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TOWARDS A BETTER HUMAN CENTRE DESIGN PRACTICE IN AN ACADEMIC CONTEXT

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ABSTRACT
This paper addresses potential challenges in executing human-centred design (HCD) in an academic environment, focusing on (i) lack of sensibility and empathy in ethnographic research, (ii) misinterpretation of qualitative data in solution design, and (iii) uncertainty in user implementation. The study aims to enhance HCD education and improve ergonomics and efficiency in Chinampas agriculture through social perspectives. It describes the implementation of HCD strategies with undergraduate design students using challenge-based learning, employing an ideal-contextual prototyping approach. Experts and professors provided diverse perspectives and guided students in sensibility, empathy, and data interpretation, resulting in multiple approaches for each design solution. The dual-prototyping approach facilitated the acquisition of competencies, leading to a working prototype with a potential positive impact. This educational model addresses HCD challenges and fosters the creation of high-impact artifacts.

Keywords: Human-centered design, regenerative agriculture, educational innovation, prototyping

1 INTRODUCTION: CHALLENGES WITH HUMAN-CENTRED DESIGN
Human-Centred Design (HCD) is a versatile yet structured method that has been adopted by the Design Department of Tecnologico de Monterrey to instruct innovation and product development. As stated by Holeman and Kane [1], the HCD approach is centred on the active engagement of users to enhance the comprehension of users' needs and task requirements. According to Mao et al. [2], this approach enables students to generate design solutions with an empathetic perspective. The incorporation of user involvement and empathy in HCD makes it a valuable technique for teaching design students how to develop products and services that accurately meet the needs of their target audience. Nevertheless, there are some challenges when implementing HCD in an ideal way. According to Vredenburg et al. [3], many practitioners fail to include actual users in their process, and when they do, practitioners may overlook user data and find it challenging to identify areas of opportunity when developing sensible solutions. If HCD can be difficult for regular practitioners, it can be argued that it can be even more challenging for design students in an undergraduate programme. In the last five years as education practitioners, we have learned that by deploying HCD in an undergraduate academic programme, teachers can face several challenges in achieving a viable design solution generated by the students. Through past experiences, we have identified three obstacles that contribute to these challenges. The first is a lack of sensibility and empathy during ethnographic research, which can be exacerbated by socio-economic inequality in the Tecnologico de Monterrey context, where most students belong to a higher socio-economic class. This inequality can lead to a belief in exclusivity and privilege among the upper classes [4], resulting in a lack of sensibility and empathy. To address this, it is essential to push students towards several ethnographic-driven field exercises to enhance empathy while identifying problems or areas of opportunity. The second is the potential for misinterpreting qualitative data during the design process. In HCD, qualitative data is collected through activities such as deep dives, shadowing, or co-creation; however, for this data to be helpful, it must be translated into meaningful insights through analysis [5]. This analysis is integral to the creative design process, but it can be difficult for inexperienced design students to gather unbiased data -due to a lack of understanding of both tacit and formative theories,

which can make it challenging to distinguish relevant and valuable data from irrelevant information. To overcome this challenge, it is essential to encourage critical analysis and to provide students with the tools and knowledge necessary to gather unbiased data, as we will explain further, utilizing generative research tactics. The more rigorous the analysis, the better chance students have of gathering accurate data. The third challenge lies in ensuring user implementation of proposed solutions, as industry partners may view them as mere inspiration or lack the resources needed. Implementing product design in a Mexican context is challenging due to factors like a low innovation culture [6] and a lack of private investment in innovation [7]. Therefore, it is crucial that the solutions proposed in an academic project consider the capabilities and limitations of the industry partner to increase the likelihood of successful implementation. This paper presents a strategy to potentially minimize the challenges previously discussed in implementing HCD in an academic setting. In collaboration with industry partner Arca Tierra, these strategies were implemented with fourth-semester design students at the Tecnologico de Monterrey's Mexico City Campus. This study evaluates the effectiveness of strategies for addressing challenges in ethnographic research, including lack of sensibility and empathy, misinterpretation of qualitative data, and implementation issues. It offers valuable insights for educators and practitioners seeking to enhance their HCD practices in academia.

2 REGENERATIVE AGRICULTURE TOOLS, A CASE STUDY

Tec21 is a novel educational model at Tecnologico de Monterrey that focuses on developing assessable, real-world skills through a deep educational blueprint [8]. As one of the goals of Tec21 is to provide real-world experiences for students, a "formative partner" is brought in to present a real-life challenge for the students to design a solution for. The idea is that the formative partner will find practical value in the design solution generated during the semester.

