Journal on Interactive Systems, 2022, 13:1, doi: 10.5753/jis.2022.2540
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Design recommendations under the Self-determination theory: Analyzing some systems and their implication to self-esteem

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Abstract

Self-esteem is a concept that refers to a person's self-evaluation that can be related to the person's success in interacting with other people and the world around them. The self-esteem of a person is built over a lifetime, influenced by experiences, social interactions, and sense-making about the world based on self-perception of life. As people, technology and society are increasingly connected, technology may also influence its user's self-esteem. In this paper, we investigate the subject through the lens of the Self-determination Theory, by analyzing literature work addressing the relation between technology design and self-esteem impact. Based on a meta-analysis of 21 papers previously selected from literature, we present, as result, 18 design recommendations to digital and physical artefact solutions; these recommendations are classified according to their main content, purpose, and aspect (personal, social, and technical). We could verify the recommendations completeness and analyze how they encompass the capacity of influencing self-esteem in four systems raised from literature and in one system developed considering these recommendations. With results of this work, we aim at providing technical support to guide designers in improving their system towards users' motivation and self-esteem, favoring a designer's reflection about how the systems they develop may affect the user's life.

Keywords: *Self-esteem, Self-determination theory, Design recommendations, Meta-analysis*

1 Introduction

Self-esteem has been characterized as an emotional response people experience, contemplate, and appraise regarding various aspects of themselves (Heatherton & Wyland, 2003). These aspects are related to self-concept, self-worth, and self-image, indicating the way people see, self-evaluate, and trust themselves. Self-esteem is an individual concept that is built over lifetime, but the person's particular experiences, social interactions and sense-making of the world have direct influence over this self-perception. In this context, people's own needs and subjective motivations are regulated by society and social groups closest to them.

Human needs and motivations are explained by the Self-Determination Theory (SDT) (Ryan & Deci, 2000). According to this theory, the human being has three types of motivation which are essential for his growth, constructive social development and personal well-being. This motivation is related to the ways people develop skills and capacities (competence), behavior themselves on their own (autonomy), and connect to other people and to the environment (relatedness) (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 his purpose (motivation) and capacities (competence) (Damásio, 2005; Srivastava & Beer, 2005 *apud* Chen & Lee, 2013). However, this purposiveness depends on the organism autonomy (Maturana & Varela, 2012). Thompson (2010) says an autonomous organism can determine possible interactions and relations with the environment (relatedness).

Thus, as the environment and the social relationship are coupled to the person's background, intent (motivation), needs, and adaptability may affect and be affected by self-esteem. Technology, as part of the environment, may also influence the user's psychological state. Some studies have analyzed the interrelationship among technology usage and psychological well-being and self-esteem. Technological devices and their interfaces provide different interaction and experiences to the user (Bittencourt et al., 2016; Thüring & Mahlke, 2007), potentially changing how people feel and allowing them to express their emotions (Shank, 2014). Regarding the user's self-esteem, some studies have focused on analyzing this relationship in social media technology, showing how social networks can positively affect self-esteem (Apaolaza, Hartmann, Medina, Barrutia, & Echebarria, 2013; Boyd & Ellison, 2007; Hatchel, Negriff, & Subrahmanyam, 2018; Lee & Jang, 2010a; Pai & Arnott, 2013). However, other studies pointed out that social networks have stimulated people to make comparisons, thus increasing the mental stress level, and decreasing self-esteem (Chen & Lee, 2013; Jang, Bucy, & Cho, 2018; Nie & Sundar, 2013; Scissors, Burke, & Wengrovitz, 2016; Zell & Moeller, 2018). Some studies have analyzed how some technologies lead the user to become addicted to a specific technological medium (Apaolaza et al., 2013; Pai & Arnott, 2013; Park, 2018). Yet, other studies emphasized the use of computer technologies to positively impact self-esteem and affective states of users (Birk, Mandryk, Miller, & Gerling, 2015; Muriana, Silva, Santos, & Baranauskas, 2019; Park, 2018). These studies, however, analyzed technological solutions that were not developed with the primary purpose of affecting self-esteem. Therefore, it is relevant to investigate the design of technological devices and applications considering some aspects and concerns to avoid negative effects on the users.

This article is an extended version of a revised and published one from IHC 2021 (Muriana & Baranauskas, 2021a). In this study, we raised design recommendations in the light

of the self-determination theory's aspects, seeking to support users to achieve their psychological and social needs, and deal with their emotions, expectations, self, and self-efficacy. After that, we analyzed the design of five systems considering these recommendations in such a way we could verify the recommendations completeness and analyze how they encompass the capacity of influencing self-esteem.

The remaining text is organized in the following way: the following subsection describes the meta-analysis process we adopted to reach our research aim; section 2 presents a background about SDT and relates it to self-esteem; section 3 presents the design recommendations and analyzes some systems on the design recommendations perspective; section 4 discusses and highlights the relevance of those recommendations to the self-esteem; and section 5 presents some last considerations.

1.1 Meta-analysis from a Systematic Literature Review

In a previous study (Muriana & Baranauskas, 2021b), we conducted a SLR (Systematic Literature Review) whose key question was "Have technologies been designed to explicitly (positively) affect/impact self-esteem?". Based on the PRISMA protocol (Preferred Reporting Items for Systematic Reviews and Meta-analyzes) (Moher et al., 2010), a specific search string drove an automatic search on the main scientific sources considered by the computer academic community: ACM Digital Library, IEEE Xplore, SpringerLink and Science Direct. We also considered manual search for related papers. Based on inclusion and exclusion criteria we defined, we read the papers and selected those that correlate technology and self-esteem. Thus, the SLR process was conducted in three stages: the automatic search in pre-defined scientific sources, to which we applied a defined search string (resulting in 3,668 papers); the pre-selection, which occurred from the reading of the title and abstract of the papers raised from the previous stage, considering the inclusion and exclusion criteria defined for this stage (resulting in 171 studies); and the final selection, which required us the full and detailed reading the pre-selected papers (resulting in 41 studies). Details of the SLR process and its major results are out of the scope of this paper, and are reported elsewhere (Muriana & Baranauskas, 2021b).

Regarding the current work, we proceeded with considering also other inclusion and exclusion criteria defined specifically for the aims of this work. From the 41 studies we got previously (Muriana & Baranauskas, 2021b), we carried out a meta-analysis on a subset of these original final selected set of papers in a way we could raise design recommendations regarding the user's self-esteem. As the 41 papers address the relation between technology and self-esteem in different ways, we proceeded with considering two specific questions defined specifically for this current work: *i*) *Does the paper discuss systems' features to affect self-esteem*? *ii*) *How and why does technology affect self-esteem*? If the paper answered both questions, then we selected it. In this way, from the 41 original set of papers, we raised 21 to support us in compiling design recommendations; this process was conducted by two researchers (who also took part in the original SLR), so we could discuss the data collected and ponder whether we should consider it as a set of recommendations.

After identifying those 21 papers that discuss features, whatever the type of system is, and the reasons for affecting self-esteem, we listed each of them and related it to how and why it influences self-esteem (for both task we considered exactly the authors' description, avoiding our own interpretation of their results). Then, we grouped them by similarity (e.g., all those addressing communication, all those related to feedback, etc.); sometimes, this group had to be split because they dealt with different issues (e.g., user feedback and system feedback). Hence, we could establish the recommendations and relate them to how they affect self-esteem and the reason for this and classify them within the SDT concepts. Finally, we report that all papers and features had the same weight in the process because society is increasingly connected, and users use several types of systems and technological devices. Yet, whatever the number of papers a recommendation is based on, we aimed to reach comprehensiveness and leave room for further investigations.

2 Theoretical Background: Self-determination Theory and Self-Esteem

According to Ryan and Deci (2000), Self-determination Theory (SDT) is an approach to understand human motivation and personality that highlights the importance of humans' evolved inner resources for personality development and behavioral self-regulation. Robbins (2009) states that motivation results from the interaction of the individual with the situation, and according to Leal et al. (2013), the motivations of people differ from each other, and are determined and guided by contexts that give subsidies to psychological needs with different manifestations.

Motivation describes the natural inclination toward assimilation, mastery, spontaneous interest, and exploration that is so essential for cognitive and social development and represents the primary source of enjoyment and vitality throughout life (Ryan & Deci, 2000). There are three sources of motivation: intrinsic, extrinsic, and quasi-needs (Ryan & Deci, 2000). Intrinsic motivation is a person's inherent tendency to seek novelty and challenge, to stretch and exercise their ability to explore and learn. Extrinsic motivation is concerned with "how people acquire motivation to perform activities" and "how this motivation affects the progress of persistence, behavioral quality and well-being." Quasi-need is about the motivation influenced by the social environment which affects how a person thinks, feels, and acts, changing behavior to meet a specific demand (Piccolo & Baranauskas, 2012). In this paper, we refer to Extrinsic motivation and Quasi-need as "external aspects".

