Digital Art, Sustainability and Design Thinking: Study of a Case in Higher Education

Sara Cruz[1,], *Célia* Vieira[2], and *José* Bidarra[3]

[1]Department of Communication Sciences and Information Technologies, Universidade da Maia, Maia, Portugal
[2]Department of Communication Sciences and Information Technologies, Universidade da Maia, Maia, Portugal
[3]Department of Education and Distance Learning, Universidade Aberta, Lisboa, Portugal

Abstract. After a brief overview on the relationship between art and sustainability, in this paper we present a practical case that illustrates the potential of using design thinking in raising awareness towards environmental sustainability in the context of Higher Education. We describe the phases in the application of design thinking by a group of students, and evaluate the impact of this procedure on their vision regarding the relationship between art and nature, and their motivation to find artistic solutions with an impact on society.

1 Introduction

When we have scientific evidence and public statements that warn us of an imminent sixth mass extinction [1] the only reliable path is to act, to take concrete steps, even though small, towards a far-reaching transformation.

There is a social responsibility to defend the general welfare, which makes us, teachers, researchers and artists, take a critical and participative look at the environmental degradation caused by industrialization. At the same time, we realize that young people play a pivotal role in promoting sustainability, not only because they will face severe environmental impacts, but also, and above all, because they are a source of new ideas and alternative actions to solve global environmental problems. In this sense, challenges regarding education increase, encouraging innovation and the search for solutions to environmental problems [2]. Therefore, this study aims to describe a creative process of designing, developing and building a digital media artifact about sustainability, using the Design Thinking (DT) methodology. Through a practical case study, it seeks to reflect on the potential of the use of DT in raising awareness of environmental sustainability in the context of Higher Education.

2 Art and sustainability

The term 'sustainability' has been slowly introduced into artistic terminology, and has generated, over the last two decades, discourses and practices that explore the interaction of social and ecological critique with contemporary art [3]. Considering that the concept of sustainable art is wider than the ecological and environmental premise, as the concept of sustainability itself operates in all spheres of the individual's actions that have consequences in reducing the destruction of the planet, the works and artists who intentionally or unintentionally approach this trend cover a wide spectrum of interventions. According to Kagan [4], artistic actions that seek to highlight the connection between Man and Landscape appeared mainly in the 1960s, as is the case of the works included in the Land Art movement. Later on, an activist intention would mark the passage of Land Art to the broader plan of Ecological Art, which assumed a more ambitious aesthetic strategy regarding Nature-Mankind interrelation in its creations [4]. From Land Art to Ecological Art, to Sustainable Art, there would be a progressive awareness of environmental problems and, consequently, a widening of the spectrum and actions of the art born from an environmental concern.

The link between art and sustainability has been developed from the beginning in educational fields, mainly through exhibition activism, but also through the visual composition and realization of installations that aim to connect with wider audiences at different levels [5]. By combining specific goals, such as ecosystem protection and ecological sustainability in the fight against climate change, with the aesthetic and visual structure provided by art, the creative process contributes to raising awareness about the extinction of life forms. The "reinvention" of nature in art legitimizes the struggle for a sustainable planet, while at the same time reinforcing and legitimizing new models of artistic investigation.

Over the last two decades, one observes the inclusion of a cultural dimension in the discourses on sustainability [3]. Considering that the fields of sustainable culture include the defence of cultural diversity and the preservation of minority cultures, the maintenance of cultural heritages and practices, the

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* Corresponding author: scruz@umaia.pt

cultural activism and the strengthening of the role of creativity and arts in societal integration, the questions that arise are the following [6]: how does art contribute to an awareness that leads individuals towards sustainable ways of living and organization? How can the artist be considered an agent of sustainability?

Over the last four decades, complex sustainability challenges have been addressed through scientific problem analysis and subsequent decision-making. Recently, this practice has been exposed to several criticisms that point out flaws and a lack of success [7]. In this sense, art occupies an intellectual, creative and social space, capable of offering promising approaches to address some issues concerning sustainability [7]. This way, art becomes a medium of vast interest for the sustainable development field, mainly because it allows cross-cutting forms of approach, susceptible to touch emotions, and it can also lead to new worldviews.

