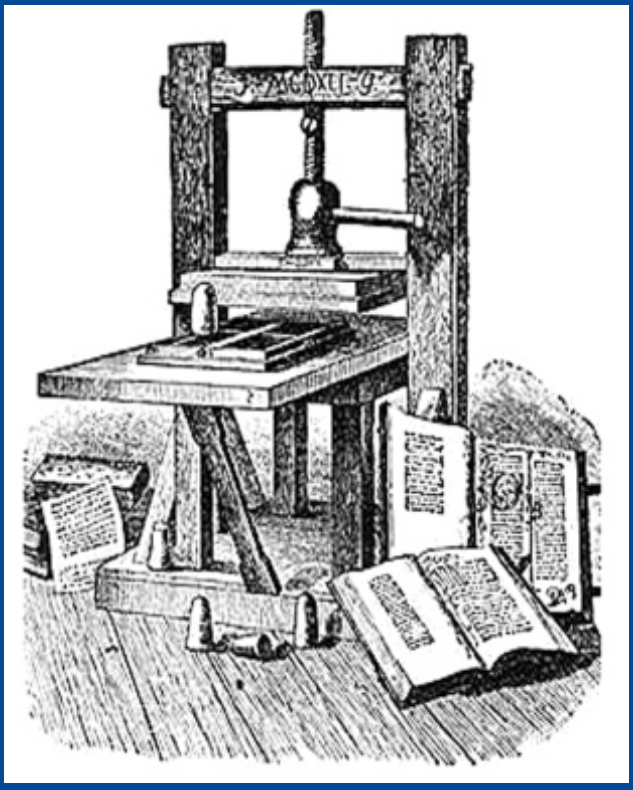
Knowledge Cultures

A Multidisciplinary Journal

Volume 12 • Number 2 • 2024



Addleton Academic Publishers

Knowledge Cultures, *12*(2), 2024
pp. 21-48, ISSN 2327-5731, eISSN 2375-6527

Cultivating Cultural Heritage and Fostering Belonging in Communities through Digital and Non-Digital Technologies in Generative STEAM Education

Ronnie Videla
ronnievidelare@santotomas.cl
Universidad Santo Tomás
La Serena, Chile
Innova STEAM Lab
Chile

Claudio Aguayo
claudio.aguayo@aut.ac.nz
Auckland University of Technology
Auckland, New Zealand
Innova STEAM Lab
Chile

José Aguilera
jaguilerahist@gmail.com
Innova STEAM Lab
Chile

Maybritt Aros
maybrit.aros@ucn.cl
Universidad Católica del Norte
Coquimbo, Chile

Camilo Ibacache
camiloibacache@gmail.com
Innova STEAM Lab
Chile

Paulina Valdivia
p.valdivia.chavarria@gmail.com
Universidad Tecnológica Metropolitana
Santiago, Chile
Innova STEAM Lab
Chile

Carola Cerpa
ccerpa@ucn.cl
Universidad Católica del Norte
Coquimbo, Chile

ABSTRACT. The predominance of Western thought, traditionally dualistic and reductionist, has simplified and devalued the complexity and richness of the historical-cultural heritage, including the tangible and intangible heritage of lagging communities and Indigenous peoples across the globe. With the increasing globalisation and migration of people from one place to another, the preservation of cultural identity has become a significant concern for communities worldwide; thus, we ask ourselves: How can the past (material and intangible historical-cultural heritage of lagging communities and Indigenous peoples) be kept alive in the present? Here, we propose that digital technology has the potential to play a vital role in helping communities maintain a sense of cultural belonging. Digital technology offers numerous possibilities for communities to preserve, document, revitalise, (re-)connect and share their cultural heritage, allowing them to maintain a sense of belonging with their roots and history. One of the most significant benefits of digital technology is the ability to document and preserve cultural artefacts, traditions and practices. Moreover, digital technology can enable communities to engage further with their cultural heritage while sharing this with a broader audience and/or other communities in similar situations. With the rise of immersive technologies like virtual reality and augmented reality, and technology such as 3D manufacturing, electronics and biomaterials, cultural experiences can be brought to people worldwide, allowing individuals to learn and appreciate different cultures without physically being present. By focusing on a case study from the commune of La Higuera, IV Region of Chile, we will explore the potential of digital and non-digital technology to keep the past alive in the present and for the future while providing key design principles for others to follow and be inspired by.