Figure 1 summarizes key aspects related to intrinsic motivation, our major concern in this paper. Emotion, cognition, and needs are constituents of intrinsic motivation. Emotion is preceded and elicited by appraisal. Cognition encompasses self, self-efficacy, and expectation. Psychological and

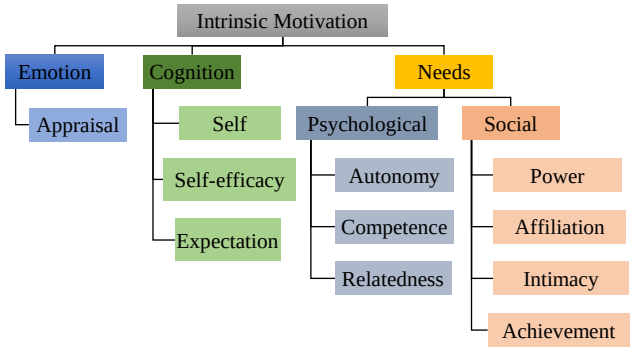

Figure 1. Conceptual schema to motivation (adapted from Piccolo & Baranauskas (2012)).

social are types of needs. Psychological comprises autonomy, competence, and relatedness, and they are the most important needs. Whereas affiliation, power, intimacy, and achievement are personality aspects related to social needs.

Emotion, according to Damásio (2012) is the modification of the body, and the sense an organism gives to it. Collombetti (2017) argues emotion is tied to sense-making activities, in which the organism self-organizes into some form. Appraisal is a central concept in the cognition-emotion relation (Piccolo & Baranauskas, 2012). **Appraisal**, according to Lazaurus (1966), is a continuous process of monitoring whether something that is happening is significant; this relevance, however, depends on the intentional purpose of the organism while interacting with the environment, and on the whole situated organism capacity of making sense of his environment (Colombetti, 2017). Piccolo and Baranauskas (2012 p. 4) say "once appraisals precede and elicit emotions, changes in the appraisal change the emotion and the perception of the affective quality of a system". In this sense, Leal et al. (2013) say this generates satisfaction. Therefore, the satisfaction focus is on the evaluation given to the affective state deriving from such an experience, which supports a person in making sense of some experience. Ortony et al. (2005) say satisfaction relates to valence, i.e., evaluation reaction to good or bad situations. Satisfaction is also related to the affective states and well-being sensation it provides.

Cognition concerns meaning and interpretation of the world, i.e., what the organism knows, thinks, and believes (Ortony et al., 2005). It is related to beliefs, expectations, goals, plans, judgment, values, and self-concept, and the human behavior. Piccolo and Baranauskas (2012) say people are motivated by their **expectation** ("can I do it?", "will it work?"). In this context, the self and self-efficacy can be aspects of cognition. According to Gallagher (2013), **Self** refers to a group of characteristic features that, when taken together, create a pattern that constitutes an individual identity (Self). **Self-efficacy** is related to the considerations people have about themselves in relation to their skills and the capacity to cope with some situation (Kersten et al., 2011).

Needs are essential conditions for living beings, and their main types are psychological and social. The **Psychological needs** refer to autonomy, competence, and relatedness (Ryan & Deci, 2000). **Autonomy** means the free choice to interact with the environment, in a way the person guides actions based on interests, preferences, and wishes. **Competence** is also a motivation source, because people carry out tasks, learn different ones, and new skills to feel useful and perceive value in themselves. It reinforces the self-confidence sensation. **Relatedness** is related to human needs to feel connected with other people. Piccolo and Baranauskas (2012) highlight it establishes close emotional bonds with other people and needs to perceive themselves well-seen by others.

Therefore, the social context of people is an essential aspect of their motivations (Piccolo & Baranauskas, 2012). **Social needs** in this sense are about expressing the psychological needs to the social context once the need-satisfying appears. Achievement, affiliation, intimacy, and power are instances of personal characteristics developed through social experiences. When people do something to show competence, they are seeking **achievement**. When want to please others and get their approval, they are seeking **affiliation**. **Intimacy** is related to warm and secure relationship they need to establish with other people, while **power** is about showing impact on others.

Thus, the social environment and its enabled social interactions are antagonist to people's inherent growth tendency and their natural psychological needs (Ryan & Deci, 2000). Since different factors lead people to act and have varied experiences and consequences, SDT has described several types of motivation. These sources of motivation impact people and influence their behavior, learning, performance, personal experiences, and affect their affective states and well-being. In this understanding, the results of the appraisal process of acting to get something may affect self-esteem.

2.1 Self-Esteem under the lens of SDT

Self-esteem refers to the evaluation that a person makes and certainly maintains about some aspects of self. When this evaluation (**appraisal**) expresses an attitude of approval, the person believes to be capable, significant, and worthy of success (Coopersmith, 1965). Although self-esteem is an individual concept, it is based on personal experiences from social interaction throughout the person's life. Thus, self-esteem is not an expression of the individual's mind, but it is a bodily state associated with social or physical environmental events that affect it (Guilhardi, 2002). Leary (2012) says self-esteem results from a system that supervises and responds to interpersonal agreement or rejection (**appraisal**) and argues that when people do something that seems intentional to safeguard or increase the self-esteem, the goal is to protect and enhance their value and thus expand their probability of interpersonal acceptance (**affiliation**) and social belonging (**relatedness**).

The social belonging (**social needs**) is fundamental to motivation, and it has a powerful effect on people's cognitive and emotional processes. Being connected to other people leads to more positive self-assessments (Srivastava & Beer, 2005), while social exclusion is related to lower levels of self-esteem (Leary, 1990).

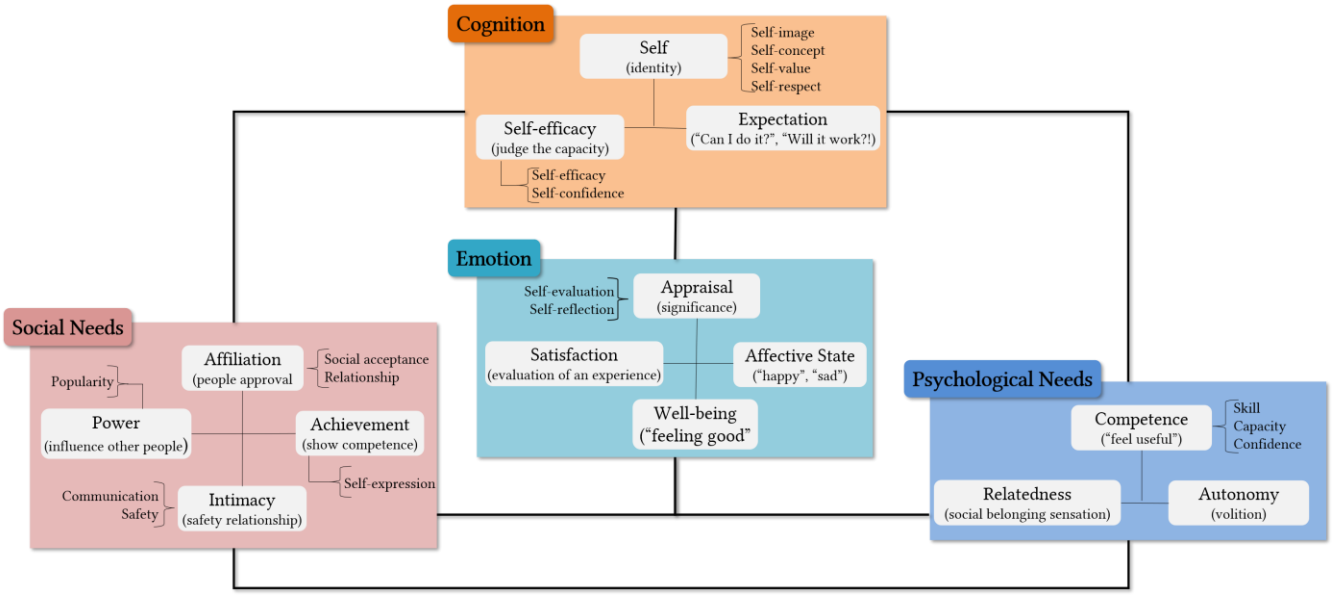

Figure 2. Self-determination theory concepts and their relation to self-esteem aspects.

Cognitive judgment is influenced by social factors (Ellison, 1989). So, we can establish a feeling of capacity to interact with the environment, getting security, confidence, and efficiency to act as we want (Cernev & Hentschke, 2013). In this way, people feel free to behavior on their own, even when there is external pressure to act and think differently (**autonomy**) (Ryan & Deci, 2000).

Confidence is a psychological resource and a positive factor in life related to achievements, good relationships, and satisfaction. Self-confidence can be defined as awareness and concern with self-efficacy. Both terms are related to each other and means fear of judging the capacity. This sense of capacity defines success or failure for many people in various contexts (Watson & Clark, 1999).