One of the challenges that arise when introducing new digital media arts is to understand how new media can enhance this awareness. The characteristics of new media, such as immersion, participation, instantaneity, ubiquity or intermediality, can be assets in creative processes that have sustainability as a goal. For example, the shift from individual authorship to collaborative creation can take a variety of forms, from public input into artist-created systems to the collaborative creation of the system underlying artwork [8]. This decentralization, which can take place both in authorship and in the raw material of art itself, increases the creative potential of artistic realization as it takes place in multiple fields of knowledge, while also enabling the creation of new environmental awareness among new generations and inspiring actions with a global impact.

3 Methodology

This study is based on the development of a digital artifact, designed for an art exhibition, and highlighting the relationship between art, technology and sustainability. For the creation of the artifact, the Project-Based Research methodology was used [9]. In a second phase of the study, data was gathered after submitting the project to a collective reformulation using the design thinking methodology in the classroom. At the end of the sessions, a questionnaire was applied to find out whether the group's awareness had been enhanced through the creative process.

3.1. Creation of the digital artifact

In a first phase, there was a process of creation of the digital artifact concept, which sought to explore the interaction between digital art and sustainability. The main goal of the work to be created would be to transmit the beauty of nature and encourage its preservation through the recovery and revisitation of sustainable practices, through an immersive experience, combining sound and visual stimuli in a virtual environment. The main purpose of the research was to understand how the interaction between these artistic elements can influence

the emotions and perception of observers for a deeper understanding of the complex interactions between humans and the environment, as well as a broader understanding of environmental issues in general.

The development of this artifact was rooted in the Project-Based Research methodology [9], approache that place the production of an artistic object and its interpretation in a dynamic relationship about the purpose, process and meaning of the development of that work or project. Practice-based research in creative arts, including new media arts, focuses mainly on the access to knowledge through the creative process itself. In this context, the artifact itself plays a pivotal role in shaping and deepening our understanding of artistic practice. The creative process and the act of making art are not isolated endeavors but rather integral components of the research methodology. By actively engaging in the creative process, artists gain valuable insights, and their works become manifestations of their explorations and discoveries. As artists delve into their creative practice, they generate new knowledge and perspectives that contribute to the broader discourse in the field. The artworks themselves serve as tangible outcomes of this process, encapsulating the artist's ideas, concepts, and expressions. These artifacts, whether physical or digital, play a vital role in communicating and conveying the newfound understandings about artistic practice [9].

It implied a long process of meditation, questioning and interpretation, in a very close relationship between the artists and the artifact. Furthermore, it involved the act of converting the idea into a set of sketches and informal drawings. In this case, the creative process culminated in an installation entitled "Afastar e Aproximar (Zoom In and Zoom Out)", which was part of a digital art creation process, with the characteristics described below.
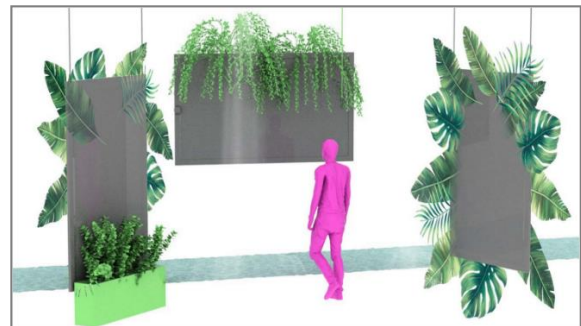

Fig. 1. 3D representation of the concept of the digital artifact «Afastar e Aproximar».

Upon entering the installation, the viewer is presented with a touchscreen LCD that provides instructions and guidance on how to interact with the work. The touchscreen allows for a tactile and interactive experience, stimulating the active participation of the observer. The exhibition room (figure 1) has three monitors positioned to surround the visitor. Each monitor displays different visual and sound elements related to nature. In the room there are sensors to detect the presence and movement of the observer. When the observer approaches one of the side monitors,

a new visual and sound element is triggered, creating a zoom in or zoom out effect on the image. This allows the observer to explore and amplify the emotions transmitted by the work. The exhibition room was designed to allow only one person at a time, which ensures that the observer has an individual and immersive experience, without distractions or external interferences. To enrich the sensory experience, natural elements were incorporated. The sound of water and the smell of aromatic plants are introduced into the room, creating an enveloping atmosphere and stimulating the observer's senses.

