Developing a Socioenactive System to Raise Awareness Against Bullying in Educational Contexts

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Abstract

Bullying is a form of violence that profoundly affects people's lives, influencing their educational outcomes and physical and psychological health. Computational technologies can help raise awareness about bullying and help stakeholders from a school context combat bullying and cyberbullying. Ubiquitous computing, in particular, enables designers to explore peoples' values and physical and social aspects of a school to help combat bullying, as a ubiquitous solution will involve the physical location and peoples' bodily interactions between themselves, the situated ambient, and the technology. Understanding bullying in a value-oriented way, this study aims to develop a ubiquitous solution to help school stakeholders, such as students and teachers, to raise awareness for combating bullying. First, a process of value-oriented problem understanding was conducted to identify stakeholders of the problem domain, their problems, and their values. Then, through collaborative brainstorming and brainwriting, a ubiquitous solution was devised. This solution was conceptually developed by the use of scenarios, prototypes, and technical architecture. Finally, discussions of the conducted value-oriented process for the solution development are presented towards the development of socioenactive scenarios.

Keywords: Human values, Value Oriented Design Process, Bullying, Ubiquitous Computing, Socioenactive Scenarios.

1. Introduction

In the school context, bullying is a problem that affects children and adolescents' educational, affective, and psychological development. The World Health Organization (WHO) estimated that one-third of students aged between 11 and 15 had been bullied by their peers [42]. This problem also occurs in the digital environment mediated by technologies, where the pandemic has impacted the increase in the amount of cyberbullying suffered by children [42].

In this context, the literature demands interventions with technological solutions to face the problem of bullying and cyberbullying [20]. We argue that adopting a socially aware and value-oriented approach is necessary when developing a technological solution to face complex social problems, such as child violence and bullying [14]. This approach should use value-driven artifacts to guide technological development, especially in cases where technology professionals lack the knowledge of how to work with human values [14].

Thus, this work aims at developing a technological solution to the problem of bullying in the school context with a socially aware and value-oriented approach. This work has as its general context the fight against child violence, in which a socially aware and value-oriented process of understanding the problem of violence against children and characterizing ideas for a solution against this problem was carried out, presented in da Silva Junior et al. [14]. This general contextualization of violence against children in da Silva Junior

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et al. [14] supported the development of this study, which has bullying against children in the educational context as a specific problem and research context.

This study methodology was inspired by the stages and artifacts of Socially Aware Design [4, 6, 7, 9] and a Value-oriented and Culturally Informed Approach to design [29]. Inspired by the Socially Aware Design stages of Design, Synthesis, and Evaluation, the problem context was characterized, and an idea for a solution was developed. Each step was conducted collaboratively between the three authors, and Brainstorming, Brainwriting, and collaborative meetings were carried out to develop the solution.

As a main result, this report presents a definition of a ubiquitous solution for raising awareness about bullying among children in fundamental education. The solution exploits social metaphors to encourage values of collective anti-bullying actions, utilizing sensors and actuators to perform actions to reinforce social metaphors. The solution is characterized by scenarios, low-fidelity prototypes, mapping of its social, physical, and digital aspects, operation context, stakeholders, and values.

Section 2 presents the background on human values, and of bullying and works on coping with bullying using technology. Section 3 details the Methodology of this work. Section 4 presents the results achieved in each stage of Socially Aware Design. Section 5 discusses the results, and Section 6 presents the final considerations.

2. Background and Related Work

Aligned with a socially aware understanding of design, we adopt the Pereira et al. [30] definition for human values: "a value is something that denotes importance to somebody for something in some respect or capacity". The definition of values of Pereira et al. [30] is theoretically informed, based on the Peirce signs definition, and aligned with the General Theory of Value of Perry [31] and Friedman [17] definition of values. This definition is related to the Socially Aware Design, the methodological approach of this work and thus is appropriate for this research as child violence and bullying are social problems in challenging contexts. In the problematic context of bullying, the human values work must be related to a socially aware understanding of the design [6, 7]. We understand that the technology design must not only consider human values, but identify stakeholders and their challenges in a broad way, acknowledging the existence of a social and human aspect before any technological design and intervention.

Bullying is a type of violence, the most common being psychological, physical, and sexual harassment [42]. A person is bullied or victimized when they are repeatedly exposed to negative actions by one or more other people [27].

Cyberbullying is also defined as using information and communication technologies to support deliberate, repeated, and hostile behavior by an individual or group to harm others [12]. Cyberbullying can take different forms: cyberstalking, exclusion, defamation, online harassment, and impersonation [26]. Tanrikulu [38] indicated the negative impact of cyberbullying on the psychological, physical, social, and academic outcomes of victims. Concerning psychological effects, involvement in cyberbullying has been linked to depression, anxiety, stress, emotional problems, low self-esteem, and suicidal thoughts.

Bullying is a problem for bullies, victims, peers, schools, classmates, and the community [2]. Bullying creates an unhealthy and insecure environment that affects all students, both the bullied and the non-bullied ones, as students who attended schools with

high levels of bullying reported lower grades than those with less bullying [36]. Although the most pronounced effects are observed in the victim, the aggressors and observers also receive learning and harmful habits that will affect their current and future behavior [18].

Bullying affects various stakeholders, such as families. Makri-Botsari e Karagianni [18] investigated the role of fathers and mothers in cyberbullying and identified that the parenting style is related to the possibility of the manifestation of cyberbullying with their children. Bystanders are witnesses and active participants who can influence bullying behavior [36]. Preventive efforts must focus on vulnerable groups, all students, and the school context [36].

The consequences of bullying in school are several. For example, children between 11 and 15 years old who have been bullied at school are less likely to finish their education [42]. Analyses indicate that depression, anxiety, health problems, absences from school, leaving school because of illness, and grades were significantly related to students' involvement in bullying and cyberbullying [22]. For the bully, the time and energy that should be used on studies are now directed to mischief, resulting in poor academic performance. For victims of bullying, there is always fear and tension that creates a tense atmosphere with no room for peace, where learning can never take place effectively [2]. Bullying also affects emotional and social aspects, as bullied students have a lower sense of belonging to educational institutions and are likelier to exhibit a lower degree of socialization than their counterparts [15]. When violence emerges early, the situation becomes even more harmful [18].

As related works, Sanoubari et al. [34] developed a co-design study with children to inform the design of a social robot to prevent bullying, in which children imagined values for these robots. In turn, Iivari et al. [20] mapped articles with a design or technology intervention against bullying, demanding for the HCI community to develop more solutions and technology to help combat bullying and cyberbullying in general. Understanding bullying as a violence, this work develops a technological solution to raise awareness about bullying in a school context in a value-oriented way.

3. Methodology

The development process followed four general stages of Socially Aware Design [4, 6, 7, 9]. Each stage has a goal, and activities and techniques were used to achieve this goal. Artifacts from Socially Aware Design [5] and Value-oriented and Culturally Informed Approach [29] were used to support our collective design activities.

In the Design stage, the objective was to understand, in the educational context, who the stakeholders are and their main challenges, barriers, and problems comprehensively. In this step, an exploratory search was carried out on materials that describe problems that children and young people suffer in educational contexts at a global level [39, 42] and specific ones [2, 15, 36, 38]. The first author read the selected materials. A mapping of the main stakeholders and their respective problems in the educational context was performed utilizing the Stakeholder Identification Diagram [24, 25] and the Evaluation Frame [5] artifacts. These two artifacts were filled in the OpenDesign platform [19], which implements the two and other artifacts of the Socially Aware Design in an Information System. A presentation and discussion were made with the other two authors on the context of the problem, regarding who the stakeholders were, their problems, and the interrelationship between them. The authors collectively discussed and consolidated the findings.

In Synthesis, the objective was to synthesize identified challenges into one core stakeholder problem to be investigated, explicitly stating the challenges, who suffers the problem, and in which specific context it occurs. In this step, the researchers selected "bullying at school" as a specific problem to be investigated to motivate the development of a solution. The main stakeholders affected or interested in resolving bullying cases were defined. For this definition, the brainstorming technique [11] was used, with the support of the artifact "Value Prospecting Frame" [16].

Then, in the Ideation stage, the objective was to explore solution ideas for the problem in a comprehensive way. The ideation stage was also motivated by the exploration beyond only digital aspects of a technological solution to think about:

1. the physical aspects of the school environment,
2. its people, and
3. the social aspects, such as peoples' values, involved in the interaction between people and a school environment.

This motivation to think about digital, physical, and social aspects aims to understand how ubiquitous aspects of technology could constitute a technological solution. At this stage, the brainwriting technique [41] was used to raise possible ideas to solve the problem of bullying in the school context for children in fundamental education.

Finally, in the Prototype stage, the objective was to evolve the solution idea, making it concrete and visual. In this stage, the Scenarios technique [13] was used, using the result of the problem understanding process, the defined problem, and the ideas raised as input. The low-fidelity prototyping technique [32] was used to illustrate the solution scenario visually. Value-oriented requirements for the solution were identified using the Culturally Aware Requirements Framework (CARF) artifact [29]. During prototyping, it was a motivation to understand and explore the solution's social, digital, and physical aspects and its execution environment. Table 1 summarizes objectives, activities, and what was used as input and resulted as output in each stage of this study.