Erthal (1991) says the way people see themselves in the world will serve as a guide for all their attitudes along life. That can cause anxiety because of the divergence between the image they perceive of them (real self) and that they indeed express (ideal self). Self-image ends up being a way for individuals to see themselves, since they learn the information that is often imposed on their behavior, physical appearance, and cognitive production (Schultheisz & Aprile, 2013).

In **Figure 2**, we relate the SDT main concepts (emotion, cognition, psychological and social needs) to self-esteem important concepts (within the braces); the main idea of each SDT aspect is within the parenthesis.

In **Figure 2**, we consider emotion as the central aspect in this schema, because of the human needs to appraisal the situations and make sense of them. In this context, how people self-evaluate and self-reflect about their competence, relatedness, autonomy (**psychological needs**), will impact on their sense of self-efficacy, self-development, and expectation of actions (**cognition**). People's cognition is also under influence of the person's power of influencing other people, showing competence through their achievements, getting approval from other people and building-up safe relationship (**social needs**). The affective state and the level of well-being sensation of a person also influence the process of appraising, which also affects the feeling of satisfaction.

Emotion is fundamental to the development and improvement of self-esteem. Nevertheless, the sense of self-image, self-concept, skill, capacity, confidence, autonomy, popularity, social acceptance, for example, are also fundamental to the process of appraisal, and will affect the person's affective state, well-being, and satisfaction. Thus, we can note both SDT and self-esteem aspects are correlated, and one affects the other mutually.

Therefore, synthesizing, self-esteem refers to the evaluation of individuals about themselves (Lopez & Snyder, 2003) and may be associated with the achievement of the interaction of the person with the other ones (**social needs**) (Hutz & Zanon, 2011), such that it expresses an attitude of approval or not (**appraisal**), and show an extent to which a person believes to be capable, meaningful, worth and successful (**cognition**) (Coopersmith, 1965); it is related to their personal beliefs about skills, competencies, social relationships, and future results (**psychological needs**) (Lopez & Snyder, 2003).

3 Design Recommendations to Affect Self-esteem

Results of the SLR (Muriana & Baranauskas, 2021b) in which 41 papers were selected for further analysis showed three main types of studies: *i*) general analysis of how technology may affect self-esteem or how the person's level of self-esteem affects technology usage; *ii*) studies discussing how and why technology may affect self-esteem; and *iii*) technological systems specifically designed to affect self-esteem. In this study, we directed attention to the 21 papers from "ii and iii studies" to carry on a meta-analysis, i.e., we looked at papers that addressed the systems' features and their influence on self-esteem.

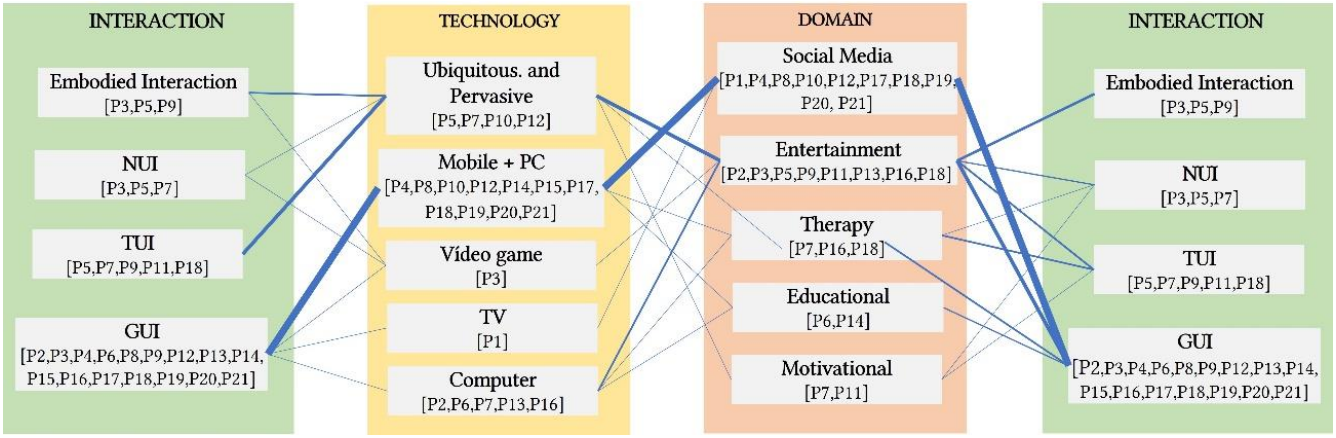

Figure 3. Correlation among technology, domain, and interaction mode

After fully reading the 21 papers, we classified them according to their domain, technology used, and type of interaction (see **Figure 3**); the references to the 21 papers are listed above the References section. Most of the selected studies focused on how social media affects self-esteem and why some features such as Facebooks' like, comments and personal profile relate to self-esteem. **Figure 3** shows how these categories relate to each other; the bigger the line width connected them is, the bigger the number of papers in these relations.

Analyzing the application domain, most of the papers focused on the impact of social media on the users' self-esteem; most of them analyzed how Facebook influences users (Faelens et al., 2019; Nie & Sundar, 2013; Schneider et al., 20172012; Scissors et al., 2016; Zell & Moeller, 2018). Some papers also discuss how entertainment (games, for instance) also acts on the psychological aspects of users (Birk et al., 2015; Compañ-Rosique et al., 2019; Gerlinget al., 2014; Muriana et al., 2019; Paay et al., 2018; Pereira Santos, Hutchinson et al., 2017; Thieme et al., 2015). Although to a lesser extent, there are papers focused on the design of technologies to engage users in therapy (Keay-Bright & Howarth, 2012; Schrammel et al., 2014; Thieme et al., 2015), others that study the relationship of technology and school performance (Jraidi & Frasson, 2010; le Roux & Loock, 2015), and still others that discuss how technology can motivate users in their daily lives (Keay-Bright & Howarth, 2012; Paay et al., 2018).

Regarding the domains, the technologies used are not so diversified. The great majority have studied social media, but they did not highlight the importance of the type of technology. When they did not mention which technology was used in the study, we classified them as "mobile + pc" because the application could be used in both types of devices. Results also draw attention to the works that address the ubiquity and pervasiveness of technology (Gerling et al., 2014; Keay-Bright & Howarth, 2012; Muriana et al., 2019; Paay et al., 2018). This shows that new technologies and the systems and applications that rely on them also impact users' self-esteem. It is worth noting that ubiquitous technology seems more entertainment oriented. The paper that addresses video game usage (Compañ-Rosique et al., 2019) discusses how making it accessible can affect self-esteem as well. Finally, the studies that adopted the use of TV (Alaoui & Lewkowicz, 2012), and Computer (Birk et al., 2015; Jraidi & Frasson, 2010; Pereira Santos et al., 2017; Schrammel et al., 2014) do not discuss why these technologies impact self-esteem; the discussion was focusing on the features of the applications and systems developed.

Finally, there are four main types of interaction observed through the technology's usage. As expected, due to the nature of most studies (social media analysis), traditional Guide User Interface (GUI) interaction was the most adopted (*e.g.* (Birk et al., 2015; Compañ-Rosique et al., 2019; Lee & Jang, 2010b; Pereira Santos et al., 2017; Thieme et al., 2015; Wohn & Lampe, 2018). However, we notice that the studies that sought to make technology more accessible and used new means of interaction, are those that provided more natural and diverse interactions (*e.g.* (Compañ-Rosique et al., 2019; Gerling et al., 2014; Keay-Bright & Howarth, 2012; Nie & Sundar, 2013).

Therefore, the design recommendations we raised from these papers encompass the main types of interaction, technology, and domain types of applications and systems. In **Table 1** we present and describe the 18 design recommendations coming out of the meta-analysis of these papers and cite all the references that are related to the recommendation. Yet, as self-esteem is based on personal and social aspects, and technology may also affect it, we classified the recommendations according to their main content, purpose, and aspect (personal, social, or technical).

Design recommendations associated with the personal aspects concern the individual interactions that each user can have in the system and consider the user's culture, customs, values, beliefs, habits, and individual behavior. Design recommendations that arouse social aspects focus on features that highlight social interactions. And technical recommendations are related to the system and to its algorithms to mediate and promote the user's interaction.

In **Table 2**, we present some systems' examples of how each recommendation may be reached; the examples are from the papers we considered in the meta-analysis.