The intention was to create an audiovisual environment that is coherent and appealing to the observer and where the movement and the body occupy a central place, exploring several contemporary dichotomies, as the real *versus* the virtual, the digital *versus* the analogue, and the natural *versus* the artificial. The appearance of new visual and sound elements through an amplification effect plays a relevant role and an opportunity for observers to create new narratives from the past in order to (re)modulate the future, evoking and awakening feelings and emotions with a power to influence their way of feeling, thinking and acting.

Subsequently, by workshop dynamics using the design thinking methodology, a group of participants was invited to carry out a collective reformulation of the digital artifact "Afastar e Aproximar". The workshop was structured to encourage the active and collaborative participation of the participants, seeking to explore new perspectives and ideas to improve the existing artifact, aiming to awaken a new environmental awareness and inspire actions that promote a more sustainable future.

3.2. Collective redesign of the artifact, using the design thinking methodology

DT is an innovative, creative and human-centered methodology that employs collaborative multidisciplinary teams to help identify problems, understand user needs, create innovative solutions and test them quickly [10].

Currently, DT is taught at leading universities around the world [11,12] and is a part of programs in business [13], engineering [14], technology [15] and, more recently, education [11-14, 16-18] due to its ability to promote creativity and innovation by applying an empathic, flexible and interactive approach, especially in the way it approaches problem-solving [10-19].

Teachers who have applied DT in education have argued that it promotes innovation, problem-solving, creativity and collaboration, and, as a constructivist learning strategy [16-19], it allows students to develop and believe in the intrinsic creativity of each human being. With the purpose of transforming challenges into opportunities, it proposes a change of mental models, where change involves not so much knowing an answer, but how to ask questions that allow for an approach and a new look at the problem to be dealt with [10-19].

What differentiates DT from other approaches is that it focuses essentially on the process, rather than the product, and, as a creative process, it follows a human-centered mindset, which advocates positivity and eliminates the fear of failure, maximizing the contribution and participation of the ones involved, which is an asset for education [11-19]. In Higher Education Institutions (HEIs), the practice of the design thinking methodology should then be applied, through proposals that challenge students to solve problems, through a participatory process.

According to the model brought about by IDEO [19], on which this study is based, DT involves 5 phases, which will be further explained: discovery, interpretation, ideation, experimentation and evolution. This model is the most suitable for simplifying the task of designing and executing educational projects.

Our objective in applying the design thinking methodology was to understand how this process of collective reflection could stimulate the acquisition of competences. Specifically, by proposing to a group of students the reformulation of the artifact "Afastar e Aproximar", we aimed to understand how the dynamics of DT lead to a change in attitudes, making this group actively aware of sustainability issues.

3.2.1 Target Group

For this case study, we chose a 1st year class of the Multimedia Art program of a university in the north of Portugal. The fact of being university students was a guarantee that they had the necessary maturity to exercise a critical sense. Moreover, being students of Arts mean a commitment to a public more at ease with the construction of artistic proposals. The study involved a total of 16 students, including 3 students of foreign nationality. The themes of the sessions were articulated with the objectives of the curricular unit "Aesthetics and Art History II", providing a differentiated didactic approach to artivism and eco-art.

The workshop was divided into two sessions of three hours each, following three fundamental practices: (1) formation of random teams composed of 4 to 5 members, to deal with a challenge common to all; (2) creation of a dedicated project space in the classroom, where all discussions, analyses and constructions were visually displayed; and (3) establishment of time periods for each phase of the process, in order to encourage focus and motivation from the participants.