Table 1. Summary of the objective of each stage, activities carried out and the respective inputs and outputs of each stage.

Stage	Objective	Activities	Input	Output
Problem understanding	Understand problems of violence in the educational context.	Exploratory search and reading of materials on violence in the educational context. Identify stakeholders and their problems and challenges using the Stakeholder Identification Diagram and Evaluation Frame [5]. Summary of information identified in a presentation. Collective discussion on identified problems and consolidation.	Contextualization of people involved and their challenges in the context of violence against children [14]. Values that children and other stakeholders communicate in this context. List of papers and documents on violence in the school context.	List of stakeholders, their issues (and their relationship to each other), and their values.
Shared View of	Make explicit the	Brainstorming about challenges in the problem	Problems identified in the Problem Understanding	Statement of the problem, who

the Problem and Synthesis	problem of bullying to be faced.	context to define a core problem to be investigated. Identify the key stakeholder suffering from the problem and their respective values.	stage. Stakeholder values in the context of the problem [14].	suffers the problem, and in which context it will be investigated.
Ideation	Raise ideas for solutions to combat and raise awareness of bullying.	Brainwriting about solution ideas that also explore digital, physical, and social aspects of the environment and people Consolidation of a single candidate idea to be explored.	Problems identified in the Problem Understanding stage related to bullying. Stakeholder values from problem context and solution requirements [14].	List of solution ideas. Consolidated solution idea to prototype.
Prototype	Develop the solution idea.	Creation of Scenarios that describe the solution. Identification of value-oriented requirements with the CARF artifact [29]. Mapping social, physical, and digital aspects of the solution and the environment in which the solution will operate. Low-fidelity prototyping to visually illustrate scenarios.	Requirements raised for a solution against children violence in the Semiotic Framework artifact in [14]. The consolidated idea of a solution. Stakeholder values from problem context.	Scenarios describing the solution. Value-oriented requirements specifying the solution. Low-fidelity prototypes of the scenario. Table with social, physical, and digital aspects of the solution and its operating environment.

4. Results

This section presents the results for each Socially Aware Design stage.

4.1 Problem Understanding Stage

At the beginning of the problem-understanding stage, the problems and challenges in the context of violence against children identified in the study by da Silva Junior et al. [14] were utilized as input. The study in [14] identified four main categories of problems related to the context of violence against children: i) variety of types of violence, ii) consequences of violence, iii) risk factors for violence, and iv) aggravating factors of violence. Below, a brief description of each category is presented.

Variety of Types of Violence. Violence can occur in many forms, such as bullying and cyberbullying, child labor, self-inflicted, community, gender-based, and structural violence. The variety of challenges indicates that the problem is complex, composed of different types of violence that a child and adolescent can suffer.

Violence Consequences. Effects and consequences of violence were also identified, indicating its impacts on individuals and the social world. Globally, violence causes economic

impacts on society, caused by resources spent on caring for people affected by violence and preventing the full development of people [28, 42]. At the individual level, victims can suffer immediate or long-term physical, psychological, and social consequences, damaging child development in the physical, social, behavioral, emotional, and cognitive spheres [33]. In the educational space, violence has profound effects, such as school dropout and low learning performance [1, 42]. The consequence of violence helps to continue a cycle of violence, causing children and adolescents who are victims of violence to suffer or cause this violence in the future as perpetrators for themselves or for others.

Risk Factors for Violence. Another category of problems was risk factors for experiencing violence during a lifetime. Children living with poverty, misery, and hunger are at greater risk of suffering violence [1, 42]. Poverty is multidimensional, meaning a family cannot access education, health, housing, nutrition, sanitation, or water [40]. The place where children live is a risk factor because living in unsafe environments favors the occurrence of violence [42]. Social, gender and ethnic inequalities are also risk factors for violence [1]. People with physical and mental disabilities or disorders are at greater risk and more vulnerable to violence, including sexual violence [28]. Related to risk behaviors, using alcohol and illicit drugs, as well as early relationships, are risk factors for violence [33, 42].

Aggravators of violence. Some factors exacerbate the impacts of violence or make violence more challenging to tackle. The main aggravating factor is underreporting, which is the situation in which not all violence cases are known, reported, or taken forward when there is an attempt to report them. As an aggravating factor, the various forms of violence are interrelated, sharing many risk factors: children may experience many different types of violence simultaneously and at different stages throughout their lives [42].

From these categories, an exploratory search was carried out on Google Scholar for materials describing problems children and young people suffer in educational contexts. The search string used was *((violence AND (educational OR schools OR learning OR teaching))*. In this exploratory search and reading, we identified the main stakeholders related to violence problems in the educational context and their specific problems related to violence.

For identifying stakeholders, we used the Stakeholder Identification Diagram [24, 25] as this artifact supports the identification and organization of stakeholders relative to five layers of different relations to the problem and operation of an information system: i) Operation (problem or information system); ii) Contribution: actors and responsible for the problem; iii) Source: customers and information providers; iv) Market: partners and competitors in the problem or its solution; v) Community: legislators, spectators, the community at large. Identified stakeholders related to violence in the educational domain are mapped in Figure 1, utilizing the Stakeholder Identification Diagram artifact implemented in the OpenDesign web platform [19].
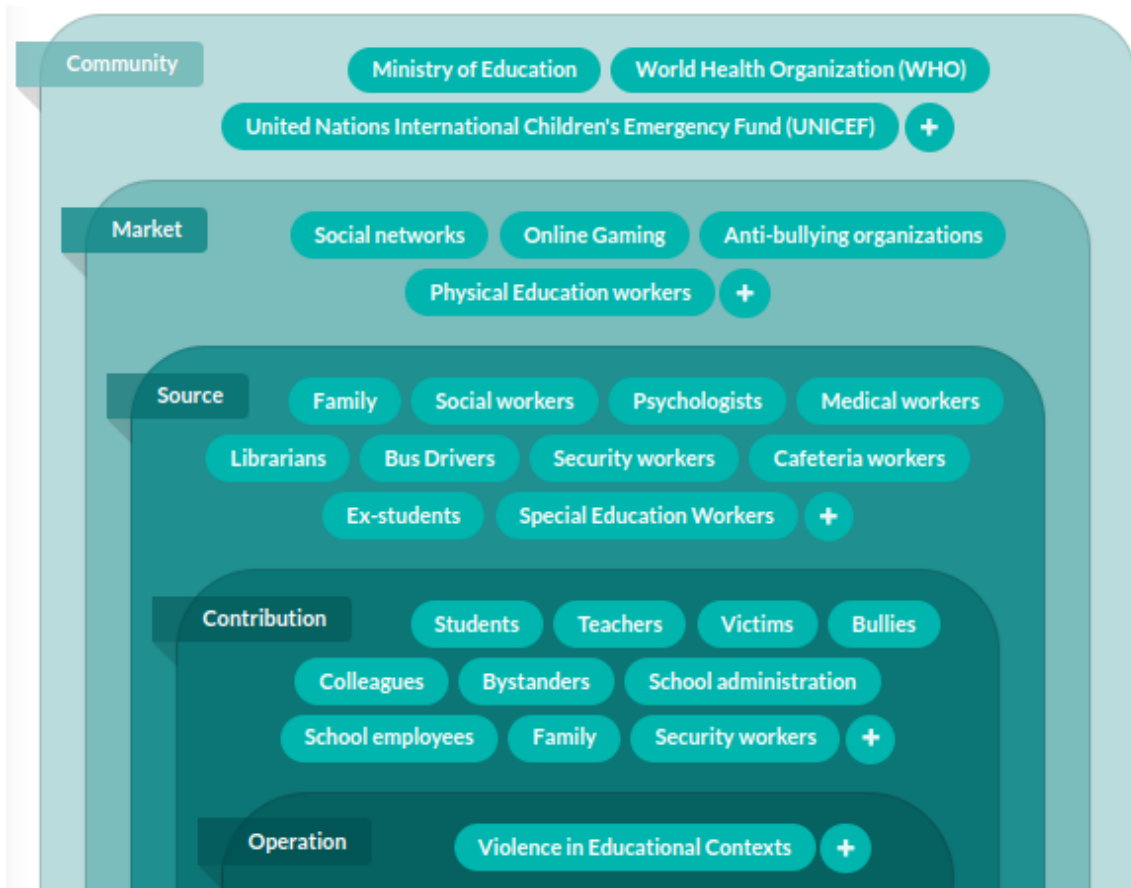
Figure 1. Identified stakeholders in the context of violence in educational settings (source: OpenDesign Platform[4]).

We identified problems, challenges, and pains for at least one stakeholder of each Stakeholder Diagram layer. For this, we used the Evaluation Frame [5] artifact from the Socially Aware Design also implemented in the OpenDesign web platform [19]. The analysis results are presented in Table 2.