Table 1. Description of the Design recommendation

Aspect	Recommendation	Description	Reference
Personal	R1. Remember and Share Memories	The system has to remind users of their past actions and achievements and allow them of reviewing and share them.	P3, P10, P15, P18
	R2. Allow Settings and Personalization	The system has to allow users to make settings in the system according to their wills and needs, as well as allow them to customize (personalize) some of the system elements.	P2, P3, P11 e P12
	R3. Enable Affective Expression	The system has to enable users to express what they are feeling emotionally.	P16 e P18
	R4. Establish Interaction Goal	The system's purpose of usage has to be clear to users, so they can establish other own purposes of usage within the context and possibilities the system enables.	P2 e P3
	R5. Avoid Comparison	The system has to avoid interfaces elements that users may use to explicitly compare themselves with other users in any aspect	P4
	R6. Promote Immersion	The system has to promote the user with the sensation of being transported into the virtual environment.	P2
	R7. Arouse Pleasure, New Experience and Meaning	The design of the system has to focus on arousing users' pleasure, adopt themes and content according to the target audience, and enable each user to have their own user experience and produce their own meanings whenever they interact with the system.	P2, P7, P9, P12, P13, P16 e P18
	R8. Develop Dynamic and Narrative to Promote Curiosity	The system must consider the application context and develops a usage scenario based on interaction dynamics, narratives, and goals according to the target audience, so that users may feel curious and set their own system's usage goals and feel motivated to explore it.	P7 e P9
Social	R9. Support Communication	The system has to provide means for users to communicate, synchronously or asynchronously, in a way they have opportunities and possibilities to start, mediate, or (re)create social interactions.	P1, P6, P9, P14, P12, P18 e P19
	R10. Make Joint Interaction Possible	The system has to make possible users to interact with each other and with the system simultaneously, and to collaboratively act to achieve some collective or individual goal.	P1, P6, P14 e P20
	R11. Provide Feedback from users	The system has to provide means for other systems' users to give "feedback" to the actions of other users.	P3, P8, P9, P14, P15, P16, P18, P19, P20 e P21
	R12. Contemplate Affordance and Culture	The system has to consider the target audience and the intended usage of the system and contemplate known affordances of the interaction devices to not demand specific skills from users (unless that is the goal of the system). The system has to make use of interaction devices (objects) known to users, and take into account their context of use, as well as rely on elements and modes of interaction that belong to the users' culture.	P2 e P9
Technical	R13. Provide Feedback from System	The system has to provide digital feedback to users after they interact with interface elements and/or interaction devices, thus establishing a coupling and communication between the two parties.	P3, P7, P9 e P16
	R14. Give random outputs	The system has to give random (different and unexpected) outputs to the users' actions from their interactions.	P3, P9 e P11
	R15. Identify User and Flex Tasks	The system has to be able to figure the "type of user" out that is interacting with it, make automatic adaptations according to that user (or find a balance between all of them, when there is join interaction) and make the tasks the users need to perform more flexible.	P2, P3, P5 e P111
	R16. Balance the level of difficulty	The system has to gradually demand more "effort" from users, but not demanding specific skills which go beyond their capacities.	P2 e P3
	R17. Provide Versatile, Diverse and Natural Interaction	The system has to provide versatile and diverse means of interaction so that the same action can be performed by users naturally.	P3 e P5
	R18. Allow choice of usage	The system has to allow users to choose what they want to use from the system, how to use it, and when to use it.	P2 e P3

Table 2. Design Recommendations and Systems' features examples.

Recommendation	Features Example
R1	The system reminds users of their past achievements (Schneider et al., 2017) and shows their past photos, old records, and evaluations related to their emotional states (Thieme et al., 2015).
R2	The user may change the appearance of a profile page of a social network (Pai & Arnott, 2013); In a game, the user is enabled to choose the difficulty level (low, medium, high) (Compañ-Rosique et al., 2019).
R3	Users expresse how they are feeling and the system adapts the colors of his profile picture according to this information (Schrammel et al., 2014).
R4	The user knows that by trimming the teddy bear, a motivational message will be said (Paay et al., 2018). The stuffed animal allows some types of hug intensity and the user understands that a strong one will allow the "animal" to take a picture (Muriana et al., 2019).
R5	A counter-example would be the system exposes to everyone the number of likes of a photo (Birk et al., 2015) the game exposes the ranking board with the name and photo of the users (Birk et al., 2015).
R6	The system keeps challenging users in accordance to their skills level and ensures suspense of outcomes (Birk et al., 2015)
R7	The system takes the user by surprise (Thieme et al., 2015), displays videos, images, audios geared towards the target audience (Schrammel et al., 2014), and uses games to motivate and engage users in therapy sessions (Thieme et al., 2015).
R8	The system was developed for children in a Hospital and was based on hugging stuffed animals to turn a Christmas tree's lights on (Muriana et al., 2019).
R9	The system allows users to send private messages to each other (Wohn & Lampe, 2018), and share knowledge/information (Lee & Jang, 2010; Wohn & Lampe, 2018).
R10	The users may create groups with common interest (Wohn & Lampe, 2018), and play games together with other people (Birk et al., 2015).
R11	The system allows users to click on "like button" (Scissors et al., 2016) and make comments (Zell & Moeller, 2018) in pictures.
R12	The system interaction is based on button-click (Paay et al., 2018); The system uses the affordance of a teddy bear hug to enable users to interact with it (Paay et al., 2018); The system adopted a stuffed monkey which is an animal known to everyone (Muriana et al., 2019).
R13	The system plays an audio message from teddy bear always users hug it (Muriana et al., 2019); The visual element of the system interface increases its size according to the user's mouse press time (Keay-Bright & Howarth, 2012).
R14	The system displays different messages on the cell phone when the user interacts with the device (Paay et al., 2018), and plays different speeches after users hug a Plush animal (Muriana et al., 2019).
R15	The system' algorithms automatically match users with similar skill levels to play a game (Schrammel et al., 2014), and change the type of score (precision level, for example) according to the user who is playing (Gerling et al., 2014).
R16	The system increases the difficulty level of a game little by little (Compañ-Rosique et al., 2019) .
R17	The system provides three types of interaction for the users to play the game: specific carpet to upright performance; movements through a wheelchair (who does not use the carpet); and interaction through a joystick control (Jraidi & Frasson, 2010).
R18	The system allows users, at any time, to change the motivational messages the stuffed animal displays (Paay et al., 2018) and draw the activity the system sorts (Paay et al., 2018);

3.1 Analyzing the Recommendations

For verifying the recommendations completeness and analyze how they encompass the capacity of influencing self-esteem, we chose four systems from the systematic literature review we performed (Muriana & Baranauskas, 2021b). We chose these systems based on their type of technology and interaction mode. For each application we checked whether each recommendation was addressed; we did it based only on the paper description of the system. Yet, we analyze the recommendations in one system developed in the context of this paper.

3.1.1 Systems from Systematic Literature Review

Next, we briefly describe the four solutions from our RSL (Muriana & Baranauskas, 2021b).

P5 - 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.

P11 – A - 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 users feel sad, they may raise the frog, which will say a motivational and

encouraging message; users can edit the messages themselves through the internet. After the frog's message is sent, 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 their affective state.

P11 – B – Sun of Fortune (Paay et al., 2018): it is also a technological ubiquitous and pervasive device for the users to avoid negative thoughts and feel confident. The object is a sun-shaped technological device composed of leds and microcontroller. To use the device, the user must write activities on a piece of paper and place it 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.

P16 – MindBook (Schrammel et al., 2014): It is an online web paged that looks like a social network system. The pragmatic use of this application is for behavioral training focused on social interactions and strengthening the self-esteem of children with depression. In this sense, the system comprises videos, images, games, and a planner for children to plan their activities during the week. And, through simulations of real situations they may face in his daily life, the child learns how to deal with them.

In the personal context, Paay et al. (2018) is the only one that did not provide features to enable users to compare themselves to other users (R5). Gerling et al. (2014) and Paay et al. (2018) (P11A) do not provide means to users express what they are feeling emotionally (R3); this feature could be useful for the system to adapt itself to the user's affective state. Related to immersion (R6), Paay et al. (2018) , due to its type of devices and applications, did not make possible for users to feel immersed in the systems, as they do not provide a virtual environment like a virtual game or a social media networking.

Under the social perspective, we can observe that none of the systems provide communication means (R9) among the users. Moreover, Paay et al. (2018) and Schrammel et al. (2014) are designed for individual usage (R10). Although Gerling et al. (2014) system allows users to interact together because they are in the same place personally, the system itself has no communication feature such a chat or digital comments, for example. Yet, Schrammel et al. (2014) system just looks like a social network (it has an interface similar to a social network, although not implementing the features of this type of system). Then, Gerling et al. (2014) and Paay et al. (2018) system, because of their technological nature (dancing game and device for individual usage), feedback from other users (R11) is not possible, and users are not able to post or share something (R1); Schrammel et al. (2014) did not describe whether the users can or cannot simulate posting and sharing something.

Regarding the technical recommendations, Paay et al. (2018)(2018) and Schneider et al. (2017) do not demand specific skills from the user to interact with the systems; however, all users perform the same activity, whoever the user is; the systems did not consider the user's level and did not adapt the tasks users have to carry on (R15). In this sense, although Gerling et al. (2014) demands some skill from the user to interact with the system, it seeks to automatically adapt the system under the type of the selected input data.