The Design Department follows the Tec21 model, and in the fourth-semester design course, students are presented with their first long-term design project that lasts the entire semester. During that semester, students go through three consecutive five-week formative units that resemble the Discover/ Define/ Develop/ Deliver design framework. The first formative unit, "Creative Thinking and Process," deploys activities that encourage secondary and primary research, the outcome of which is a validated design brief. In the second formative unit, "Specification of Products and Services," students are encouraged to create a minimal viable product through a highly iterative prototyping process, the outcome of which is the documentation for production and a working high-resolution prototype. Lastly, the third formative unit, "Design and Innovation," focuses on showcasing their idea through an entrepreneurial engagement by further validating their prototype, creating a visual identity, and preparing a business pitch to be presented to the industry partner.

In February 2022, we implemented this model with 20 design students divided into six teams. Our formative partner was Arca Tierra, a company based in Xochimilco, Mexico, specializing in regenerative agriculture and working with local farmers and other local producers as a way to recover and preserve the chinampa [9]. The chinampa is an ancient agro-hydrological system developed by the Aztecs in Mexico City. It involves constructing rectangular plots of organic soil over shallow wetlands for agricultural use and is notable for its sustainability and preservation of pre-Hispanic design. Despite its long history, local producers still use chinampas today [10].

As the farmers working with Arca Tierra use basic, makeshift tools, the formative partner challenged the students to create ways to make the local agricultural process more efficient and enjoyable, which became the brief of the project.

2.1 Implementing HCD Research on a Tec21 Model Design Course

In the first unit of the creative thinking and process course, the focus was on HCD Research. During this unit, two potential challenges were identified and addressed. The first challenge was the lack of empathy and sensibility in solution generation, a common issue for the students´ socio-economic sector. To address this, students were encouraged to participate in several field trips and to use questioning techniques such as the five why method and deep-dive interviews.

The second challenge was the students' difficulty in understanding the difference between qualitative and quantitative research methods. To address this, a team of three professors, two of whom were experts in Design Strategy and HCD Research, provided tutoring and constantly reviewed and questioned the students' HCD tactics. The professors emphasized the importance of qualitative data collection

techniques such as shadowing and deep-dive interviews and data analysis methods like clustering and problem statement insights.
Hanington [11] states that by using proactive generative research techniques, subjects of the research can project their thoughts, feelings and desires, and extract design elements that can be used to develop concepts closer to the needs of the users. The professors' guidance and support helped the students to better understand the value of qualitative research methods in HCD research.
To start applying the design strategies, an initial field trip was conducted to observe the regenerative agricultural process and gather ethnographic data through photography and video. The collected data was analyzed to identify three potential opportunity areas for product design. The professors emphasized the importance of linking tangible evidence to their hypothesis and validating the relevance of their concept through critical thinking and complementary field trips.

2.2 Implementing Ideation on a Tec21 Model Design Course

The ideation phase involved a combination of Dalton's five principles of effective insight definition [12] and Alquemist's Elements of Value [13] to understand better and differentiate the functional and emotional needs of the Arca Tierra workers. This approach helped the students become more empathetic, better understand the workers' needs, and generate more realistic design proposals.
Dalton's five principles allowed for the effective articulation and validation of the initial hypothesis, while the application of Alquemist's Elements of Value helped the students consider both functional and emotional aspects in their design proposals. This combination of methodologies facilitated a thorough and holistic approach to product design, ensuring the relevance and impact of the final design solutions.
A thorough understanding of the context was considered to address the third challenge of ensuring user adoption of the proposed solutions. As previously noted, Mexico presents difficulties deploying innovation practices in product design. This results in farmers and workers having to create their own tools, commonly referred to as "herramientas hechizas" (makeshift tools, which we will refer to below as "hechizo tools"), which are made from scraps and lack any certification from a manufacturer. These makeshift tools also have equivalents in the market that are certified and manufactured by recognized units with a quality system [14].
The use of "hechizo tools" by farmers and workers is driven by economic constraints and the unavailability of the specific tools needed for a task, making it a challenge for the design project. On the one hand, the students must be sensitive to the economic and infrastructure limitations of the users' living environment and avoid proposing solutions that require industrialized manufacturing techniques, such as injection molding or metal casting, which may not be feasible. On the other hand, fourth-semester industrial design students must acquire knowledge of these mass production processes; this presents a unique challenge in Challenge-Based Learning (CBL).
To address this conundrum, an approach inspired by speculative design was taken as this approach helps to question our current practice [15]. In the first formative unit, the professors encouraged the students to research not only the functional and emotional needs of the users but also their access to manufacturing processes, trades, and artisans. In the second formative unit, the students focused on generating solutions using a concept called *"Treasable Manufacturing"* [16], a speculative design tactic that encourages the design of a product as if it were made from standardized materials, and the manufacturing process was very traceable. This approach would allow the final user to utilize the result as a blueprint for replication.
In the third formative unit, instead of focusing on the pitch and visual identity of the project, the professors decided to take an "idealist" speculative design approach. The students were tasked with designing the "hechizo tool" as if it were designed by a global hardware company, requiring them to continue their research on industrial production processes and materials.
Overall, the approach balances the need to address the limitations faced by the final user and the need for the students to acquire foundational knowledge in industrial design.