Keywords: cultural identity; cultural heritage; digital technology; design; La Higuera

How to cite: Videla, R., Aguayo, C., Aguilera, J., Aros, M., Ibacache, C., Valdivia, P., & Cerpa, C. (2024). Cultivating cultural heritage and fostering belonging in communities through digital and non-digital technologies in generative STEAM education. *Knowledge Cultures*, *12*(2), 21-48. https://doi.org/10.22381/kc12220242.

Received April 8, 2024 • Received in revised form July 12, 2024
Accepted August 15, 2024 • Available online September 1, 2024

Introduction

UNESCO's Education Agenda 2030 reaffirmed the commitment of states to recognise that digital transformation requires the use of technology as part of broader systemic efforts to transform education, making it more inclusive, equitable, effective, relevant and sustainable (Foundation Digital Country, 2023). A core imperative of these macro initiatives is to promote the social cohesion and cultural responsibility that educational policies must promote these changes from the bottom up (OECD, 2022). With the purpose of catalysing these initiatives within the generation of cultural value and sense of belonging in communities in the Global South, it is necessary to rethink how new technologies have the potential to allow for the cultivation of the heritage past and belonging. In that sense, we posit, does the design and reconstruction of cultural heritage favour

belonging by being embedded with digital and non-digital technologies? Our basic argument is that the valorisation and respect of the sociocultural environment arise from the enrichment of local knowledge using various digital and non-digital resources and strategies that amplify the ways of perceiving and, therefore, the ways of knowing that contribute to fostering belonging. A characteristic example of this type of initiative is cultural heritage.

People inhabit places with history and, in many of them, there are special places where the community's own culture has been forged, coming to symbolise within its territory material and immaterial patrimonies that provide roots and territorial belonging (Bahho, Vale & Milfont, 2023). Recognition of material heritage sites and their preservation, historical sites, cultural artefacts and the intangible memory of community stories and narratives are important when it comes to preserving and cultivating community roots to remain visible. In this study, we focus on the community of La Higuera, located in the Coquimbo Region in Chile (Figure 1), South America, where exquisite material and intangible cultural heritage can be identified. Unfortunately, this cultural heritage has been left behind in its preservation and promotion in educational contexts. This has led us to ask ourselves how to preserve and cultivate heritage with digital and non-digital technologies, in which participatory co-design processes with the community can be considered to promote new forms of learning based on contemporary postcognitivist evidence from the 4E cognition (embodied, enacted, embedded and extended) approach, which is based on relational ontology, in which the brain, body and environment are considered a complex system of multiscale interactions (Aguayo, 2023; Aguayo, Videla & Veloz, 2023; Parada & Rossi, 2020; Penny, 2017). In turn, we emphasise embodied, enacted and embedded digital design, where community members, particularly schoolchildren, teachers, neighbours and local elders, represent knowledge because of historical relationships between individuals, communities, environments and physical artefacts.

Inspired by culturally situated design tools (CSDTs) studies to develop heritage artefacts with technologies from a generative and non-extractive approach (Bennet & Eglash, 2023), as well as the Ethical Enactivism for Smart Learning Design (EESLD) for the generation of culturally situated digital and non-digital environments (Aguayo, Eames & Cochrane, 2021; Aguayo et al., 2023), in this article, we set ourselves the following general and specific objectives:

General objective:

- to foster the belonging of the educational community through the co-design of digital and non-digital technological resources based on local cultural heritage.

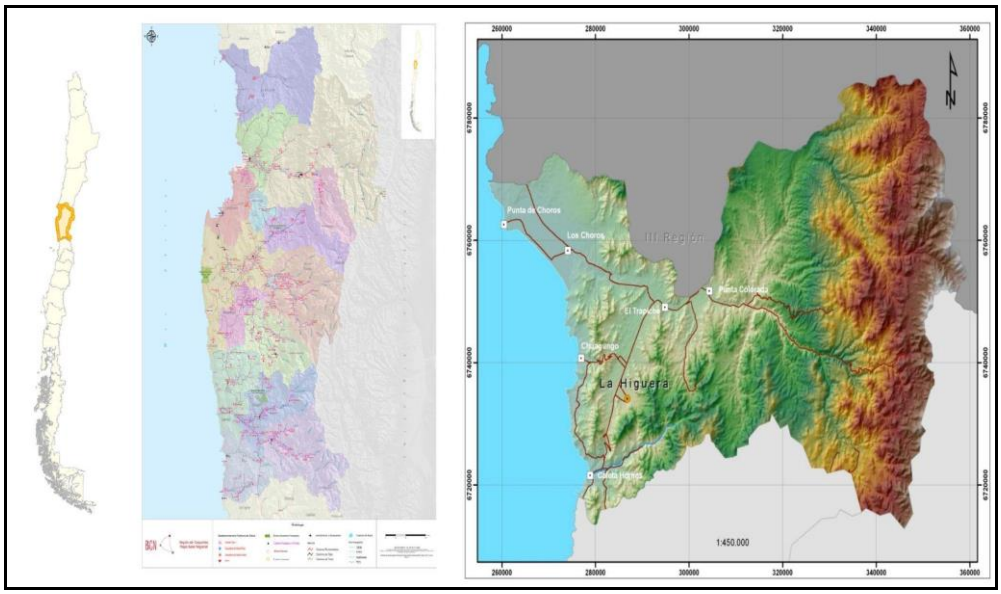
Specific objectives:

