

HUMAN-CENTERED DESIGN FOR ENVIRONMENTAL EDUCATION: CO-CREATING PLAYFUL TOOLS TO ADDRESS TEXTILE WASTE IN CAMPANA-ALTAMIRA

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ABSTRACT

Fast-fashion textile waste has become an increasingly pressing environmental issue, particularly in vulnerable urban contexts where waste-management systems are limited. In the Campana Altamira Initiative in Monterrey (Mexico), textile residues constitute up to 40% of the waste found in the Arroyo Seco, a situation intensified by structural constraints, local consumption habits and deficiencies in municipal waste-collection infrastructure. Responding to this challenge, this study conducted by undergraduate design students at Tecnológico de Monterrey in Mexico presents the development and implementation of a Human Centred Design (HCD) strategy aimed at reducing the environmental impact of textile waste while promoting sustainable education among children through an interactive community-based product. The research employed ethnographic observations, user analysis and semi-structured interviews to examine the social and cultural dynamics of the community, with a particular focus on children and young people who participate in activities at the community hub “El Oasis”. These insights informed the design of a series of four educational workshops that combine principles of education for sustainable development, hands-on activities with recycled materials, and an interactive pedagogical set of games. The games were designed to support children’s cognitive, psychomotor, and socio-emotional development, introducing key concepts related to water conservation, waste management, and textile reuse through collaborative and play-based learning activities. This work details the students’ design process, highlighting how participatory methods and contextual research shaped the development of both the workshops and the interactive set of games.

Keywords: Higher education, innovative education, design for social impact, environmental education, Human-Centred Design

1 INTRODUCTION

Fast-fashion textile waste has become an increasingly pressing environmental issue. Since its rise, the textile industry and the waste it generates have become increasingly important. The textile industry pollutes the land and water, not only with the chemicals used in the garment manufacturing process but also with the amount of waste left behind after use [1]. This industry utilises enormous amounts of water, as it is responsible for the consumption of about 20% of industrial wastewater worldwide. [2] In addition, the short lifespan of fast fashion clothing and the lack of discarding and recycling policies leads to the formation of massive textile waste landfills, which can take decades to decompose [3]. Moreover, the excessive amount of textile waste and the lack of care when disposing of it often results in accumulation in nearby bodies of water due to pollution from runoff, particularly, this phenomenon is common in vulnerable urban contexts where waste-management systems and policies are limited.

In the Campana Altamira Initiative (CAI) in Monterrey, Mexico, textile residues constitute up to 40% of the waste found in the Arroyo Seco (Dry Creek), a situation intensified by structural constraints, poor policies, local consumption habits and deficiencies in municipal waste-collection infrastructure [4]. This initiative is a community-based effort among a territory of fourteen neighbourhoods that seeks to sustainably improve the quality of life for the residents of the area [5]. This social and economically marginalised community is located a few kilometres away from Tecnológico de Monterrey and they are both connected by the path of the Arroyo Seco (Dry Creek) but presenting a strong contrast between the

two territories. Most households in the area typically lack stable infrastructure and basic services such as electricity and running water. This area is home to around 19,543 residents, of which around 33.87% are minors [6]. Despite the great challenges that the inhabitants face, Campana-Altamira is an engaged and participatory community that is constantly seeking to improve their living conditions [7].

Responding to this textile waste collection challenge, this study conducted by undergraduate design students at Tecnológico de Monterrey in Mexico presents the development and implementation of a Human Centred Design (HCD) [8] strategy aimed at reducing the environmental impact of textile waste while promoting sustainable education among children through an interactive community-based product. The research employed ethnographic observations, user analysis and intercept interviews to examine the social and cultural dynamics of the community around water use practices and textile waste management, with a particular focus on children and young people who participate in activities at the community hub “El Oasis” [9]. These insights informed the design of a series of four educational workshops that combine principles of education for sustainable development, hands-on activities with recycled materials, and an interactive pedagogical set of games. The purpose of designing games was to support children’s cognitive, psychomotor and socio-emotional development, while introducing key concepts related to water conservation, waste management and textile reuse through collaborative and play-based learning activities. Using toys and play as a conduit for education encourages children’s brain development. It promotes exploration and curiosity and makes the education process not as tedious for the children [10]. Children’s natural curiosity allows them to experiment, explore, problem solve, and stay engaged in meaningful activities, developing critical thinking skills through problem-solving [11]. This work details the design process, highlighting how HCD and participatory methods [12] shaped the development of both the workshops and the interactive set of games aimed to raise awareness among the residents of Campana-Altamira.