On the one hand, if some recommendations were not covered, we notice the applications considered the context and target audience in a way the users got motivated to explore them (R8). All systems also considered the users' known devices' affordances and their culture in the interaction modes (R12). The achievement of these recommendations may help to figure out why all solutions also focused on the user's pleasure experience, and the meaning they make from the interactions (R7) and supported them to have in mind the system goals and motivated themselves to interact with these computational solutions. The users' motivation to interact with the devices and systems can also be explained by the digital responses (system's feedback) to the users' interaction (R13) and their randomness (R14).

3.1.2 Aquarela Virtual System

The applications previously analyzed, although they can influence self-esteem and motivate the users, they were not developed considering the design recommendations, nor considering social aspects, which is fundamental for the development of self-esteem. In this sense, a system was developed aiming at social experiences during the COVID-19 pandemics, the Aquarela Virtual System.

This system was developed within the context of the FAPESP Thematic Project Socioenactive. This project has explored new concepts and dimensions of interactive computing systems and has sought to expand the way of developing technologies through systems that are socioenactive. "Socioenactive systems" consider the involvement of the social in the interaction of people with physical and digital artefacts; the interaction between people affects and is affected by the interactive computing system in a coupled way (Baranauskas, 2015).

The Aquarela Virtual System provides the users, children with the average age of six years old, with ways of interacting socially with physical objects, seeing their actions digitally reflected in the computer system. The narrative for the system is based on the Aquarela song[1]. From physical objects that are cited in the song, such as castle, airplane, and seagull, and emojis that represent affective states (happy, calm, sad, angry, sleepy, and afraid), users, remotely distant from each other, interact with the system simultaneously and collectively. Each object and emoji have a QRCode that, when the system read it, it triggers an action on the interface, for instance: emojis rising on the screen or an animation referring to the object shown with the corresponding music sample. The system was developed so that users have the

[1] Aquarela song is composed by Maurizio Fabrizio, Guido Morra, Antonio Pecci Filho and Marcus Vinicius da Cruz de M. Moraes

freedom to show the objects and emojis whenever they want in such away, they may create their own narratives and meaning in the interaction experience.

Figure 4. A child showing an object.

Figure 5. A child expressing affectively himself.

In Figures 4 and 5, snapshots of the Aquarela Virtual System can be seen. In **Figure 4** a child is showing an object (sun) to the system. In the system interface there is an animation related to this object and there are three avatars (monkey, cat and panda). These avatars mean that three users showed some object related to this animation.

In **Figure 5** a user is expressing himself affectively through the "happy" emoji. In the system interface some emojis rising up can be seen on the right bottom corner (*individual feedback*), and also, the list of online users in the system and a button that users may take pictures.

Next, we describe the functionalities of the Aquarela system, correlating them with the design recommendations.

In the Aquarela System interface there is a button that allows the user to take pictures from his webcam (see the right bottom corner in **Figure 5**); the user can take as many pictures as he wants and when he wants. The photos taken by all participants are displayed at the end of the interaction for all online users, as a video clip with Aquarela music playing in the background. The act of displaying the photos refers to design recommendation R1, which refers to remembering and sharing memories.

In the Aquarela System users need to log in to interact with it. Thus, the first step is to type their names and choose an avatar (in **Figure 4** there are some avatars examples). The avatar choice is a type of personalization (recommendation R2) because the users can "customize" one system's element according to their wills and needs. Yet, the pictures the system shows in the end of the interaction can also be considered a kind of personalization because this final presentation will always be different from on section to other due to different photos.

The Aquarela System allows users to express their affective states at any time during the interaction (R3) (see **Figure 5**). When the system recognizes that an affective state has been shown, it triggers an individual animation referring to the read affective state; for the other users, the read emoji is displayed next to the user's avatar.

The interaction goal (R4) becomes clear to users as soon as they start interacting with the system when they notice they just need to show the objects QRCode to the webcam, to trigger system actions.

Comparison is one factor that can affect self-esteem. Thus, the Aquarela system does not have interface elements that favor comparison between users (R5).

Due to the nature of the Aquarela system, users' immersion in the virtual environment is afforded when they see their avatars in the scene being displayed, as well as when their actions are reflected in other animations in the interface (R6) (**Figure 4**). In addition, the meaning and experience that each user has with the system makes them create their own interaction narratives, which is also a way to be immersed and feel transported into the virtual environment.

The theme of the system, its elements, music, and responses to interactions are relative to the target audience; besides providing user immersion (R6), the system allows them to create their own narrative and experience of using the system (R7). The interface and its system elements are playful and colorful, focusing on the users' enjoyment and child context.

As the interaction objects have QRCodes and, because of the dynamics adopted in the system and its algorithm, the system arouses the user's curiosity to explore and experiment with it (R8), since each QRCode represents a distinct animation in the screen.

To decrease data consumption and computational processing needs, the Aquarela System makes parallel use of Google Meets to support communication among users and system's mediators and managers during the Aquarela activities. In this way, the users who are interacting through Aquarela, have their communication and social interaction (R9) provided transparently by the Google Meet system.

The Aquarela System is for collective interaction; users can interact with each other through voice and through their actions, influencing each other's (R10) (see the list of online users in **Figure 5**). Yet, the users have individual interactions

Table 3. Conformity of the five systems with the design recommendations

	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18
P5		x		x		x	x	x		x		x	x	x	x	x	x	x
P11 - A		x		x	x		x	x				x	x	x			x	x
P11 - B		x	x	x	x		x	x				x	x	x			x	x
P16			x	x		x	x	x				x	x					
Aquarela	x	x	x	x	x	x	x	x	x	x		x	x				x	x

with the system such as when he takes a picture, which composes the final clip of Aquarela.

The animations, colors, music, and other elements of the system were planned according to the age of the target audience intended to interact with the system: the participants' avatars are cartoons of animals' faces (there are 12 possibilities to be chosen), the affective expression displays an animation with previously known emojis rising on the screen. In this way, the Aquarela System makes use of the affordances and elements of the children's context (R12).

Aquarela System provides sound and visual feedbacks for every user's action (recommendation R13), such as: the system emits a sound warning when reading a QRCode; when users take a picture, the visual element with their image gets bigger; when displaying an affective emoji, besides the sound, an animation with emojis rising on the screen is displayed. In this way, every action of the user has some reflection in the system.

The interaction with the system occurs naturally, without requiring specific skills from the users (R17): they only need to place the QRCode in front of the webcam to have it read by the system, as can be seen in Figures 4 and 5.

Aquarela System is not a system stuck in its narrative: users are free to choose what to use from the system and when to use it (R18). For example: they can express an affective state or take a picture whenever they want, as well as choose when and which object related to the music they want to show in order to make the related animation appear in the screen.

However, just like the other systems we analyzed, Aquarela System is still limited in the application of some recommendations. Although the system allows them to change their name and avatar at any time, customizations (R2) such as changing colors and sounds, for example, or other types of settings according to their needs are not possible yet. Moreover, although a user can make a voice comment for another user's action, this feedback is not registered and may not be understood, or even directed, by the other user, still not allowing other users to give feedback to some specific user's actions (R11).

Other limitations of the Aquarela System are present in the technical context. Although there are several animations and effects in the system and they occur in an undetermined order, when showing a QRCode to the system, the animations and sound effects will always be the same for that specific QRCode; there is no random output (R14). Also, the system cannot automatically identify the user and make adaptations according to that user (R15). Finally, given the simplicity of the system, the users' actions are simple; the system does not impose further efforts of users during interaction (R16).

3.2 Design Recommendations and the Systems Analyzed

The systems we analyzed have distinct purposes, means of interaction, and domains. Paay et al. (2018) focuses on two systems for users to avoid negative thoughts. Schrammel et al. (2014) aims at behavioral training focused on social interactions. Gerling et al. (2014) propitiates social inclusion. And the Aquarela System focuses on remote social experiences during joint interaction with the system. From the analysis of the design recommendations in the systems, we may notice that no system addresses all recommendations (see **Table 3**). Although the use of all the recommendations does not guarantee that the system will affect the user's self-esteem or that the more they are contemplated the greater the impact on the user, we believe the recommendations are means to potentialize this phenomenon, since they are related to both self-esteem and SDT aspects.

Self-esteem is a feeling developed from social relations (relatedness). Thus, systems that provide social functionalities, such as the recommendations we propose (R9-R12), enable social inclusion, making the user feel a sense of social belonging and fulfillment of their social needs. As seen in **Table 3**, the Aquarela System is the one that most contemplates the recommendations of the social context, especially for its goal of promoting social experiences.