3.2.2 Workshop Space and Materials

For the workshop, the educational agents provided various materials and created a physical environment enabling creativity. The classroom was prepared with three large white walls, a whiteboard and a video projector with device support. In addition, laptops and a flip chart were provided for notes and discussions. To stimulate creativity, a variety of drawing tools were available, such as large sheets of white paper, cardboard, colored pencils, colored post-its of different sizes, double-sided tape, scissors, rulers, squares, stickers,

miniature lego blocks, fluorescent markers and various objects.

3.2.3 An Icebreaker Activity

In order to promote a welcoming, positive, and creativity-stimulating environment, we carried out an icebreaker activity called "The Marshmallow Challenge", created by Peter Skilman [20]. Participants were randomly divided into groups of 4 to 5 students, who were given 20 minutes to build the tallest tower possible using only the materials provided: 1 meter of duct tape, 1 meter of yarn, and 20 strands of spaghetti. The challenge ended with placing a marshmallow on top of the tower (figure 2). This initial activity allowed the participants to become familiar with each other, stimulate teamwork, and exercise their creativity in problem-solving.
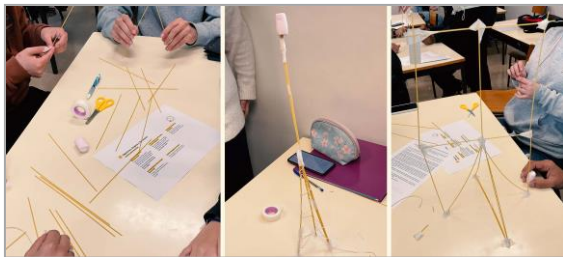

Fig. 2. A team-building activity: "The Marshmallow Challenge".

Next, the objectives and agenda of the workshop were presented to the participants. To provide a comprehensive understanding of the DT mindset and methodology, all phases of the process were explored in a presentation that emphasized visual communication and design (figure 3). This allowed participants to familiarize themselves with the key concepts and steps of design thinking, preparing them for the practical work that would follow.

Fig. 3. Introduction to design thinking: principles, mindset, process and phases.

3.2.4 Application of the design thinking methodology in the context of the digital artifact "Afastar e Aproximar"

After the presentation, we started the application of the design thinking methodology, composed of five phases, planned in the IDEO model, in the context of the digital artifact "Afastar e Aproximar", with the objective of improving its conception and execution.

Discovery: workshop participants were encouraged to immerse themselves in understanding the problem and explore the wider context in which the artifact is embedded. This phase included preliminary immersion, which aimed to provide an initial understanding of the problem and contextualize it. To this end, works on sustainability were explored. Printed cards were presented, containing images taken from short videos, accompanied by QR codes that allowed the videos to be viewed on the students' smartphones. This approach facilitated quick consultation and manipulation of the information (figure 4). At this phase, it was important for participants to adopt an empathetic approach, seeking to understand the emotions and perceptions of observers in the face of the proposed artistic interactions. Participants worked in groups and recorded information on insight cards, covering relevant topics. They then participated in group discussions where they could share their perspectives, insights and knowledge about art and sustainability. These discussions were moderated by a facilitator and contributed to building a collective understanding of the problem and context.

Fig. 4. Gather inspiration session.

In this phase of discovery, it was possible to identify guiding principles for the project, which were divided into two main topics:
(1) Points that they considered relevant in the conceptual and technical creation of the work:
• the interaction of the observer with the installation environment and how his behavior completes the work;
• the visual and sound perception, through video and audio support;
• the fact that it has an "artistic soul" and is able to transmit and provoke different kinds of sensations and emotions;
• the appeal to the conscience of human action in environmental issues;
• the story (digital narrative) that transports the observer to another reality, by exploring dichotomies between the real and the digital;
• the use of sustainable natural materials, such as earth, water, leaves or branches, to create the artwork.
(2) Less positive points in terms of project viability:
• the relationship is one to one, so there cannot be more than one person in the scenic space;
• the artifact has no "seduction" mechanisms that invite dialogue and interaction;
• the interaction between the artifact and the observer is not user-friendly;
• its an equipment whose cost is excessive, considering the intended budget;

• the equipment may interfere with other installations present in the same space (sounds, sensors);
• there are difficulties arising from the construction and transportation of physical elements of the installation.