Table 2. Stakeholder's problems and challenges in the context of violence in educational contexts identified in the OpenDesign Platform [19].

Stakeholder	Problems
Students and Victims	Fear, pain, and anxiety come from physical, psychological, and verbal violence. Persecution and violence from bullying and cyberbullying cause pain, fear, anxiety, running from school, and poor academic performance. Abandonment and isolation come from child negligence by teachers, administrators, and family, feeling that "I can not trust anybody" or "I can not talk about this with anybody." Give up school entirely because of violence. Lack of trust and healthy relationships with colleagues and school staff. Adopting risky behaviors in school, such as drug consumption, hinders human development and can cause more violence to themselves and others. Prejudices, discrimination, and other types of violence have gender or race-based motivation. Shame or feeling guilty for being a victim of violence.

Teachers	Not knowing or not having enough knowledge on how to deal with violent cases, such as stopping bullying or reporting abuse. Lack of education and concrete orientations about dealing with violence. Guilt from not knowing how to deal with cases of violence. A feeling of impotence from not educating to their best ability and not solving violent cases. Lack of motivation and satisfaction at work. Work Burnout. Vandalism and theft with school and peoples' property. The bad climate in class and in school in general. Poor student grades, evasion, and failing in class.
Family	Suffering and preoccupation as knowing their child can be a victim of violence. Do not know how to deal with a family member who is a victim of violence. A feeling of the impotence of being unable to protect their family member (e.g., child, siblings). A feeling of rage, revenge, and shame when knowing that a family member is suffering violence.
Ministry of Education	More children are out of school and are not finishing their education because of violence. Poor level of education. Economical impacts in healthcare to treat victims and adults that had its development negatively affected by violence, impeding citizens from thriving. A culture of widespread violence in a country. It cannot create a culture of peace and well-being for most of its citizens.

Then, contextualized by the stakeholders and their challenges, we identified values for the previously analyzed stakeholders. For identifying values, we used the Value Identification Frame [29]. Some of the values from the "Students and Victims" and "Family" are also present in the value identification of d[14]. We also included our authors' values since some of these values influenced the purpose of this study in the first place. The results of stakeholders' values identification in the educational context are presented in Table 3.

Table 3. Stakeholder's values from problem context.

Stakeholder	Values from Problem Context
Authors	Respect; Accessibility; Inclusion; Creativity; Innovation; Sharing; Participation.
Students and Victims	Autonomy; Freedom from violence; Feeling accepted; Feeling validated; Conversation about difficult themes; Feeling safe and protected; Trust; Attention and care; Empathy; Love and Affection; Justice for myself and my friends.
Teachers	Education to deal with problematic situations; Empowerment to combat violence; Satisfaction with my job; Motivation to do my job; Feeling safe to do my job; Justice for myself, students, and colleagues; Well-being for myself and my students.
Family	Justice; Security and Protection for their children and family members; Safe environments free of violence; School compliance with moral and ethical work Compassion, feeling accepted and supported; Professionalism and responsibility with their children and family members; Attention and care to their children and family members; School transparency and open communication.

Ministry of Education	Ending violence; Better education; Culture of peace and tolerance; Well-being for all populations.

4.2 Synthesis and Shared Problem Understanding Stage

In this section, one of all identified problems was chosen as a core problem to focus efforts on developing a solution. In practice with the Brainstorming technique [11], the three authors identified ideas, discussed, and decided to investigate the bullying and cyberbullying problem in educational contexts, focusing on developing a solution for raising awareness about bullying with the main stakeholder as children from 6 to 10 years old in school.

Bullying is not widespread among children from 6 to 10 years old. However, when violence emerges early, the situation becomes even more harmful [18]. In this way, we focused on raising awareness about bullying in this context, where children are starting to learn about bullying. Thus, our context of investigation is the bullying in the first years of elementary school, which in Brazil is called "Ensino Fundamental".

Finally, we declared the problem as follows: *Students aged from 6 to 10 years old suffer bullying and cyberbullying in school, and the poor awareness about the theme and difficulty in dealing with and communicating about this type of violence promotes suffering, anxiety, fear instead of education and safe relationships in schools.* With this problem synthesis, we started the Ideation phase to explore solutions for this problem.

4.3 Ideation Stage

This section presents the results from the Ideation stage. A brief qualitative summary of Brainwriting and the consolidation of the ideas are presented.

4.3.1. Brainwriting

The three authors were participants in Brainwriting [41]. The authors wrote their ideas in 3-minute cycles in a shared Google Document. At the end of one cycle, they had to read the ideas written by another participant and contribute with new ideas, additions, and variations. The brainwriting session lasted about 21 minutes. A total of 24 ideas and contributions were raised for a solution. After brainstorming, the participants consolidated their ideas in a synchronous discussion.

4.3.2 Idea Consolidation

In consolidation, ideas were grouped by similarity into categories. Analyzing the results from Brainwriting, the following categories were formed: i) Tangible Artifact, ii) Metaphors, iii) Interaction, and iv) Questions. Table 4 below presents an image exemplifying the ideas grouped into categories.

Table 4. Fragment of Brainwriting Idea Categories.

Category	Examples of ideas
Tangible Artifact	Tangible artifact for a child 'communicate/express'; playful and simultaneously, it must fight the bullying. Tangible artifacts to be used in dynamics, like unraveling a puzzle in the room through its positions and spatial movements.

	Tangible artifacts can operate individually or in combination.
Metaphors	A tree represents bullying in the school's physical space, reflecting the collective situation and how healthy the environment is. A tree bears flowers and fruits when there are reports of a healthy environment; when not, it rots. Tree 'withers' or 'drops' its leaves with each reported bullying action.
Interaction	The child 'records' his speech with the artifact, and someone will listen to this speech. Generate storytelling (drawings and stories) expressing emotion, how you feel, and using characters. Explore something with gestures or the position of the children in order to promote an integrated action that communicates the idea of union, support, or hand-in-hand.
Questions	How to make it possible for the artifact not to be just a 'joke' but a concrete form of expression? How to report bullying? How would this leaves/LED scenario promote anti-bullying action? How to take advantage of the "inputs" to generate something interesting that could raise awareness or produce some insight?

Tangible Artifact. Ideas were expressed in developing a tangible artifact, individual or collective, for the child to 'communicate/express' their feelings. The artifact should be playful but, at the same time, combat bullying. The artifact could be used in a ludic dynamic, such as solving a challenge. A tangible artifact also could promote changes related to emotion and (cyber)bullying in the environment and in the artifact itself. The artifact could be associated with children's physical elements, such as wallets, badges, or other personal accessories that express emotion and how they feel.

Metaphors. Ideas of solutions that represented or worked through metaphors were raised. One of the metaphors raised was a fountain of water and lights controlled through the children's movement and collective action to promote their collaboration and healthy relationships. Another metaphor was a tree that represents bullying in the school's physical space, in which the health and state of the tree reflect the collective situation and how healthy the environment is for bullying and violence. This tree metaphor was explored in more ideas, such as the tree blossoming and bearing fruit when there are reports of a healthy environment; when not, it rots, 'drops' its leaves, or 'fades' with each reported bullying action. The action of storytelling could be associated with the tree branches for the child to express/communicate his problem in a fictional story.

Interaction. In this category, the ideas representing interaction with the solution were grouped. One form of interaction pointed out was the child recording his speech with the tangible artifact so that someone could listen to this speech. Explore gestures and physical positions in the environment to promote integrated actions that communicate the idea of union and collaboration, indicating that they need to work together to overcome challenges. Another possibility was to use storytelling with characters to express emotions and feelings between themselves.

Questions. This category represents concerns and constraints posed as questions during Brainwriting. Among the questions, it is pointed out: how to make it possible for the artifact not to be just a 'joke' but a concrete form of expression? How to report bullying? How could an idea for a solution promote anti-bullying action or awareness? How can a child who has been bullied feel empowered or express their problem? These questions guide and

need to be answered during solution development.

After this analysis, the three authors selected a candidate solution idea to be developed to solve the problem. This selection was made by simply voting for the best or favorite idea. The authors also selected aspects, characteristics, and requirements in Brainwriting that should be considered as a premise in developing the solution, aiming to promote ubiquitous interaction and features. Table 5 below presents the main aspects that were consolidated for developing a solution.

Table 5. Consolidation of important aspects for the development of a solution.

Premise	Description
Metaphors	Good actions generate nutrients for the tree (sun, water, fertilizer, etc.) - light up the three. Bullying generates injuries to the tree (diseases, withering, rotting) - turn off lights.
Requirements	Combating bullying in the educational context. Ludic experience. Engage the emotion and expressions of students. Develop student autonomy. Promote perceptual changes to the environment. Use spatiality/corporeality. Operate individually or in combination. Use a tangible artifact in dynamics, with puzzles or storytelling. Bullying cannot be more attractive to the child than doing a good action. Be present in the school environment (Tangible tree in the classroom or the schoolyard; Wearable: badges and accessories. Walls).