When discussing the impact of fast fashion, although most consumers claim to be knowledgeable about sustainability-related issues, most of them lack precise and accurate knowledge on aspects linked to production, supply chain, materials, recycling, or re-use of fashion items [13], [14], [15] as part of an awareness that seeks to address the textile waste problem at its root, by teaching the children about the importance of water conservation and textile waste management [16],[17].

2 METHODOLOGIES

The project was developed by two students coursing the 7th semester of the Design bachelor at Tecnológico de Monterrey in Mexico who conducted the research employing participatory methods to design educational game-based solutions to tackle the need for sustainable education among the children from Campana-Altamira, presented in a series of workshops. The use and adaptation of HCD was crucial to develop suitable results along with community members, allowing the design students to prioritise respect and empathy [18].

The individuals considered for this research were mostly young boys and girls between the ages of 8 and 12 coursing basic education, living in the Campana-Altamira community in the vicinity of the Arroyo Seco (Dry Creek) increasing their condition of vulnerability; with a particular focus on children and young people who participate in activities at the community space “El Oasis”.

Figure 1 shows the Design process followed for the project: during the first stage (1) *Discovery* on site ethnographic observations and semi-structured interviews were conducted to understand the perceptions and the level of knowledge of the community about water conservation practices and textile waste management [8]. During the second stage (2) *Define*, specific needs were identified by analysing the ethnographic results and at the same time, gaps in sustainable education and waste management were framed.

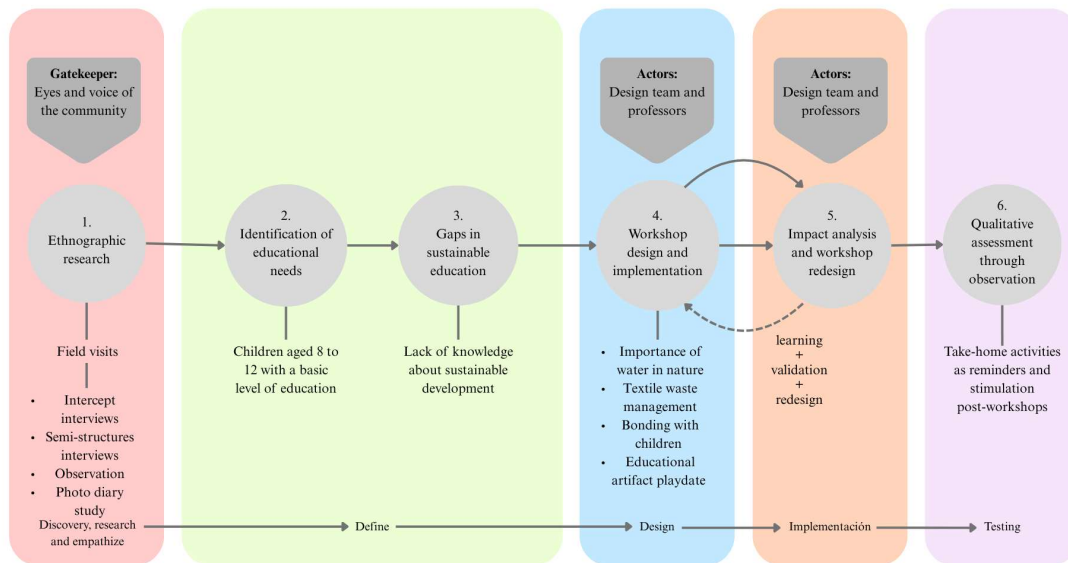


Figure 1. Human-Centred Design (HCD) process diagram. Adapted from established HCD frameworks; author's own elaboration

At the (3) *Design* stage an extensive sustainable education practices literature review was carried out to design two workshops that were implemented with the participating kids at El Oasis to address the identified challenges. During the (4) *Testing* stage (workshops 1 and 2) observations and intercept interviews were carried out with the children to understand their perspectives and opinions. Ethnographic information was analysed using an affinity diagram to categorise the findings and identify key patterns from previous experiences. After that, an iteration of the workshops occurred during stage 4, leading to a more game-based activities orientation. During the last stage (5) *Implementation* workshops 3 and 4 were prototyped and tested considering the previews of learnings and including the use of the set of games as a learning tool. As an additional instrument, a colouring activity sheet was designed to observe the children's learning outcomes.

As shown in Table 1, the first two-hour workshop, a brief presentation about the importance of water in nature was given by four instructors. Afterwards, the participants were given around one hour to complete an activity involving recycling materials. The instructors were always available to help and answer any questions. The second workshop took place a week after the first workshop. A brief presentation about textile waste management was given, and the participants had around an hour to complete an activity that used recycled materials to illustrate the information given in the workshop.