Interpretation: based on the information gathered in the discovery phase, the participants performed an analysis and interpretation of the data. This was followed by in-depth reflexion, which aimed to identify the needs and opportunities of the potential users of the work, guiding the creation of solutions. To understand the universe of potential users in a more empathetic way, each group was encouraged to collaboratively fill out the profile of a fictional character. This humanized approach allowed to trace a detailed profile of the potential users of the artifact, taking into account their interests, personality, dreams, social life and motivations. The groups were asked to write "3 reasons why I should interact with the work 'Afastar e Aproximar" and "3 reasons why I should not interact with the work ' Afastar e Aproximar", highlighting relevant characteristics, feelings and behaviors. Each team member wrote their ideas on post-its, which were then organized and regrouped as required. The creation of the fictional characters provided a 'real' representation of these users, making it easier to understand their motivations (figure 5). These insights were key to the further development of the project, guiding towards the solutions to be designed.
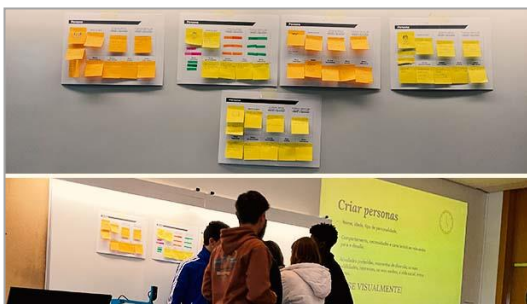

Fig. 5. Create *persona* session to define insights.

Fig. 6. Brainstorming session to develop innovative solution.

Ideation: the ideation phase involved generating creative and innovative ideas for the "Afastar e Aproximar" artifact. Participants were encouraged to think "outside the box" and explore different possibilities. Through brainstorming sessions, they generated a variety of concepts that integrated artistic elements (figure 6). This phase aimed to broaden the options and foster the group's creativity.

Experimentation: each group developed several physical prototypes of the digital artifact "Afastar e Aproximar". This phase allowed participants to explore and test different approaches and tangible solutions to the project. Using a variety of materials including lego blocks, cardboard and scenery paper, each prototype was built with the aim of visualizing and experimenting with the proposed functionalities and interactions in the context of the work. Participants were able to interact and test the prototypes, observing how the sound and visual elements combined, how the audience could interact with them and how the overall experience was affected. This physical experimentation approach allowed for greater engagement and understanding of the challenges and possibilities of the artifact, as well as for facilitating the identification of necessary improvements and adjustments. Through the feedback and observations of the participants during the interaction with the prototypes, it was possible to refine and improve the design of the digital artifact, making it more suitable to the expectations and needs of the target audience. This phase of physical experimentation was fundamental to validate and redefine the ideas, ensuring that the final result of the project was consistent with the established objectives and capable of providing an immersive and impactful experience for the observers (figure 7).

Fig. 7. Prototype session to refine requirements and explore design solutions.

Evolution: in the evolution phase, a pitch session was held to present the developed prototype. At this phase, participants had the opportunity to share their ideas and solutions in a concise and persuasive way, seeking to convey the essence of the digital artifact "Afastar e Aproximar" and its potential impact on raising awareness of environmental sustainability. The pitch was structured to highlight the key points of the prototype, such as its functionality, aesthetic appeal, interaction with the public and the value it can offer to the experience of observers. The presentation was held for an audience composed of colleagues and professors involved in the workshop, allowing the exchange of feedback and improvement of the prototype before its final implementation (figure 8).
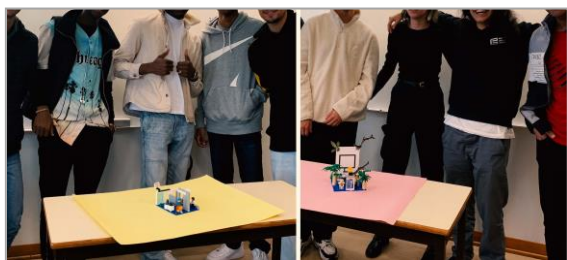
Fig. 8. Presentation of innovative solutions based on a five-step process.