As a candidate idea for prototyping, we developed a ubiquitous installation with sensors exploring the metaphor of a tree that reacts to positive reports, such as good deeds, and negative ones, such as reports of bullying. A tangible technological tree in the school environment can "wither" its leaves, for example, by "turning off" LEDs when receiving a bullying report. On the one hand, the metaphor indicates that collective bullying by a school class affects a tree's health. On the other hand, in the case of good and constructive deeds, the tree can "light up" and "bloom" its leaves from accumulated reports.

4.4 Prototype Stage

In the prototyping stage, we sought to develop the idea consolidated in the previous stage. A scenario was used to represent a stakeholder interacting with the ubiquitous solution, illustrating aspects of problem characterization, the metaphor of the solution, and its operation. The scenario is presented below:

"Oto is a first grader and has many friends at school. However, Some classmates make some "unfunny" jokes about Oto, such as when they call him mean nicknames. Oto already complained once to the teacher, but things have not changed. Oto feels uncomfortable talking about it at home because he does not want to upset his parents. One day, the teacher tells Oto's class that there is a "living tree" in the school library. The teacher said that the tree is a children's friend and that it listens very patiently with its big ears to all the good and bad things the children have to share and also responds by talking or changing itself. The teacher said that the tree sleeps almost all day, and if the child wants to share a good action with the tree, they need to pass a green card on the tree's ear to wake it up. If the child wants to say something bad or about mean pranks that happened to him at school, he has to put a red card on the ear of the tree so that she will also wake up to listen. Oto goes with his classmates to the library and sees

the tree with a big ear on the trunk and leaves made from small bulbs. Oto takes his green card and touches the tree's ear. The tree makes a yawning sound and says, 'Hi, Oto! Got something nice to tell me?'. Oto is surprised that the tree knows his name and tells the tree that one of his classmates had shared a toy earlier and had a snack with him. After Oto finishes speaking, the tree lights up an LED representing a leaf. Some of Oto's classmates notice something has changed in the tree but do not know exactly what. The tree replies to Oto: 'Thank you, Oto, your good deeds make me stronger and happier!'. One day Oto is called a mean nickname in Physical Education class. After class, Oto goes to the library with his head down to talk to the tree. Oto takes his red card and touches the tree's ear. The tree wakes up and welcomes Oto. Oto says, 'Hi tree, today the boys called me that name again. I was sad'. After Oto finishes speaking, the tree turns off two of the LEDs. Oto notices that the room has gotten darker. The tree asks if Oto wants to talk to a teacher or if he wants the tree to try to help him talk about it with adults, saying that if so, Oto needs to pass the red card in her ear again. Oto swipes the card again and sends a notification to the class teacher via a web system and email."

The scenario presents several stakeholders in the context of bullying, their problems, values, expectations, and reactions. Also, the scenario presents the expected behavior of technology and its desired impacts, which are aligned with the personal values of each stakeholder in the school context.

As the main values communicated by the scenario, we can point to the values of communication, where a child feels safe to talk about difficult themes or anything she wants; that is also a value of receiving attention and feeling accepted in their everyday experiences. A tree that always listens and reacts could promote the value of empathy, as it can simulate active listening to the child without judgment and gossiping about it. This active and safe listening could promote the value of trust, as the kid can build trust to talk about difficult themes with the tree. Feeling loved and affection is a value for any child. The tree can simulate this affection with lights and sounds and forward information about suffering to an adult, such as parents and teachers, to express affection.

Moreover, all in all, the aspects of the solution were made to promote freedom from violence and justice for students regarding bullying actions. For the teacher, the value of justice and empowerment to combat violence is communicated by this solution because the teachers can understand how the students are affected by bullying and in what frequency students express that they are being bullied and then take action. If the solution helps combat and reduce bullying, the teachers' values of feeling safe in school are communicated and can help the values of motivation and satisfaction with their jobs.

4.4.1 Low Fidelity Prototype Design

The first author developed low-fidelity prototypes on paper to visually illustrate the scenario. This form of prototyping was developed as it is a low-cost process that demands few resources. Prototyping also helped to mature and consolidate the solution idea. Figures 2 and 3 below present the scenario and different aspects of the solution and stakeholder interaction.
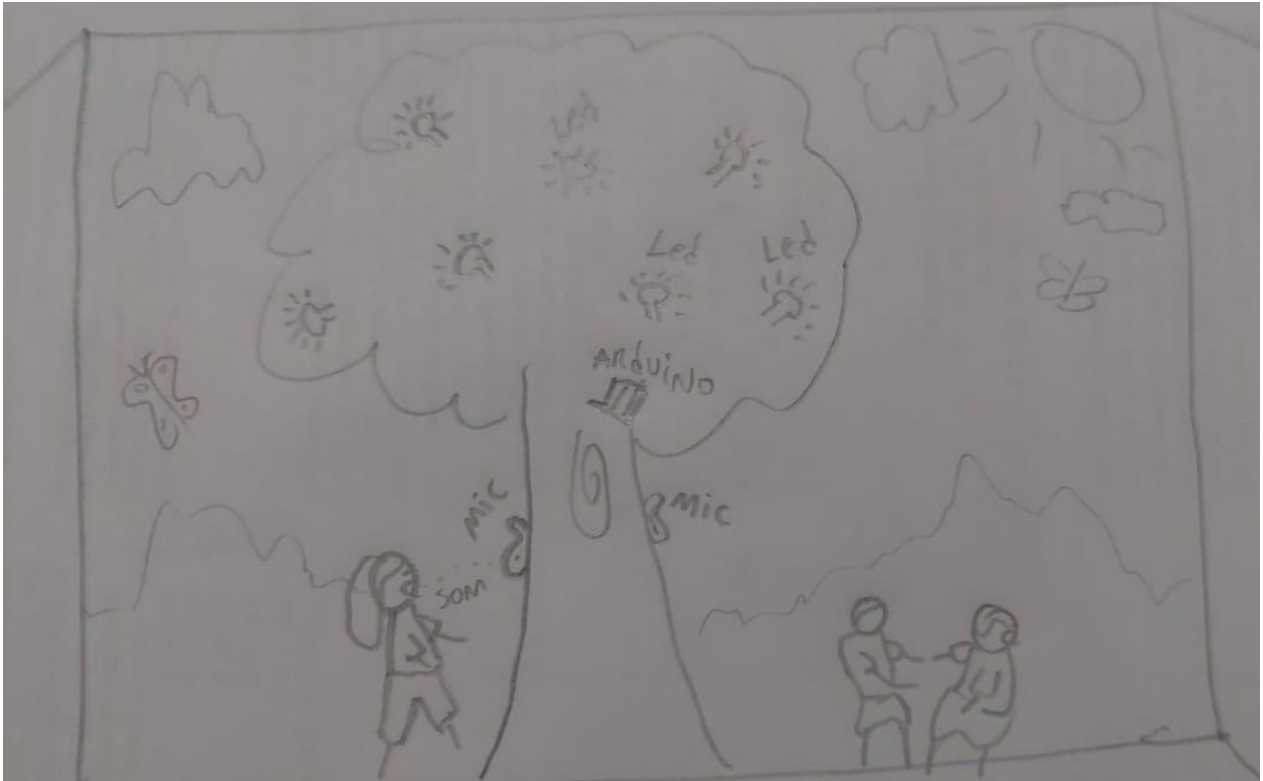
Figure 2. Low fidelity prototype with children playing around the tree and interacting with its trunk (sensors), leaves and fruits (LEDs).

In Figure 2, the children are near the tangible tree with her "big ears." The idea is that the tree occupies an environment where children can access it anytime. This environment could be adorned with figures and paintings reminiscent of gardens or forests. The tree has LEDs with different colors that represent flowers and leaves that would lighten up when children touch their green card on one tree's ear. One LED would turn off when a red card touches one of the tree ears. Near the tree ear or trunk, a sound speaker could be placed to respond to a child with a voice.