From the comparison of the five systems and the technologies they used, there seems to be evidence that the use of ubiquitous and pervasive systems, when compared to the traditional use of GUI-based systems, has greater potential to cover the recommendations. Except for Schrammel et al., (2014)'s system (P16), all other systems are applications that covered a greater number of recommendations. Although it is not possible to compare which system affected users' self-esteem the most, we believe that more natural interactions (R17) favor users by requiring fewer specific skills and giving them more freedom to create their own interaction goals (R4). Also, this favors the achievement of the user's psychological needs, providing them autonomy, highlighting their competencies, and supporting their sense of social belonging.

From the results, we highlight that the non-compliance of some design recommendations might be related to some challenges in the self-esteem context, such as balancing social and individual contexts in the interaction with the system

and balancing the user's ability to interact together and not feeling himself incapable. The results also show some of the technical difficulties involved in developing systems to contemplate the technological context recommendations, since some of them would require complex algorithms, such as recommendations R15 and R16.

Next, we analyze how the design recommendations relate to the SDT's aspects and discuss their implication to the self-esteem.

4 Design Recommendations, Self-esteem, and Self-Determination Aspects Correlation

Computational systems, technological devices, and their interaction modes can exist in various domains. They have several types of pragmatic purposes, and users may have different motivations to use them (Muriana & Baranauskas, 2021b). However, as the 21 selected papers we analyzed pointed out, whatever the digital system is, they may impact the users' self-esteem.

The design recommendations presented in **Table 1** cover all intrinsic, extrinsic, and quasi-needed motivation aspects Also, the recommendations cover the main technological means people use, as well as several forms of interaction and consider several application domains, which make the recommendations comprehensive and free of context of use.

Next, we discuss the design recommendations and their relation to the SDT's aspects and self-esteem and correlate them with the systems we analyzed.

Memories (R1) may remind the user of his past achievements and trigger positive thoughts and emotions (Paay et al., 2018; Schrammel et al., 2014); sharing these memories is related to feedback from other users and their approval and appreciation. In Virtual Aquarela Systema, for instance, when the users see their pictures, they may feel well and appraise the pictures and the experience in such a way they feel satisfied. As the users interact together and share pictures, after using the system they can interact in person and strengthen social relationships. Thus, this recommendation is also related to some social, psychological and cognition aspects of SDT.

Allowing users to make their own **settings and personalization (R2)** bring the sense of uniqueness to him and highlight and strengthens his self, at the same time he is free to make his own system usage choices. In P5, the users may set the kind of interaction they want, without compromising the game dynamic. In P11, users may personalize the activities the artefact will sort (P11-B) and the messages the frog will show (P11-A). In this sense, the system influences people's affective states, autonomy, and satisfaction, as SDT proposes, once the users have the autonomy to choose what they want and how they want to be influenced by.

Enabling **Affective expression (R3**) can be a useful information for the system to adapt itself in a way to affect the user in reaching some goal. P11-B, P16 and Aquarela System enable users to express their affective state. However, no application makes use of this information; Aquarela System is the only one that show some information at the interface. Although the systems do not consider this information, for users it may be great to express themselves, and in the Aquarela System case, the other users may react to another user affective state and be influenced by it. Thus, expressing the affective state is related to appraisal and may affect the user's self.

When users have a clear and pragmatic view of the system and establishes an **interaction goal (R4**), they may experience and control the system and its outputs (Birk et al., 2015). In all applications from the literature we analyzed, the users understand the systems' usage, although they were not aware the applications were focused in affecting their self-esteem and well-being. Thus, the user's autonomy and satisfaction are improved because they could control the systems and experience them in a way they wished. Although the Aquarela System has not this explicit control from the user, as it is an enactive system, the users can still have the sensation of controlling it.

Comparison (R5) is usually a motivational aspect for people. However, it can also cause negative effects on them. Comparison impacts on the users' self-evaluation and may bring them depression and anxiety symptoms (Faelens et al., 2019). Therefore, it is important to avoid them. P11 and Aquarela System make clear they did not use elements that trigger comparison: both P11 applications are for individual usage; and the Aquarela System, although it is for several users at the same time, it does not have elements such as the amount of likes or other numbers and did not show the pictures during the main interaction. Therefore, avoiding comparison is related to appraisal and sense of affiliation and the self.

Promoting Immersion (R6) engages and involves the user to use the system (Birk et al., 2015), which might affect his autonomy. In P16, for instance, users may have the sensation of being transported to the system once they need to solve solutions that demand their engagement. In Aquarela System, on the other hand, the immersion is based on embodied interaction because the users are represented in the interface by their avatars when they interact with the application. In both systems, the users' autonomy is fundamental because they need to involve themselves with the systems to experience the proposed interaction. So, it may also be related to external aspects, such as feedback and social approval.

When the design focuses on **Pleasure, Experience, and Meaning (R7)** the user may motivate himself to interact with the system; the entertainment and beauty of things may help him fulfill his social and emotional needs (Thieme et al., 2015). Yet, arousing pleasure supports users to make sense of its usage, encourage him to incorporate it as part of their daily life because he may have pleasurable experiences; they may use the system as emotional and social endorsement (Thieme et al., 2015). In all systems we analyzed, we notice they seem concerned about triggering good feelings, meaningful experience: P5, for instance, is an entertainment game focused on social inclusion; in P11, the sense-making of the

messages and activities may provide pleasure; P16 and Aquarela System support users to make sense of its usage because of the elements and, above all, the entertainment domain. Thus, this recommendation is related to affective state, well-being, social aspects, and external feedbacks, and may uphold the self and self-efficacy, because they enable social interaction, the sense of capacity and autonomy, for instance.

Dynamic, Narrative, and Curiosity (R8) enable the users' immersion while they interact with the system and provide a coupling between the user and the system, because the system builds a positive affective environment to them (Muriana et al., 2019). A system with dynamics and narratives according to the target audience may also motivate the user to explore it and, even, to reflect on their actions (Keay-Bright & Howarth, 2012). In all applications we analyzed, we notice they considered the target audience to develop the applications in such a way the users may feel motivated to interact with them. In this sense, this recommendation may influence the users' affective states and the feeling of relatedness.

Provide means for supporting communication (R9) upholds social interactions and the people's intimacy, and can improve emotional aspects, the feeling of self-efficacy, and the self (identity) development. In Aquarela System, for instance, the communication by speech is supported by Google Meets. Although the Aquarela System itself does not provide this functionality, Google Meets in the background enables users' talk between them and improve their experience with the system, because they may work together, create new narrative and dynamics, for example.

Joint Interaction (R10) supports the felling of relationship with other users. It is important to keep the user's engagement with the system (Wohn & Lampe, 2018), and uphold those who feel alone and the social interaction lacking (Alaoui & Lewkowicz, 2012; Schrammel et al., 2014). Interaction with other users simultaneously and collaboratively may forge close ties among users and their well-being. In P5, the users are together in the same room to interact with the system. In Aquarela System, because of its social experience goal, users are each one in one distinct place (they can be in another cities and countries, by the way). Also, the Aquarela System enables a great number of users at the same time. Thus, joint interaction enables new social relationships, new experiences at each new interaction because people are different and that may be good for the social needs' aspect of SDT, for example.

Feedback from other users (R11) is important for those who seek social approval (external aspects). In this sense, when the system provides external feedback, users can have positive views of their own actions and behaviors and recognize their accomplishments. It affects, therefore, emotional and appraisal aspects, social needs such as affiliation, power, and intimacy, the sense of self-efficacy, and the image of the user's self. All systems we analyzed do not provide this functionality. But we highlight that in P5 and in Aquarela System, this feedback can be indirect through communication: in P5 users in the same room can say something directly to other users; and in Aquarela System, users can make use of the Google Meets. P11 and P16 are applications for individual interaction.

Affordance and Culture (R12) are ways of avoiding the demand on specific skills from users. So, users do not need to learn new things to interact with the system and it may support them to use it because they are fearless (Muriana et al., 2019). All systems we analyzed considered this recommendation. In P5, for instance, the wheelchair users are used to move their chair in several ways, so they will not likely have problems with the game. Also, in Aquarela System, children probably will not have trouble in showing the objects to the webcam once it is only necessary to put the QRCode in front of the cam. Therefore, Aquarela considers affordance and culture in the users' sense of competence and autonomy to explore the system, and consequently their satisfaction, because users do not need to learn how to do new things feeling themselves comfortable to explore the system.

Feedback from the system (R13) is also a form of engaging the users (Keay-Bright & Howarth, 2012), motivating and encouraging them to keep trying new things (Compañ-Rosique et al., 2019), and enhance their feeling of capacity. In all analyzed systems there is an output from the system to every user's action. But, differently from the other applications, Aquarela System, for instance, have different feedbacks at the same time: when a user takes a picture or show a QRCode, for this user the system has specific feedbacks, but for the other users, the system also gives another specific feedback to inform that some users interact with it. Thus, feedback from the system may improve the user's affective states and satisfaction.