The third workshop was a presentation of an illustrated story developed by design students to showcase how waste disposal in rivers and bodies of water can affect the environment and the creatures living in it. After the presentation, activity sheets such as mazes, connecting dots, and character drawings were given to bond with the children while promoting recycling as a community. The activities were designed with the intention of being continued at home. These served as a reminder to keep recycling and conserving water, even after the workshop is done.

The fourth workshop was the presentation of the educational games the students developed based on the information gathered through observing and talking with the children in the previous workshops. These games are designed to support children's cognitive, psychomotor, and socio-emotional development, introducing key concepts related to water conservation, waste management, and textile reuse through collaborative and play-based learning dynamics [11]. Through observation of the participants interacting and participating in the games, we could see an increase in the interest in water conservation and waste management.

Table 1. Workshops

Workshop	Main objective	Additional Resources	Outcome
Small actions today can lead to big changes in the future: Nature & Water	Learn about the water bodies, their importance, and care.	Videos on the topics, and plastic bottles to make plant pots.	Significance of water conservation and actions at home that can help preserve it.
Did you know your clothes can pollute water?	Understanding textiles, textile pollution, and how to recycle clothing.	Videos on the topics, and fabric cases for hand painting.	Importance of sustainable development and preventing textile pollution.
The Water Guardians	Bond with children through games and drawings promoting recycling.	Activity sheets such as mazes, connecting dots, and character drawings.	Importance of recycling as a community.
La Juegateca	Learn about waste sorting, recycling, and sustainable development.	Artifact featuring 5 mini games.	Cooperation among children, coexistence, and learning together.

3 RESULTS

Semi-structured interviews were carried out before and after the intervention, with the help of supporting drawing and colouring activities to gain an understanding of the children's perception of textile waste and water use in their community [8]. Results show a clear difference in the responses before and after the intervention, as the children started incorporating textile waste into their responses when asked what main types of trash are found in the creek and how to dispose of them correctly. There is also a difference in the responses received that refer to recycling, as more children incorporate reusing textiles to support their community, as evidenced in the colouring activities implemented.



Figure 2. Participatory Design Community Intervention

Findings from pre- and post-intervention community perception assessments suggest that integrating participatory design with environmental education can foster meaningful shifts in awareness and

behaviour. The study contributes to ongoing discussions in design education by demonstrating how student-led, human-centred interventions can generate social and environmental value in underserved urban communities.

The artifact consists of five games made with HCD that each tackle different important developmental areas for the children: including a cooperation game, an executive function game, a fine motor skill game, a spatial awareness and cognition game, and a hand-eye coordination game. All the games used topics of recycling and water conservation, teaching important lessons while being used to develop children's social and motor skills.

4 DISCUSSION AND CONCLUSION

The findings of this study confirm existing research suggesting that awareness of sustainability does not necessarily translate into informed action. Pre-intervention interviews revealed that community members possessed a general understanding of textile waste accumulation but lacked specific knowledge regarding disposal and recycling practices, aligning with consumer awareness gaps [12]. This disengagement between general concern and practical knowledge became a key driver for the design of the workshops, reinforcing the need for targeted environmental education in vulnerable urban contexts.

Observations throughout the workshops indicate that children initially recognised the importance of water conservation but did not perceive textile waste as a significant environmental threat. Following the intervention, participants began incorporating textile waste into their descriptions of pollution in the Arroyo Seco (Dry Creek) and suggesting reuse practices within their households. This shift supports the idea that children can act as agents of change when provided with structured sustainability education [14], [17]. The effectiveness of the game-based approach further supports research on playful learning as a trigger for engagement and cognitive development [10], [11]. The transition from presentation-based sessions to interactive storytelling and collaborative games resulted in increased participation and motivation. The designed artefact, integrating cooperation, executive function and motor skill development, demonstrates how educational tools can simultaneously strengthen environmental understanding and developmental competencies [16].

At a systemic level, textile waste in Campana–Altamira remains embedded in broader industrial; infrastructural and policy challenges identified in prior environmental studies [1], [3] and local documentation [4],[6]. Educational interventions alone cannot resolve these structural constraints. However, the application of Human-Centred Design and participatory methods [12], [18] illustrates how design can function as a catalyst within complex systems, translating contextual research into accessible, community-responsive strategies.

In conclusion, this study contributes to product design education by evidencing that student-led, human-centred interventions can generate tangible social and environmental value. Grounded in Research by Design approaches [15], the project demonstrates how academic initiatives can bridge universities and vulnerable communities while fostering environmental awareness and collective responsibility. Although systemic change requires multi-level action, empowering younger generations through participatory and playful design represents a viable and replicable pathway toward long-term cultural transformation. Next steps for this research would encompass the pursuit of strategies to improve the waste management infrastructure of Campana–Altamira, which can only be achieved by the collaboration between the government, academia, and the community.

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