Figure 3 presents a variation of the scenario presented in Figure 2. We explored other ways of interaction between children and technology and new ways to represent this interaction. In Figure 3, we represented a projector that would stream pictures of the students' class to represent students' emotions when a good and healthy environment is presented. A room speaker could play music selected by children with their teachers when the school environment is considered "healthy" to stimulate emotion and their playful collaborative actions. Tangible fruits and flowers interacting with the tree could also enable new ways to interact and express their opinions and emotions, for example, fruits and flowers glowing when good actions are expressed to the tree.
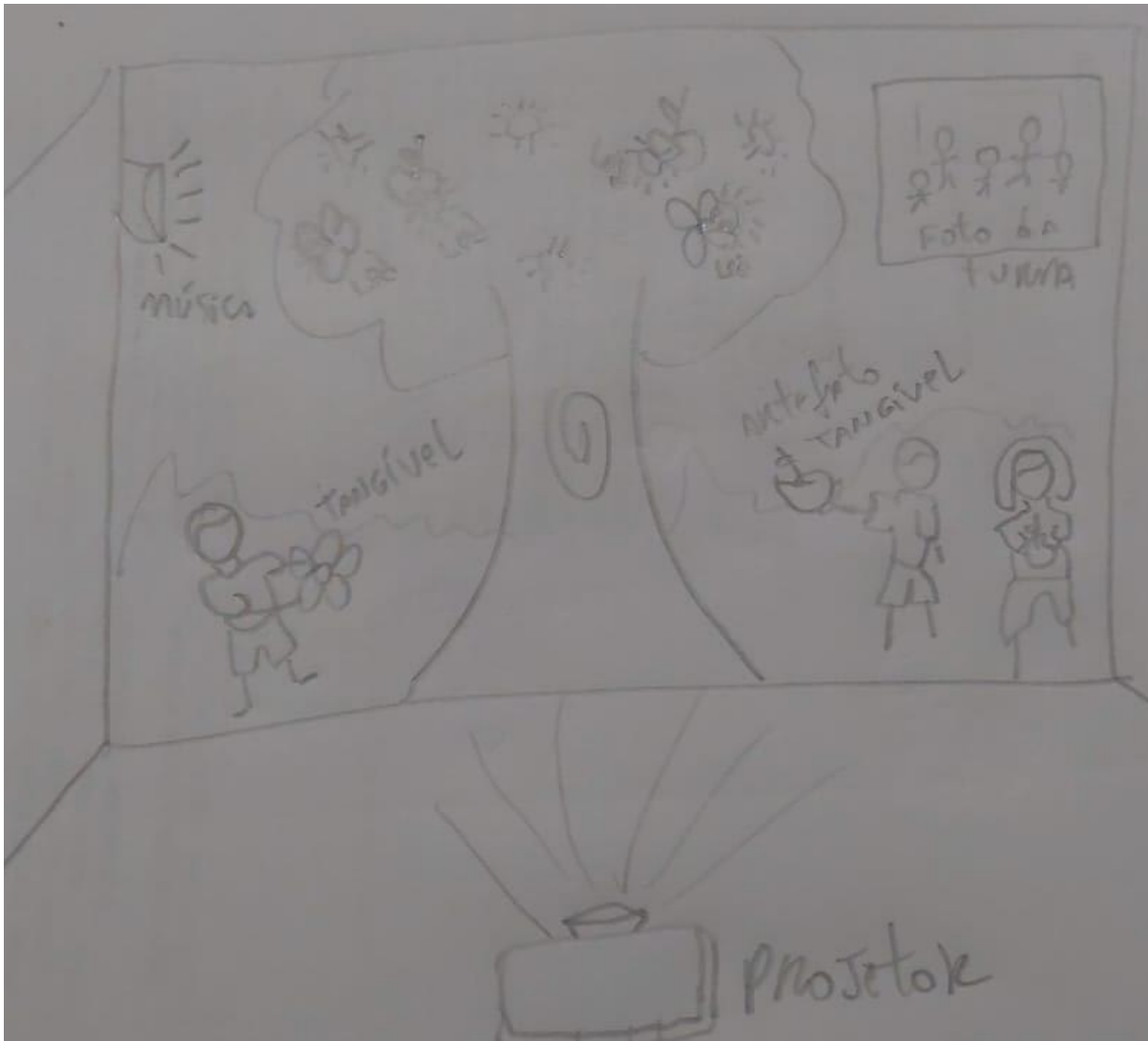
Figure 3. Prototype with children interacting with each other and with tangible artifacts, which in turn provoke reactions in the tree (turning lights on and off, sound emission).

In a meeting of the three authors, the scenarios were presented. One scenario was consolidated with values to be communicated, interaction characteristics with people and technology, social exchanges between people, and physical elements of the school context. The consolidated scenario is presented in Figure 4 below. In Figure 4, a tangible tree in a school environment, such as a library, has fruits, flowers, and leaves accompanying a LED with different colors.

Figure 4. Consolidated scenario for the tangible and technological tree.

Children can be present in the same environment as the tree to play and interact with each other. To interact directly with the tree, one child must touch the green or red card in the tree ear placed on the tree trunk. When a green card is placed, a child can share their good action, and the tree would light up a leaf, flower, or fruit LED. An Arduino or another microcontroller placed inside the tree trunks controls the solution, receiving inputs and emitting digital outputs such as registering child reports in an IS system and physical outputs such as lighting a LED.

Da Silva Junior et al. [14], using the CARF artifact [29], identified high-level and value-oriented requirements for a solution against child violence, such as "A solution must encourage the collective participation of users in reporting violence, communicating that violence is everyone's problem and action by those who witness violence is necessary." The high-level and value-oriented requirements were utilized in this stage as input to think about functional and non-functional requirements for the ubiquitous solution to combat bullying. Thus, using the CARF artifact, we identified specific and detailed requirements to operationalize some of the high-level and value-oriented requirements defined in the study of [14]. Table 6 presents some of our requirements inspired by da Silva Junior et al. [14] requirements, where each requirement is related to a cultural area and the value of some stakeholders.

Table 6. Requirements for the ubiquitous solution against bullying.

Culture Area	REQUIREMENTS	Stakeholder and Values
Interaction	*A solution must presuppose understanding and respect for the identity of children and adolescents as beings with their own desires, experiences, opinions and needs, leaving aside an idea that the child is just someone to be controlled or dominated by an adult* [14].	
	NFR01. The solution must work from the intentional interaction of the child. NFR02. The child controls when the solution can or cannot notify teachers in the event of a report of bullying.	Children: Autonomy, Feeling validated
Association	*A solution must not tolerate violent practices of conversation* [14].	

		FR03. The solution should report bullying cases to teachers when the child consents. FR05. The solution must reflect a negative report with visible effects on the tangible technology that leads to the understanding that the negative action harmed the health of the "tree."	Children: Feeling safe and protected Attention and care
		A solution must interoperate its information with institutions fighting the problem to strengthen detection and prevention, respecting people's anonymity and privacy [14].	
		FR06. The solution must present information in dashboards that allow teachers to learn about bullying at school. FR07. The solution should allow teachers to filter temporal and student-related information to support their decision-making.	Teachers: Empowerment to combat violence
Learning		*A solution can, through a dialogue or interaction with a user, screen the type of violence that this user suffers or wants to report* [14].	
		FR11. The solution must recognize an interaction with red cards as a report of a negative action and a green card interaction as a report of a positive action the child saw or suffered.	Children: Conversation about difficult themes
Play		*A solution can raise awareness to children and adolescents about the effects, risks and reporting channels of digital violence, in which a virtual character can feel the effects of violence in their daily lives, so that children and adolescents can feel empathy* [14].	
		FR12. The solution must represent negative impacts by turning off LEDs, which means having its leaves and fruit dry and rotting. FR13. The solution can represent negative impacts by making tiredness sounds and appearing sick when a negative report happens. FR14. The solution should represent positive impacts by turning on LEDs meaning blooming leaves, flowers, fruits, and a healthy status overall. FR15. The solution can represent positive impacts by making bird sounds and humming tree sounds, having health and a good mood.	Children: Freedom from violence Attention and care Love and Affection
		Case involves digital spaces for reporting, reporting or learning about violence, a solution must ensure that a feeling or experience of safety, trust and protection is maintained [14].	
		NFR03. The tree (tangible technology) must have an appearance that draws attention and is inviting and welcoming to students who wish to communicate with the tree. NFR04. The solution must be available at any time within the school for a child whenever he or she wants to interact and make a report.	Children: Feeling accepted, safe and protected, Attention and care
Defense		*A solution must guarantee the use of security mechanisms throughout the life cycle of sensitive information that involves reporting and reporting violence* [14].	
		NFR05. The solution must use data protection and security mechanisms in the database and the access and authorization of the web system.	Family: Feeling of impotence of not being able to protect their family member.
		The solution must show confidence and security for a health professional who uses the solution to assist or receive reports or complaints from the victim, clearly and explicitly guiding procedures, rules, steps and helping to recover from errors [14].	
		FR20. The web solution may have a section introducing teachers to the correct protocol for a violence report and how to communicate about violence. FR21. The web solution can present links, websites, and reporting channels to report an occurrence of violence.	Teachers: Education and empowerment to deal with problematic situations, Feeling safe to do my job

All of the value-oriented requirements [14] are at a high level of abstraction, defining ways of functioning, high-level functionalities, characteristics, and restrictions that, to be

implemented, must generate more specific functional and non-functional requirements. For example, the requirement related to the family and institutions tackling the problem says, "*A solution must interoperate its information with institutions fighting the problem to strengthen detection and prevention, respecting people's anonymity and privacy.*" This requirement motivated us to create a web information system that teachers could identify students mentioned being bullied and how often this occurred. A web system with a dashboard that shows students in the class who have reported suffering violence is how this requirement will be operationalized in this ubiquitous environment. With each report of violence, a notification will also be sent to the teachers' email, who will then be able to take action, for example, by intervening in the problem or contacting the parents.