Randomness outputs (R14) (different and unexpected responses to the user's actions) grabs the users' attention (Compañ-Rosique et al., 2019), evoke their curiosity (Keay-Bright & Howarth, 2012), and provide the possibility of immersion (Muriana et al., 2019). The randomness is related to the feedback from the system (R13). In P11, for instance, the activity sorted from Sun of Fortune (P11-B) and the message from the Happy Frog (P11-A) are random. Through **identification of the "type of user" (R15),** systems may adapt themselves, make tasks flexible to each user according to their level. Therefore, the user may feel self-confident in interacting with the system. Yet, it upholds them to deal with their expectations and support some social aspects. In P5, when a wheelchair user is identified, the system adapts its algorithm to a specific system of punctuation. This kind of flexibility, for example, may affect the users' emotional aspects and improve their sense of capacity and self-efficacy.

Related to that, if the system gradually demands more effort from users **increasing and balancing the level of difficulty (R16**) and the users' capacity and skills, it supports them to have feelings of personal progress (Compañ-Rosique et al., 2019). In P5, for each kind of interaction mode (carpet, wheelchair, or a control like a joystick), the system balances the game level of difficulty for a more egalitarian game. It relates to user autonomy, self-efficacy, and competence. Also, it deals with the user's expectations because the user may feel confident to interact with the system.

Providing versatile, diverse, and natural interaction (R17) enables the possibility of users' choice under their

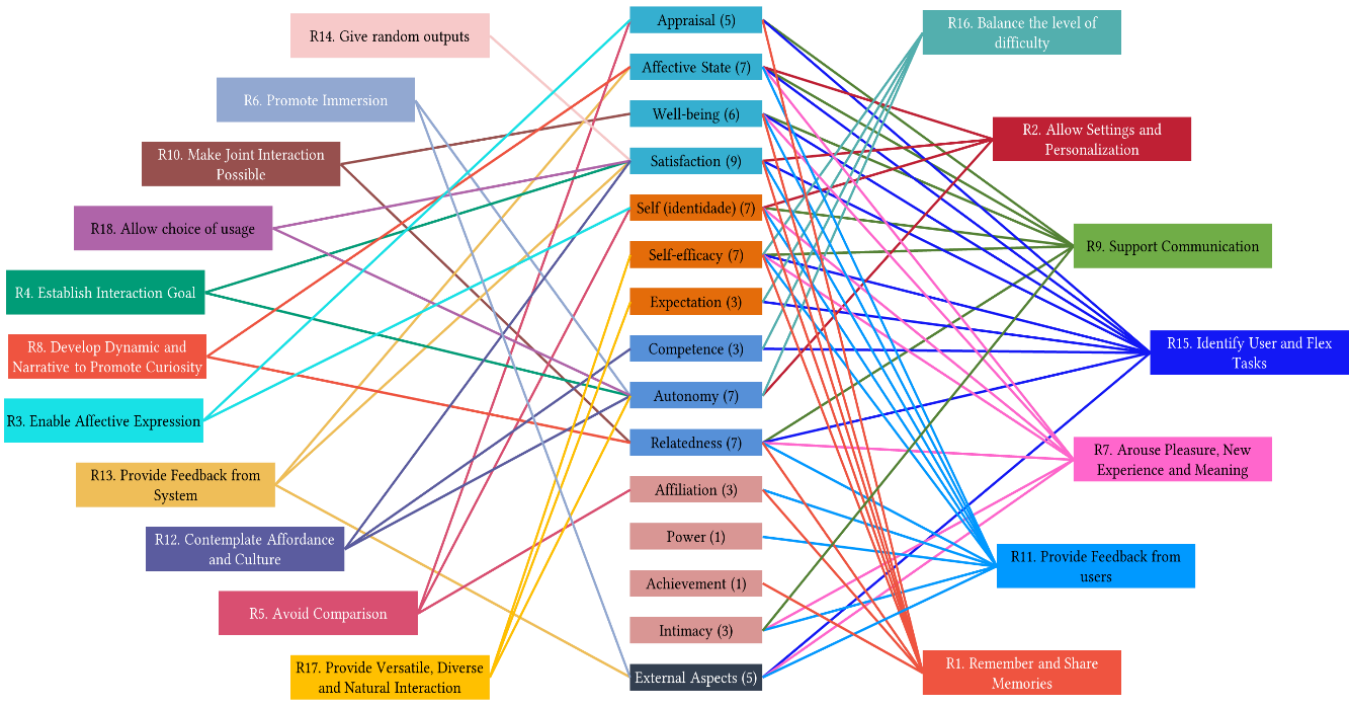

Figure 4. Relation between SDT's aspect and the Design Recommendations

skills, wishes, and goals. Yet, it promotes accessibility to the system and ease motions (Compañ-Rosique et al., 2019). In P5, there are three kinds of interactions mode to interact with the systems and all of them allow users to performer the same actions in the system. In P11, users may write their own activities and messages under their needs. And in Aquarela System, the interaction is more natural once users do not need specific actions and skills; they only need to point the QRCode to the webcam. Therefore, users may perceive themselves autonomous, self-effective, and they can also deal with their expectations.

Allowing choice of usage (R18) gives the users freedom of choice under their wills, capacity, and/or skills. In P5, users may choose the device they want to use to interact with the system. In P11, they are free to use the systems whenever they want at any moment. And in Aquarela Systems, users may choose what functionality they want to use also at any moment. It collaborates toward increasing the user's sense of autonomy and satisfaction, because there are alternatives to usage.

In **Figure 4**, we relate each recommendation to the SDT's aspect it covers; in the middle of the Figure there are all the SDT's aspects, and the number of recommendations related to each aspect (in parentheses). These relations are based on the 21 papers' discussion we considered in the meta-analysis.

In **Figure 4**, we observe that some design recommendations seem to promote the motivational aspects more than others. R10, for example, is the recommendation that influences user the most; this makes sense because people seek approval from other people as motivation to do things. The recommendations allow the users not to be afraid to interact with the system and technological devices, because specific skills are not required from them. In this way, users can feel themselves confident and motivated to interact with technology.

The design recommendations related to individual use of the system focus on motivating users to make their own choices (R2, R4). So, their autonomy and sense of competence are developed. Still, these recommendations focus on the development of the self, highlighting the users' achievements (R1), and preventing them from comparing themselves to other people (R5). Yet, they promote the user's pleasure, experience, and new sense-making from the interaction (R7), in such a way as also promoting immersion (R6). Therefore, through immersion, the user can feel "attached" to the system. These design recommendations also focus on the self-expression (R1) and the emotional state (R3).

The recommendations to promote the social aspects that are also essential for the development of self-esteem, facilitate to the user the social belonging feeling (R9-R12). Communication (R9) promotes closer ties, while joint interaction (R10) allows the user to feel competent, part of a group, and improves their self-importance if the group supports itself to carry out an action together; the devices and interactions with known affordances and from user's culture (R12) may support the collaboration among users and relatedness feeling. Therefore, feedbacks from other users (R11) are also fundamental and this strengthens the user's sense of competence, the formation of their identity, and the self-appraisal, affecting emotional aspects improvement.

Last, the technical recommendations are focused on usability and accessibility (R15, R17, R18), adaptability (R15, R16), availability (R18) and reciprocity (R13, R14). Thus, enabling a greater number of users to interact with the system, which gradually demands skills and competencies from

users according to their capacities, might promote self-efficacy, self-confidence, competence, and autonomy, also promoting the development of the self.

From **Figure 4**, we also highlight the importance of emotional aspects (appraisal, satisfaction, affective state, and well-being); it also supports why emotion aspects are central in **Figure 2**. People need to feel satisfied; this satisfaction evokes various feelings in the users, which are decisive for the feeling of achievement of their objectives (motivations). The satisfaction also upholds how fundamental social approval is for people. Ryan & Deci (2000) argue if the other aspects (cognition, psychological and social) are satisfied, they conduce people toward well-being. Pyszczynski et al. (2004) also emphasize that when social conditions support and provide opportunities to people accomplish these aspects, well-being is enhanced.

Thus, when the design of systems and technological devices consider individual, social, and technical aspects that may impact user's daily life, these digital solutions are likely to positively affect the user's behavior. When people feel autonomous, competent, and related to other people, their behaviors may be "taken in' and internalized to become more autonomously regulated, even whether they have not been initially intrinsically motivated (Gunasekare, 2016).

In this sense, as self-esteem is a concept developed from the personal experiences of a person in society and refers to the assessment people in relation to themselves, Pyszczynski et al. (2004) says when all needs are satisfied, self-esteem is stable and secure, and people do not concern about it all anymore. However, when self-esteem seems to be fragile, people give more significance to relatedness than to autonomy and competence. This significance difference can explain why many individuals are first motivated to do things that are well-seen by others, willing to have their behavior valued as significant by whom they want to be connected (Ryan & Deci, 2000).