3 RESULTS

The students formed six teams, applying User-Centred Design tactics to develop agricultural tools for chinampa farming. They gained insights into farmers' work processes, identified areas for improvement, and created prototypes for local replication and industrial production. The work process involved mud collection, transportation, flattening, grid tracing with a "cortadora" tool, seed placement, and transplanting. Each team developed Hechizo and Ideal prototypes (see Figure 1).

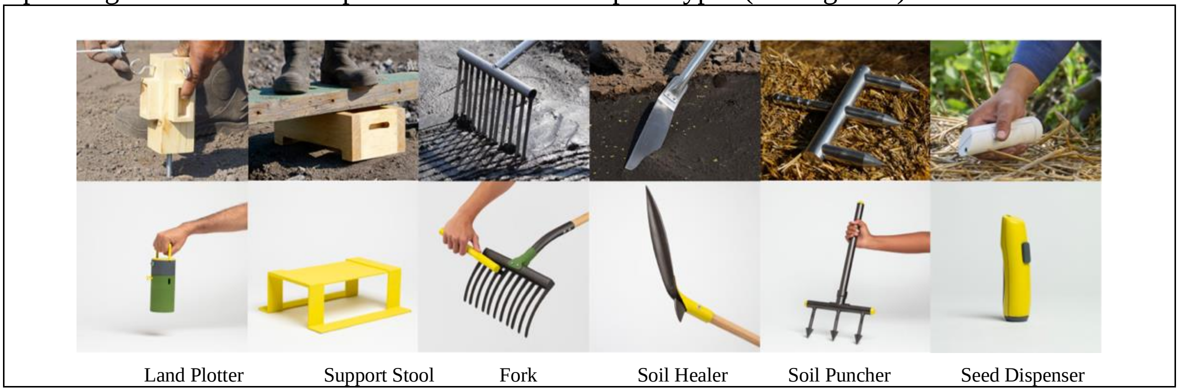

Figure 1. "Hechizo tools" Prototypes (above) and Ideal prototypes (below)

3.1 Land Plotter

These students developed two prototypes to improve the accuracy of tracing growing beds in chinampa agriculture. The first prototype featured a wooden square with a retractable reel, nylon thread, and a low-cost laser guide. It enabled farmers to mark and divide the terrain accurately using laser light and retractable thread. The second prototype was an ideal redesign with an injection-casted polypropylene enclosure, providing versatility for rural architecture and construction. These tools aimed to enhance bed tracing accuracy and efficiency in chinampa agriculture.

3.2 Support Stool

Another student group addressed the challenge of manually flattening growing beds using a wooden plank and bricks, which was unsafe and required multiple workers. They developed two prototypes: an optimized wooden stool for easy transport and a metal stool made of carbon steel sheet. The metal stool offered improved stability and mobility, ensuring safety during planting.

3.3 Soil Healer

One student group addressed the inefficiency of the mud-flattening process using a machete. They designed the "Soil Healer," a leaf-shaped tool with an extended handle to let the farmer flatten, patch, and heal the soil surface without bending down. The first prototype utilized a steel tube and tip, while the second prototype employed die-casting and plastic injection for crack repair in seedbeds. The aluminum sheet design featured a rib for strength, reinforced at the pressure point, and included a hinged lid for convenience.

3.4 Fork

The students recognized the need for improved ergonomics and mud displacement in the makeshift tool to trace the growing bed's grid. To address this, they created two prototypes. The first prototype was a metal steel tube and steel screed "fork" designed to prevent mud from sticking and enhance visibility and precision. The second prototype featured a redesigned tool made of galvanized steel and ash wood, utilizing die-cutting and plastic injection techniques. This version incorporated a mud cleaner, resulting in a dynamic and practical work process.

3.5 Soil Puncher

A group of students aimed to improve the efficiency of the hole-punching process for farmers by designing a new hand tool. The tool, consisting of a fork with three movable spikes, allows farmers to punch multiple holes at once, reducing the time and effort required and avoiding potential injury to their fingers. The first prototype was crafted from lathed aluminum, while the second utilized a combination of polypropylene, carbon steel, and aluminum for its construction.

3.6 Seed Dispenser

The students designed a seed dispenser to address the time-consuming and labor-intensive nature of planting seeds in chinampas. The dispenser aimed to reduce seeding time by 25% and improve agricultural efficiency. The first prototype utilized 3D printing and was donated to farmers in Arca

Tierra. The second prototype was designed for mass production using injection molding. This innovative solution enhanced ergonomics, minimized worker strain, and saved time in the seeding process.