4.4.2 High Fidelity Prototype Design

We developed a system architecture using the Semiotic Framework [35] to represent the technological system broadly. We choose the Semiotic Framework [35] to represent the proposed solution's different layers of the human and technological infrastructure (Figure 5). Figure 5 presents the system architecture.
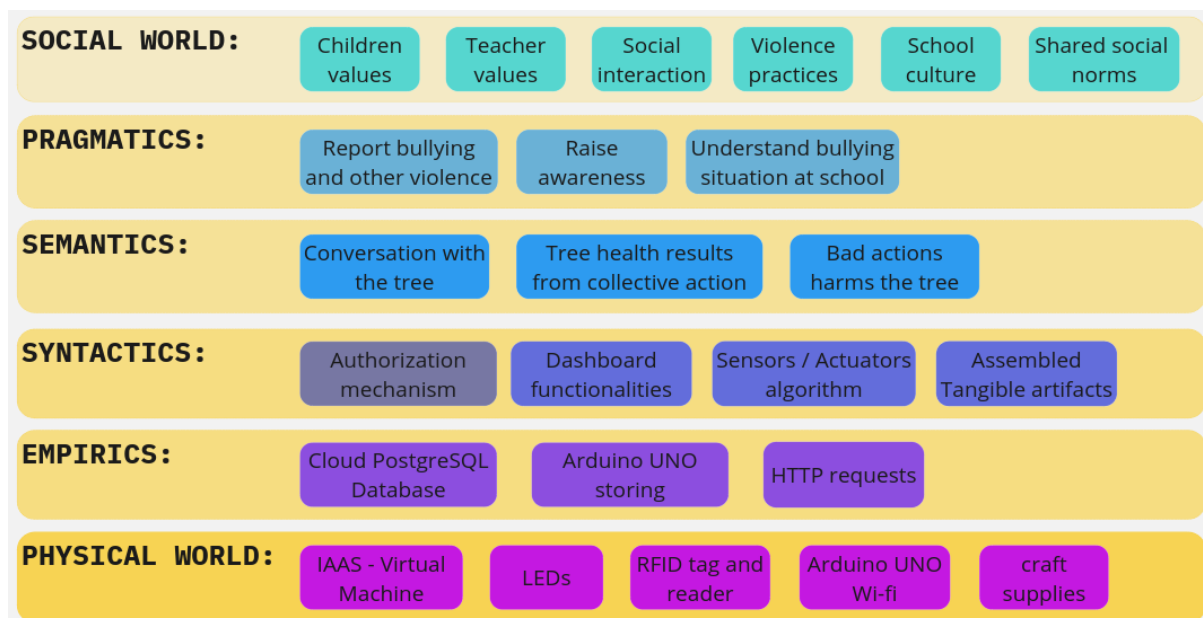

Figure 5. System Solution Architecture.

In Figure 5, the Social Layer represents social and human aspects that will influence and be present in the moment of the system's adoption and use, such as children and teacher values, their social interaction with each other, the school culture and violence practices that are present in their context, and shared social norms that will implicate in their moral and ethical thinking and action. The Pragmatics Layer represents stakeholders' purpose and intentions in using signs in communication and sense-making to report, understand and raise awareness about bullying. The Semantics Layer represents stakeholders' meaning-making about the signs in the context and solution, centered in a metaphor that communication with the tree and the status of good/bad actions in the school affects the tree's health. The Syntactics Layer represents how the signs are structured in the solution, its main features, and its communication. The Empirics Layer represents how signs and communication are conveyed and persisted in databases. Finally, the Physical

Infrastructure Layer represents the physical properties of signs and technical infrastructure demands, such as a Virtual Machine to run the application, physical and technological components such as LED, RFID, and Arduino, and other supplies for crafting all the elements of the physical scenario.

From this architecture, we developed a technical view of the scenario elaborated in Figure 4. Figure 6 presents the scenario where the elements are decomposed, and a flux of interaction is represented.
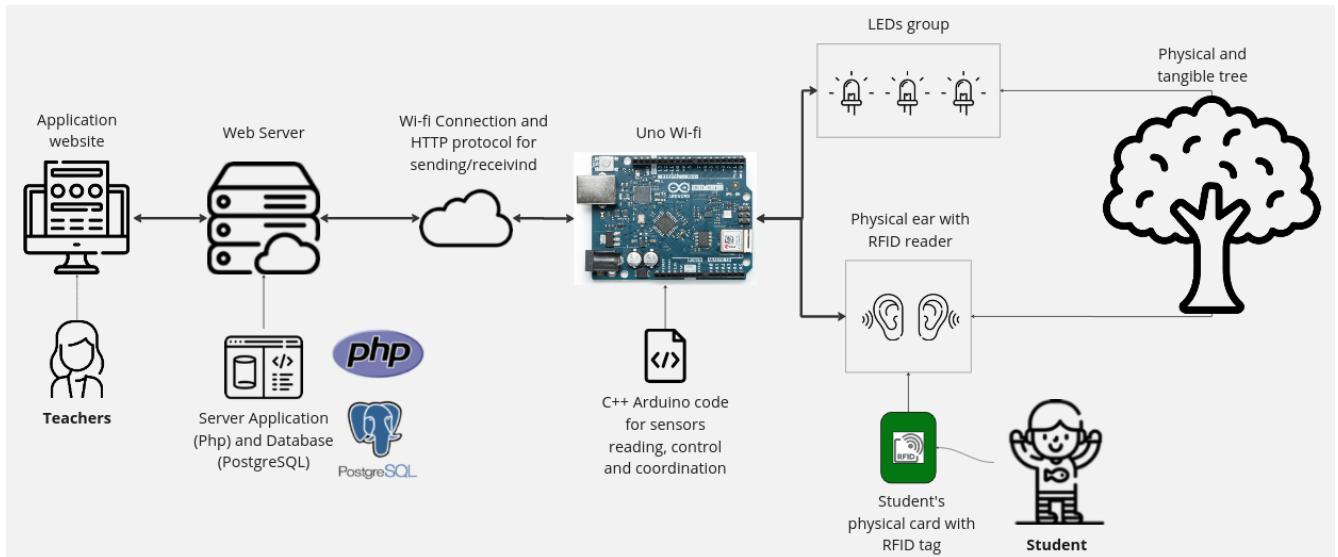

Figure 6. Technical scenario for the tree installation.

A tangible tree will have attached to it a group of LEDs and physical ears with an RFID reader. Suppose a student touches their physical cards with a unique RFID tag in the RFID reader. In that case, the student will be identified. This information will be stored in the Arduino UNO with Wi-fi protocol and transmitted to a Web Server database (PostgreSQL technology). This Web Server will also host an application (in Php programming language) for Teachers to consult who interacted with the tree, what are the types of the interaction (good actions or bullying), and quantitative information about the frequency of bullying for each student. Locally, the Arduino UNO controls the LEDs in the ambient depending on the card type and can collect and transmit audio if the child consents. A prototype of the physical interaction was implemented in the TinkerCad platform[5], which permits simulating circuits using Arduino, sensors, and actuators. In Figure 7, the circuit is presented. The circuit and the implemented code are available online[6] and are open to free sharing and adaptation.

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[5] Last access on 13/10/2023. Available at: <https://www.tinkercad.com/>
[6] Last access on 13/10/2023. Available at: <https://www.tinkercad.com/things/7z4fVTShvci>
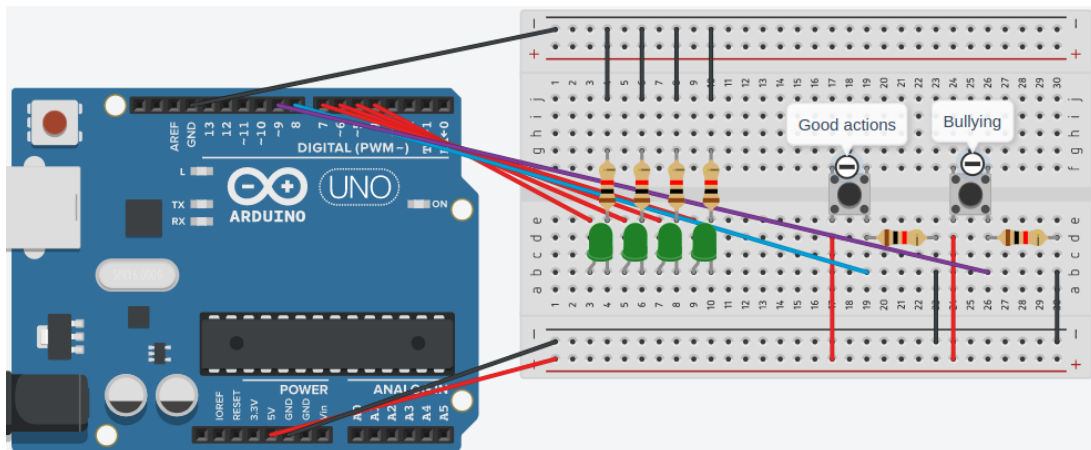
Figure 7. Simulation of technical feasibility of the logical connections between technical elements and digital code for the tree ubiquitous installation.

