also, considering the Semiotic Ladder and the Semiotic Framework perspective, we highlighted how social awareness, social experiences, and the social, personal, and technical values should be considered to enhance the design of these applications, promoting more meaningful, valuable and engaging interactions.

In synthesis, there is a demand for further work to explore new modes of interaction since pervasive and ubiquitous technology have evolved and altered the way people interact with them and with each other. Besides, in a society that is increasingly interconnected and dependent on computer technology, it is necessary to balance technical, personal and social values, while investigating aspects of technology design for mediation of self-esteem and affective states, which affect people's life.

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Authors' Contributions

Luã M. Muriana contributed to the search, selection, and classification of the papers of the systematic literature review considered in this study. M. Cecília C. Baranauskas supported the discussion and classification of the selected papers in the Organizational Semiotic perspective, raising the research challenges addressed. Luã is the main contributor and writer of this manuscript. All authors read and approved the final manuscript.

Competing interests

The authors declare that they do not have competing interests.

Availability of data and materials

A Appendix – Selected Papers

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- S2. Apaolaza, V., Hartmann, P., Medina, E., Barrutia, J.M., Echebarria, C., 2013. The relationship between socializing on the Spanish online networking site Tuenti and teenagers' subjective wellbeing: The roles of self-esteem and loneliness. Computers in Human Behavior 29, 1282–1289.
- S3. Baturay, M.H., Toker, S., 2019. Internet addiction among college students: Some causes and effects. Education and Information Technologies 24, 2863–2885.
- S4. Birk, M.V., Mandryk, R.L., Miller, M.K., Gerling, K.M., 2015. How self-esteem shapes our interactions with play technologies, in: Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play. pp. 35–45.
- S5. Burke, M., Kraut, R., Marlow, C., 2011. Social capital on Facebook: Differentiating uses and users, in: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. pp. 571–580.
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