4 CONCLUSIONS

In conclusion, the methodology of constant tutoring that focused on empathy, insight generation, and people values has generated new tools that are currently being used by the farmers of Arca Tierra. The first prototypes were donated to the community and received positive feedback from the leaders. The project was also awarded the "best of show" prize at the *Horizontes* exhibition[1] and winner at the *Diseña Mexico Awards*[2], showcasing the project's successful outcomes and highlighting the importance of integrating empathy, people values, and flexible educational models in design projects. This approach can contribute to developing more insightful, viable, and sustainable projects that effectively address real-world issues. The authors would like to acknowledge the financial support of Writing Lab, Institute for the Future of Education, Tecnologico de Monterrey, Mexico, in producing this work.

REFERENCES

[1] Holeman I. and Kane, D. Human-centred design for global health equity. *Information Technology for Development*, 2020, 26(3), 477–505. https://doi.org/10.1080/02681102.2019.1667289.

[2] Mao J.-Y., Vredenburg K., Smith P. W. and Carey T. The state of user-centred design practice. *Communications of the ACM*, 2005, 48(3), 105–109. https://doi.org/10.1145/1047671.1047677

[3] Vredenburg K., Mao J.-Y., Smith P. W. and Carey T. A Survey of User-Centred Design Practice. 1, 2002.

[4] Saraví G. A. Miradas recíprocas: Representaciones de la desigualdad en México. *Revista Mexicana de Sociología*, 2016, 78(3).

[5] LeCompte M. D. Analyzing Qualitative Data. *Theory Into Practice*, 2000, 39(3), 146–154. https://doi.org/10.1207/s15430421tip3903_5.

[6] de la O Campos J. R. and Güemes-Castorena D. Critical Data: Teaching Design through critical design, physical computing, and digital data. In *International Conference on Engineering and Product Design Education, EPDE´19*, UK September 2019. https://doi.org/10.35199/epde2019.26.

[7] Rullán S. A review of the Mexican national innovation system. *International Journal of Business and Economic Sciences Applied Research*. 8(3), 2015, pp 59-68.

[8] González Almaguer C. A., Caballero-Montes E., Acuña López A., Zubieta Ramírez C., Saavedra Gastelum V., Barbosa Saucedo E. A. and Lule Salinas M. Design thinking and design of experiments: the fusion of the school of design and industrial engineering to create learning experiences in the Tec21 educational model. In *International Conference on Engineering and Product Design Education, EPDE´21*. https://doi.org/10.35199/EPDE.2021.71

[9] Azpíroz A. V. *Sabor a tierra, lo nuevo de Arca Tierra*. Food & Wine en español. Available: https://foodandwineespanol.com/sabor-a-tierra-lo-nuevo-de-arca-tierra/ [Accessed on 2023, 13 February], (2022) 16 August.

[10] Robles B., Flores J., Martínez J. L. and Herrera P. The Chinampa: An Ancient Mexican Sub-Irrigation System. *Irrigation and Drainage*, 2018, 115-122. https://doi.org/10.1002/ird.2310.

[11] Hanington B. M. Generative research in design education. In *International Association of Societies of Design Research IASDR07,* Hong Kong, Available: https://www.sd.polyu.edu.hk/iasdr/proceeding/papers/Generative%20Research%20in%20Design%20Education.pdf (2007) November.

[12] Almquist E., Senior J. and Bloch N. *The 30 elements of consumer value: A Hierarchy*. Harvard Business Review. (2021).

[13] Dalton J. *What is insight? The 5 principles of definition insight*. Thrive, Available: https://thrivethinking.com/2023/01/06/what-is-insiht-the-5-principles-of-definition-insight/ [Accessed on 2023, 14 February] (2023) 7 February.

[14] Engineering and Product Design Education. https://doi.org/10.35199/EPDE.2021.71 Gutiérrez,

[1] The annual design exhibition showcasing the best project of all the Tec de Monterrey Design Departments nationwide.

[2] The only product design awards currently in Mexico.

A. S., & Mezarina, P. V. (n.d.). Trabajo de investigación para optar al grado de: Bachiller en ingeniería industrial.
[15] Auger J. Speculative design: Crafting the speculation. *Digital Creativity*, 2012, 24(1), 11–35. https://doi.org/10.1080/14626268.2013.767276.
[16] O José de la. *The Way Stuff Could Look Like in a Post Covid-19 World*, Available: https://medium.com/@jousaideilaiow/the-way-stuff-could-look-like-in-a-post-covid-19-world-c5a7bfe6b9d3 [Accesed on 2021, 12 December], (2020) 25 April.