In the circuit of Figure 7, an Arduino UNO board and a protoboard are used to connect LEDs and two buttons and power the connections with energy. The button on the left represents the left ear of the tree where students will report good actions, and the button on the right represents the bullying report action. A LED will be turned on or off each time the button is pressed. The 4 LEDs are green to represent the tree's leaves. When turning on/off a LED, resistors (1 kΩ) are used to prevent excess current that can burn out the LED. Components such as microphones, RFID cards, and readers will be added to the technical configuration in a complete implementation.

5. Discussion

This design process started from a comprehensive understanding of the context of the problem, the people, and their values. In the future steps of this study, the synthesis of the context of the problem and the idea of the prospective solution will be taken for discussion and co-design with people from the context (experts, educators) and their values before actually implementing any technological apparatus in a real context.

This section presents our discussion about artifacts and techniques used, identified values and their influence in ubiquitous development, and a final discussion about moving from ubiquitous computing to socioenactive systems.

5.1 Design Artifacts and Techniques

Our design process was conducted in a Socially Aware and Value Oriented way. One of the fundamental elements of Socially Aware Design is "artifacts and systems" to mediate the (inter)action between people and a co-design process with them [9]. In this study, culturally and value-oriented artifacts enabled us to identify and represent different stakeholder values at various stages of the design process. Values-oriented artifacts are needed so that values are not forgotten and to make explicit how and which values are being progressively imbued in the development process.

From the perspective of ubiquitous computing, the scenario described ubiquitous functionalities for the solution where the technology becomes perceptually invisible, is present in the environment, and uses different and natural forms of interaction. Designers who need to fully understand the concept of ubiquitous computing can find it challenging to

understand which aspects should be represented or exploited in a scenario for a ubiquitous solution.

The high-level value-oriented requirements for the general fight against violence [14] have been translated into scenarios, functional and non-functional requirements, system architecture, and prototypes. The requirements specification represents how high-level requirements will be fulfilled. The challenge was how to detail value-oriented and high-level requirements in technical terms and in a form of representation that allows people to detail how that value will be respected or communicated. In our experience, we used the Brainwriting technique and the CARF artifact to enable us to develop the application technically. However, this detailing of value to requirements, the value representation, and tracking in more technical steps of the process was challenging. Considering our experience, we can point out opportunities to develop new artifacts to support design activities, such as value-oriented prototyping and architecture modeling.

Another difficulty was understanding whether the proposed solution is aligned and really informed with the sense-making about values created by the people involved in the design situation. This difficulty is an opportunity for developing artifacts to support designers to investigate and evaluate if the solution is coherent with the value-oriented design process.

Thus, we indicate a research opportunity to develop design artifacts to allow different stakeholders to make their participatory sensemaking [9] about human values in more formal and technical design stages, agreeing with the literature that indicates this challenge [30]. In the context of Ubiquitous Computing, this needs to make human values explicit and traceable is even more vital since the field has developed with a focus on more technical issues and lost sight of the deep motivations behind ubiquitous Computing, such as supporting human interpersonal interactions and relationships [37].

5.2 Influence of Values

In our design process, stakeholders' values were the starting point for a feature to be specified in the first place. In this sense, value has an existential relationship with the functionalities of technology, in the sense that without thinking about someone's value, a technological feature could not even exist. In the early stages of the value-oriented design process, stakeholders' values will drive the identification of functional and non-functional requirements. The CARF artifact [29] allowed a technological feature to be created from a value-of-someone.

In ubiquitous computing, technology has a more profound impact on people's lives by being present in the physical environment, promoting a continuous collection of contextual information, and being coupled in people's perception-action cycle collectively with the materials of their context. This deep insertion of technology in peoples' lives and physical spaces of living requires understanding the impacts of technology on society and how it shapes people's relationships with each other and with technology itself. Thus, the ubiquitous context demands the need to understand and track the people's values in the context holistically in the technology lifecycle, going beyond its development and evaluation. Table 7 below prospects different non-exhaustive ways in which values can influence technology in a ubiquitous context and examples of this influence of values in the ubiquitous installation proposed in this study.

Table 7. Influence of values in a design process for developing a technology.

How values influence technology?	Description	Example in proposed ubiquitous solution
Existential influence: creation of technology itself and its features	A value can influence a ubiquitous technology's creation (or non-creation) and features. Examples of value representation: features (functional requirements) and user stories.	Children's and Teachers' values of "Feeling safe and protected" was the starting point for our technology proposal creation. The solution is intended to help the safety and feeling of protection of school people.
Characteristics	A value can influence the definition and creation of characteristics of a ubiquitous technology, how it should look and behave, and restrictions on its existence and operation. Examples of value representation: ideal rules [30] and non-functional requirements.	The value of "Feeling accepted, safe and cared" impacted the creation of NFR03, which states that the tree (tangible technology) must have an appearance that is inviting and welcoming to students who wish to communicate, especially in cases when they could feel not accepted or listened to in school.
Rules and Norms	A value can bring normative definitions, in the sense of restrictions for ubiquitous technology, about what it should or should not do and the responsibilities and consequences of a particular normative rule. Examples of value representation: norms [24], non-functional requirements, and business rules.	Children's value of "Autonomy" impacted the creation of requirements NFR01 e NFR02 which state that the child controls whether she will interact with the solution and when a report will be made for teachers and parents. Both NFR01 and NFR02 represent a rule to be respected in the solution.
How things should be developed	A value can be considered in the design process of a ubiquitous technology. The value of openness, for example, influences the adoption of open-source technologies and collaborative programming. Other values that may influence the development process include teams of diverse gender, race, and culture and equal payment between people. Examples of representation: non-functional requirements and rules about the team formation.	In our project, our values influenced the choice of using ubiquitous technology to investigate new ways to help combat the violence of bullying in situated scenarios.
Use	A value can influence people's use of and relation with technology.	How people's values affect their relationship with the proposed solution in and after use will be investigated in future works. The literature already investigates values when using ubiquitous computing [21] and in post-usage and recycling IoT technologies [23].
Post-usage	A value can influence what people do with the technology after it has been used, for example, thinking about how people will dispose of or recycle a technology.	

Table 7 presents that a value influences the creation of technology itself, and its features, characteristics, rules, and norms influence how things should be developed, in use, and post-usage. In this way, values influence technologies beyond the existence or non-existence of technical functionality.

5.3 Towards Value-Oriented Socioenactive Systems

Ubiquitous and pervasive technologies enable new forms of interaction. In this work, we identified opportunities to support designers in a value-oriented design of ubiquitous solutions. The design possibilities were wide-ranging, without any direction or examples of how to explore these new forms of interaction to solve the problem. There were difficulties in understanding what should be done to explore the possibilities of developing a ubiquitous solution and not exploring new ways to solve the problem that engage more natural characteristics of interaction and collectivity between people.

In this challenging context, socioenactive systems appear as a candidate to understand interaction in these new scenarios of ubiquitous and pervasive systems. Socioenactive systems is a theoretical and enactive informed approach to interaction centered on human experience in a physical and social environment and views the relation of human-technology as the couplings between social, physical, and digital elements of a situated context [10]. Because it views a social aspect of human values, culture, experience, and interaction in a socially constructed world [10], the socioenactive systems already recognize human values as a constituent of embodied humans in social interactions. Thus, the socioenactive system is a relevant scenario to investigate what role and how human values could transform the ways ubiquitous technologies are developed.

Based on the consolidated scenarios (Figures 5-6) and advancing on the development of the solution, we mapped the socioenactive tripartite relation (see Baranauskas et al. [8, 10]): social, physical, and digital aspects of the ubiquitous solution. These aspects can then be mapped into a conceptual model or architecture for effectively implementing the ubiquitous solution and a socioenactive system.

Table 8 below presents the mapping of dimensions engaged in the ubiquitous solution. Each column presents aspects of the solution, classified as social, such as peoples' interaction; physical, which comprises physical elements of the solution and environment; and digital, comprising the digital aspects of the solution that will be implemented. In the social column, we explicitly specify the Children's (main stakeholder) values being communicated.

In the social aspect of our ubiquitous solution, we mapped social awareness about the problem and the need for research on bullying awareness, children's values and cultural context (study being conducted on Paraná state), and perspectives of the type of experience that we are projecting, such as sharing emotions, promoting awareness about bullying, and social metaphors to the ubiquitous interaction. In the physical aspect, we mapped the elements of the situated context, such as the school space, embodied people, and materials of the ubiquitous solution, such as the cardboard and craftwork objects, LEDs, microphones, microcontrollers, tangible cards, and RFID sensors. Finally, in the digital aspect, we mapped the solution processing and storing aspects such as source code that controls the system behavior, servers, software libraries, databases, and a web program to notify teachers.

Table 8. Social, Physical and Digital dimensions of the Ubiquitous Solution.