3.3. Revision of the artifact, resulting from the application of DTs (criticisms and proposals)

To recap, we submitted the artifact "Afastar e Aproximar" to a design thinking methodology, not only with the purpose of enriching this artistic proposal, but mainly to assess how the participants in the design thinking sessions developed their own critical thinking regarding the sustainability issue.

During the process, we also understood that this kind of artifact, in which art, technology and sustainability converge, has its own requirements.

We understand that the work should not only attract attention, but also actively invite visitors to participate, intervene and reflect about their own role in the artwork. This specificity of the works in digital media art leads to a new perception of the visitor, whose action is no longer only contemplation, but also intervention, collaboration or participation.

We will now describe the suggestions applied in the prototypes and the way they impose a revision of the proposed artifact.

One of the aspects highlighted was the need to create a scenic space designed to engage participants through multisensory experiences that awaken the senses and promote a deep connection with nature. The aim is to provide complete immersion through sensorial stimuli, enabling a holistic and transformative experience.

Among the main features proposed, we highlight:
• the creation of a charcoal wall covered with red LED lights, suggesting fire. This simultaneously visual and tactile representation refers to nature's energy and vitality;
• the installation of a padded floor where participants will be invited to walk barefoot, providing a sense of comfort and relaxation;
• the use of headphones to listen to sounds, such as birdsong, the murmur of a stream or the sound of leaves being blown by the wind. This feature will create an immersive listening experience, transporting visitors to natural environments and reinforcing the emotional connection with nature;
• the creation of a memory wall, where participants could leave their memories, thoughts or reflections through text, paintings, or any other form of artistic expression. This strategy would stimulate interaction, allowing people to share their experiences and create a sense of community and connection;

• the provision of seasonal fruits in the space, which participants can taste, promoting an appreciation of natural and seasonal foods;
• the creation of a mechanism that releases aromas, such as the scent of flowers, leaves, sea or wet earth, by pressing buttons, which stimulate an olfactory connection with nature and stimulate memories associated with different natural environments;
• the placement of the artifact in a box that physically delimits the experience so that there is no interaction with other external elements and where immersion is enhanced.

3.4. Implementation of the survey

At the end of the workshop, the participants received an anonymous questionnaire with the aim of assessing how the application of the DT methodology contributed to the collective reformulation of the artifact "Afastar e Aproximar", resulting in a change of attitudes and leading the group to acquire an active awareness in relation to the sustainability theme. The results obtained below presented the same type of answers "Yes, "Maybe Yes", "Don't know", "Maybe Not" and "No":
• When asked if this was the first time, they had used the DT methodology in project development, 14 students answered "Yes" and 2 students answered "Maybe Yes".
• Regarding the importance of addressing environmental sustainability issues in the classroom, all students (16) responded affirmatively.
• Regarding the importance of using digital media art in the development of works related to sustainability, the vast majority (14 students) answered "Yes", with 1 student answering "Maybe Yes" and only 1 student answering "No".
• Regarding the contribution of DT methodology to the awareness of environmental sustainability, the majority (13 students) answered "Yes" and 3 students answered "Maybe Yes". No student answered "No".
• Next, when asked if teachers should use the DT methodology in the classroom, 11 students answered "Yes", 3 "Maybe Yes" and 2 "Don't know", and again no student answered "No".

Next, when asked to select 3 activities that they most enjoyed doing to help find solutions to (re)design the digital media artifact "Afastar e Aproximar", we can see that there is a clear preference for the creation of the "Prototype", which was the most chosen, with 16 references, followed by "Brainstorming", with 14, and the third, "Persona Creation", chosen by 9 students.

These results indicate that the participating students recognized the positive contribution of the DT methodology in the design, development and construction of a digital media art artifact in the context of sustainability. Moreover, they showed interest in using this methodology in their projects, emphasizing the importance of digital art in the development of works related to environmental sustainability.

Overall, the students perceived the DT methodology as a positive ally in teaching/learning, promoting teamwork, learning from mistakes and creative confidence.