In a nutshell, the design recommendations we presented also articulate some ideas of Baumeister et al. (2002) about why people deal with self-esteem. Therefore, when considered in the systems, the recommendations may support the user to: *i*) maintain well-being and positive affect; *ii*) have feedback about his efforts; *iii*) reflect on his individual status; *iv*) facilitate self-determination and sense-making from the system usage; and *v*) assess information about his eligibility for social belonging.

5 Final Considerations

The Self-Determination Theory studies the human motivation behavior, oriented to seek the sense of autonomy, competence, and relatedness in such a way it provides means to the development of the self. Self-esteem is related to this concept because people have their own needs and motivations, but many times they based on society and its behavior patterns and reactions to other people's actions and thought. Technology and digital environments as part of our life in society are more and more impacting people's well-being.

This study considered the same base of literature work we got previously relating technology and self-esteem (Muriana & Baranauskas, 2021b). Differently from the general results regarding types of technologies and application domains, in this work we could go deep on features of the systems selected from the base and discuss how and why they affect self-esteem, under the SDT perspective. Moreover, we have argued that digital systems and devices should address human motivation and self-esteem. In this sense, the major aim of this paper was to bring up, group and present some design recommendations regarding the subject, raised from literature work. By a meta-analysis of 21 papers, we got 18 design recommendations to guide designers to build digital applications and technological devices considering self-esteem issues. The recommendations we presented in this study intended to: *i*) provide support for designers to improve the system on the way to influence user's self-esteem; *ii*) raise on designers, reflection on how the system they develop may affect the user's life.

Results of an exploratory investigation of the proposed recommendations in different systems have shown that appraisal seems to be a relevant aspect to consider in the self-esteem development process, because from the sense of satisfaction people ponder about their actions. Although satisfaction is fundamental, it is not influenced only by competences. Social and environmental contexts and their affordances have also a role on people's motivation and the self-development.

In this study, we limited ourselves to raise some design recommendations through a meta-analysis and analyze their presence/absence in four systems raised from our previous literature review. Yet, we analyzed the design of a digital application developed specifically to verify these recommendations in the practice of design

So, based on results of this work, in the future we intend to test our system with users in such a way we may investigate whether and how the system affects the behavior of users and how the social context and the environment affordances affect them while they interact with the proposed system. After the formal evaluation of these recommendations, we can refine them, and eventually include others. It will enable us to transform them into socially aware design guidelines focused on the psychological well-being of the users, especially on their self-esteem. Yet, besides the aspects of self-esteem our recommendations already consider, we also intend to include other parameters such as human, social, and technical values, and embodied interaction aspects, so they may provide more natural interactions and fulfill life social experiences. Hence, future work also involves analyzing how the social, physical, and digital dimensions of a system coupling affect each other so to impact on the user's self-esteem within a ubiquitous and pervasive technological environment context specifically.

Therefore, in this sense, we hope software design can positively promote self-esteem through systems that motivate users and support them in achieving their own psychological goals and needs. Although there is still a path to go towards making the results a more straightforward 'tool' for designers, we see this work as a first step.

Acknowledgment

This work is financially supported by National Council for Scientific and Technological Development (CNPq) through grants #140400/2020-6, #306272/2017-2, and #304708/2020-8, and by the São Paulo Research Foundation (FAPESP) through grant #2015/16528-0. We also thank Emanuel Felipe Duarte, José Valderlei da Silva, Josiane Gaia Pimenta, Maria Jêsca Nobre de Queiroz and Yusseli Mendoza for the Aquarela Virtual System development.

List of Papers Selected to the Meta-Analysis

P1. Alaoui, M., & Lewkowicz, M. (2012). Struggling Against Social Isolation of the Elderly—The Design of SmartTV Applications. In J. Dugdale, C. Masclet, M. A. Grasso, J.-F. Boujut, & P. Hassanaly (Orgs.), *From Research to Practice in the Design of Cooperative Systems: Results and Open Challenges* (p. 261–275). London: Springer London.

P2. Birk, M. V., Mandryk, R. L., Miller, M. K., & Gerling, K. M. (2015). How self-esteem shapes our interactions with play technologies. *Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play*, 35–45.

P3. Compañ-Rosique, P., Molina-Carmona, R., Gallego-Durán, F., Satorre-Cuerda, R., Villagrá-Arnedo, C., & Llorens-Largo, F. (2019). A guide for making video games accessible to users with cerebral palsy. *Universal Access in the Information Society*, *18*(3), 565–581.

P4. Faelens, L., Hoorelbeke, K., Fried, E., De Raedt, R., & Koster, E. H. (2019). Negative influences of Facebook use through the lens of network analysis. *Computers in Human Behavior*, *96*, 13–22.

P5. Gerling, K. M., Miller, M., Mandryk, R. L., Birk, M., & Smeddinck, J. (2014). *Effects of Skill Balancing for Physical Abilities on Player Performance, Experience and Self-Esteem in Exergames*.

P6. Jraidi, I., & Frasson, C. (2010). Subliminally enhancing self-esteem: Impact on learner performance and affective state. *International Conference on Intelligent Tutoring Systems*, 11–20. Springer.

P7. Keay-Bright, W., & Howarth, I. (2012). Is simplicity the key to engagement for children on the autism spectrum? *Personal and ubiquitous computing*, *16*(2), 129–141.

P8. Lee, E.-J., & Jang, J. (2010). Profiling good Samaritans in online knowledge forums: Effects of affiliative tendency, self-esteem, and public individuation on knowledge sharing. *Computers in Human Behavior*, *26*(6), 1336–1344.

P9. Muriana, L. M., Silva, J. V. d, Santos, A. C. dos, & Baranauskas, M. C. C. (2019). Affective state, self-esteem and technology: An exploratory study with children in hospital context. *Proceedings of the 18th Brazilian Symposium on Human Factors in Computing Systems*, 1–11.

P10. Nie, J., & Sundar, S. S. (2013). Who would pay for Facebook? Self-esteem as a predictor of user behavior, identity construction and valuation of virtual possessions. *IFIP Conference on Human-Computer Interaction*, 726–743. Springer.

P11. Paay, J., Nielsen, H., Larsen, H., & Kjeldskov, J. (2018). Happy bits: Interactive technologies helping young adults with low self-esteem. *Proceedings of the 10th Nordic Conference on Human-Computer Interaction*, 584–596. Oslo Norway: ACM. https://doi.org/10.1145/3240167.3240180

P12. Pai, P., & Arnott, D. C. (2013). User adoption of social networking sites: Eliciting uses and gratifications through a means–end approach. *Computers in Human Behavior*, *29*(3), 1039–1053.

P13. Pereira Santos, C., Hutchinson, K., Khan, V.-J., & Markopoulos, P. (2017). Measuring self-esteem with games. *Proceedings of the 22nd International Conference on Intelligent User Interfaces*, 95–105.

P14. le Roux, P., & Loock, M. (2015). The impact and opportunities of e-tutoring in a challenged socio-economic environment. *2015 International Conference on Computing, Communication and Security (ICCCS)*, 1–6. IEEE.

P15. Schneider, F. M., Zwillich, B., Bindl, M. J., Hopp, F. R., Reich, S., & Vorderer, P. (2017). Social media ostracism: The effects of being excluded online. *Computers in Human Behavior*, *73*, 385–393. https://doi.org/10.1016/j.chb.2017.03.052

P16. Schrammel, A., Hlavacs, H., Sprung, M., Müller, I., Mersits, M., Eicher, C., & Schmitz, N. (2014). Mind Book–a social network trainer for children with depression. *International Conference on Games and Learning Alliance*, 152–162. Springer.

P17. Scissors, L., Burke, M., & Wengrovitz, S. (2016). What's in a Like? Attitudes and behaviors around receiving Likes on Facebook. *Proceedings of the 19th acm conference on computer-supported cooperative work & social computing*, 1501–1510.

P18. Thieme, A., Wallace, J., Meyer, T. D., & Olivier, P. (2015). Designing for mental wellbeing: Towards a more holistic approach in the treatment and prevention of mental illness. *Proceedings of the 2015 British HCI Conference*, 1–10.

P19. Valkenburg, P. M., Koutamanis, M., & Vossen, H. G. (2017). The concurrent and longitudinal relationships between adolescents' use of social network sites and their social self-esteem. *Computers in human behavior*, *76*, 35–41.

P20. Wohn, D. Y., & Lampe, C. (2018). Psychological well-being as an explanation of user engagement in the lifecycle of online community participation. *Proceedings of the 2018 ACM Conference on Supporting Groupwork*, 184–195.

P21. Zell, A. L., & Moeller, L. (2018). Are you happy for me… on Facebook? The potential importance of "likes" and comments. *Computers in Human Behavior*, *78*, 26–33.

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