	Social	Physical	Digital
Children's Values Conversation about difficult themes Defense, Protection Trust, Attention and care Freedom from violence, feeling safe and protected Feeling accepted, validated Empathy, Love, and Affection Justice for myself and my friends	Understand and justify a solution development on children and teacher values about the problem of bullying in schools. Sharing emotionally relevant situations. Bullying is a relevant issue that affects many children and teachers in a cycle of violence. Awareness about violence. Being able to report bullying. Students' social context tree (e.g., if Paraná-Brazil, use local trees such as Araucária tree) Trees could be inserted in a "garden": a room could be decorated with more items, such as drawings and paintings, built by the students. A tree could have a bird that lives in it; when the tree is not healthy, the bird goes away and is silent.	Tangible tree (cardboard, wire, etc.). Green LEDs (for leaves). RGB LEDs (for flowers). Microphone to collect audio. Arduino or Raspberry with WiFi module. RFID, RFID Reader. Red and Green Tangible Cards (cardboard, RFID sensor). School space to install the tree and its objects (books, chalkboards, tables, chairs, etc.). People's bodies and their interaction in the context.	Code in C/C++. Web server to receive information. Libraries for software operation of sensors and actuators. A coded program that collects inputs (RFID, audio). Database storage of the number of positive and negative reports and captured audio. A coded program that processes information and generates tree behavior (turning off and on LEDs) and notifications. Web program that shows bullying notification to teachers (with the info of which student reported bullying).

We created Figure 8, which represents the coupling between the various elements of the ubiquitous solution: Social-Physical-Digital tripartite of a socioenactive system [8, 10].
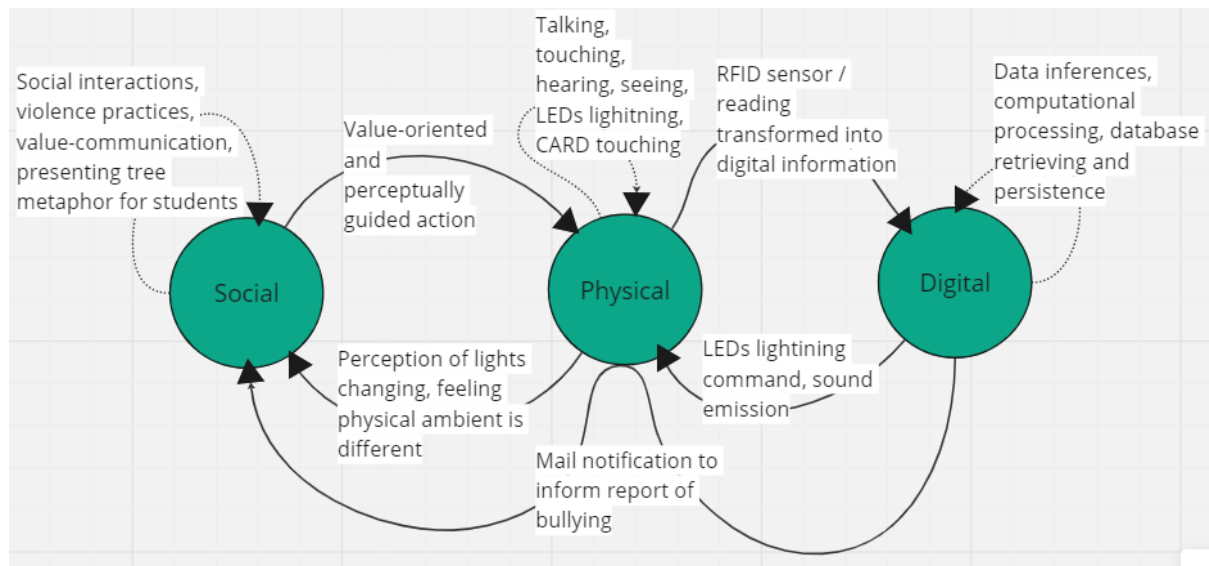

Figure 8. Social, Physical and Digital aspects of the technological solution. Model adapted from Baranauskas et al. [8, 10]

Next, we present a discussion about each aspect of this tripartite coupling. This discussion is an exercise of viewing aspects separately, but in practice, all aspects are coupled and can not be separated.

Social. In the social aspect, peoples' social interactions are mediated by their values and culture in a social context [10]. In our scenario, students, families, teachers, and school staff, with their joint action and joint coordination, create and exchange values and meanings related to their shared experience in a situated context. In the social-physical coupling, embodied people interact socially with materials and other bodies. People's collective experience with their bodies relates to their joint perception, action, and value-making with others and the environment to construct and communicate their meanings and values. In our scenario, embodied students will together communicate their values and perceive the physical characteristics of the school environment where the solutions are integrated.

Physical. In the physical aspect are interactions and changes that occur in an environment, their embodied (and physical) people, materials, objects, and things [10]. In our scenario, embodied people will interact with each other and the physical environment by seeing, talking, hearing, touching, and feeling, such as touching their cards and the tangible tree. In physical-social coupling, environmental changes promote changes in people's perceptions, valuing processes, and actions. In our scenario, people will perceive light change and sound emissions that will affect the construction of their shared meaning, enacting their values related to violence and security. Finally, the physical-digital coupling represents sensing the physical environment that acts in the digital, for example, when storing data about physical ambient (light, temperature, localization, pressure, etc.). In our scenario, RFID sensors will create digital data about a student who made a report and information about a LED (on or off).

Digital. In the digital aspect are processing, functions, and control of technology and its features [10]. In our scenario, a server will enable sensor operation, capture and store

valid information, and process commands to control the solution behavior. The digital-physical coupling represents actuators controlled by processing that will change the physical environment, such as LEDs and a sound speaker. The digital relates to the social through the physical, that mediates this relation in the physical world. Thus, the digital-physical-social coupling refers to the interactive digital web application that will notify teachers whenever a student makes a bullying report. The application will also inform teachers about bullying cases, their frequency, and statistical data.

In practice, the social-physical-digital tripartite is coupled and embodied students and teachers will enact their values with others through social interactions in a technology-enhanced environment. People's joint attention, joint meaning-making, and joint action [10] will affect the physical situation where technological artifacts capture contextual information and promote changes, affecting what people perceive, value, and how they will act with others and with the environment.

6. Conclusion

In this study, we developed a ubiquitous solution to raise awareness about bullying in schools with 6-10 years old students. The solution uses a "healthy tree" social metaphor to stimulate social awareness about the collective situation of bullying in a school. The students' collective actions of good action or actions of bullying affect a tangible tree "health" represented with LEDs. The solution was developed through a socially aware and value-oriented approach, from problem understanding, identifying stakeholders and their values, and ideating the ubiquitous solution using brainwriting, scenarios, CARF artifact, and system architecture using the Semiotic Framework. The socioenactive approach to interaction [10] enabled us to understand and project the relationship human-technology in a ubiquitous computing context through the social-physical-digital tripartite.

The ubiquitous installation can act directly on the school's physical environment, formed by people and their interactions and loaded with norms, values, and culture of people in their social interaction. The ubiquitous solution designed in this study intends to reflect the school's state of violence through a technologically implemented metaphor, changing the environment itself and the children's perception, stimulating a reflection on the quality of the socio-physical environments they live in and their interactions.

One possibility ubiquitous computing brings is to collect information and act on a phenomenon of reality from wearables, sensors, and actuators working in conjunction with people and the physical environment. Ubiquitous computing allows understanding a phenomenon from new perspectives and creating different forms of interaction with people in their living environments. Not every ubiquitous solution needs to explore all these possibilities. However, these less-explored forms of interaction open up new ways to constitute a socioenactive interaction and contribute to people being able to build meaning and work together to solve their challenges collaboratively. At this point, the socioenactive approach is a guide for us to understand the interaction that occurs in a ubiquitous scenario and can offer lenses and guiding questions for us to be able to explore, model, implement and evaluate the collective interaction of people and its coupling with ubiquitous technology and the physical environment in which the interaction takes place.

In this socioenactive scenario, values are one important human aspect that constitutes the social aspect of the socioenactive tripartite. Literature demands more human-centered computing [3], with a focus on the human [37] and understanding system

design as a social phenomenon [6, 7, 9]. Thus, to create this type of computing, we must recognize one of our foremost human aspects: our values. As a human activity, technology development is loaded with values, dilemmas, and decisions informed by these values. Working with values is a way of making this human aspect explicit so that people can dialogue and talk in a participatory way about what they want for themselves, technology, and the world.

We point to an opportunity to develop a value-oriented approach specific to socioenactive interaction and ubiquitous computing, seeking to bring elements of ubiquity explicitly and understanding the coupling between environment, technology, and values of embodied people interacting socially. Even though existing value-oriented methodologies, used in the context of desktop and mobile computing, support a design team in developing ubiquitous technologies, it does so to some extent. If we want to consider all relevant aspects of socioenactive interaction, especially those that indistinguishably constitute ubiquitous computing, we must use artifacts designed and modified for this context.

Subsequent work involves co-designing with interested parties in the design situation the proposed solution in a semio-participatory workshop [9], the effective solution implementation, and understanding how people experience this technology in their situated context. The couplings between elements of a socioenactive system could be investigated to characterize how they happen in practice and peoples' experiences in a ubiquitous scenario.

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