Graphic. 1. Reasons for the use of the DT Methodology in the classroom and the use of art in raising awareness of environmental sustainability.
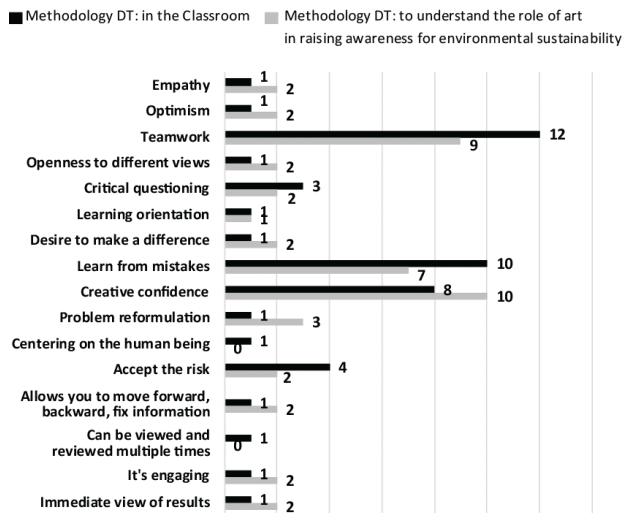

Looking at graphic 1, when asked about the top three advantages of using design thinking methodology, 12 students highlighted "Teamwork", 10 students highlighted "Learning from mistakes" and 8 students highlighted "Creative Confidence".

When asked about the top 3 advantages of using design thinking methodology to understand the role of art in raising awareness for environmental sustainability, 10 students mentioned "Creative confidence", 9 "Teamwork" and 7 "Learn from mistakes". The least mentioned advantages were "Learning orientation" (1 student) and "Centering on the human being", "Can be viewed and reviewed several times" (0 students).

These results indicate that students perceive the design thinking methodology as a collaborative approach, and that they value the opportunity to learn from mistakes and explore creativity.

In graphic 2, it can be seen that the degree of satisfaction with the workshop activities stands between "Satisfied" and "Very Satisfied" levels of satisfaction.
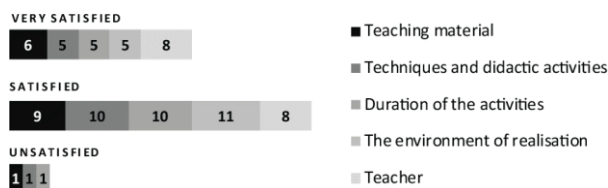
Graphic. 2. Satisfaction with the workshop activities.

Additionally, we wanted to get the participants' feedback on their experience. We asked «What should those who wish to participate in this workshop be prepared for?». The vast majority of the students answered the question and emphasized the following points: not being afraid to make mistakes; working hard; talking about others' ideas without judgement; accepting mistakes as solutions and not as failures; working in a team; going "outside the box"; and creating various ideas quickly.

Results and Discussion

Design thinking allows for the combination of different dimensions of thinking, namely intuitive, analytical, creative and imaginative thinking, as well as the development of sensitivity and expressiveness [10-19]. By applying this methodology, we were able to perceive that the digital artifact was improved and that this methodology applied to artistic creation helped designers/artists to discover new ways of solving unforeseen problems. Its relevance becomes even more evident when artistic objects that require a great interdisciplinary and call for the combination of different knowledge are at stake. At the same time, the results of the applied survey revealed that the collaborative creative process contributed to a reinforcement of environmental concerns but, above all, it motivated the participants to try to find solutions that could have an impact on the community, turning them into agents of that awareness.

Conclusions

The case study presented confirms the success of the application of the design thinking methodology in raising environmental awareness. We believe that the description of the phases of the process may be useful for the development of pedagogical and artistic practices that favor thinking about the balance between man and nature. Based on this study, we can conclude that a digital media art project can play a relevant role in raising awareness about environmental issues and exploring innovative interactions between humans and nature. According to the suggestions, one should think about how to make and show the artifact "Afastar e Aproximar". The project demonstrated a great potential to raise a new environmental awareness among new generations and inspire actions for the construction of a more sustainable future. Our future goal will be to extend the scope of the experiment to other groups in order to identify the limits and challenges of the application in other contexts

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