- to characterise the people and the context of the cultural heritage of the Commune of La Higuera

- to discuss the theoretical, epistemological and methodological foundations that highlight the preservation of heritage and belonging in communities in the Global South
- to reflect on the potential of digital innovation from research based on Culturally Situated Design Tools (CSDT) and Ethical Enactivism for Smart Learning Design (EESLD) in the preservation of cultural heritage and belonging
- to design digital and non-digital educational resources focused on the cultural heritage and belonging of the La Higuera Community that promote new ways of teaching and learning through a postcognitivist 4E cognition approach.

Figure 1

Map of Chile, highlighting the Coquimbo region



Note. The Coquimbo region is divided into three provinces, Elqui, Limari and Choapa, and is made up of 15 communes, including the commune of La Higuera (Biblioteca del Congreso, n.d.). Copyright Biblioteca del Congreso 2024.

La Higuera

The commune of La Higuera is in the Coquimbo region, Chile. It was declared a commune on December 21, 1891, although its final installation was in 1892 (Aguilera, 2022). It extends to the north, with the communes of Freirina and Vallenar, and, to the northeast, with Alto del Carmen, all these belonging to the Atacama region. To the east and southeast, with the commune of Vicuña and, to the south, with the commune of La Serena, and, to the west, with the Pacific Ocean. Its total population, according to the 2017 census, is 4,241 inhabitants, broken down into 2,005 women and 2,236 men. The communal area is 4158 km² (Aguilera, 2023).

The commune is made up of the towns of La Higuera (communal capital), Caleta Apolillado, Caleta Punta de Choros, Los Choros, El Trapiche, Punta Colorada, Agua Grande, Los Pajaritos, Los Morros, Caleta Chungungo, Caleta Totoralillo (North), Quebrada Honda, Caleta Los Hornos and Los Hornos. Currently, only La Higuera, Caleta Los Hornos, Punta Colorada, El Trapiche, Punta de Choros and Los Choros are recognised (Municipality of La Higuera, 2021). Its main economic activities are fishing, seafood harvesting, mining, goat farming, gastronomy, tourism and agriculture (Aguilera, 2022). Although the PLADECO (i.e., Plan de Desarrollo Comunal, or 'communal development plan') points out that agriculture is significant, with the cultivation of olive trees and vegetables, other key activities are mining, fishing and livestock farming (Municipality of La Higuera, 2021).

In La Higuera, we can find the presence of individuals belonging to various Indigenous peoples. In the 2017 census, those corresponding to the Mapuche, Diaguita and Aimara people (Municipality of La Higuera, 2021) stood out, along with the Chango people originally from Chango, with a long history in Punta de Choros, currently been added given their official recognition by the State of Chile with Law No. 21,273 (Rivera, 2020). The commune of La Higuera has seventeen formal education establishments, including schools and kindergartens, following the guidelines of the Ministry of Education and JUNJI (Municipality of La Higuera, 2021).

The Complexity of Historical-Cultural Heritage at La Higuera

One of the challenges that the 21st century poses for cultural heritage is how we integrate our current society into discourse, thought and materiality. A diverse, inclusive, fair, dialoguing and respectful society. Historically, the fact that the societies in which we live are made up of different people has been denied or made invisible (Marsal, 2022). This has given rise to what is referred to as a heritage issue, the recognition of two dimensions that have reconfigured the uses and valorisation of heritage in a large part of Western society (Valencia, 2021): the social expansion of assets and records considered heritage and a growing participation of new social subjects, and the use of heritage as a defence strategy of various organisations and social movements (Valencia, 2021). This phenomenon has also been portrayed in our commune of La Higuera, although much of the research carried out on it, from the 1990s until more or less 2010, focused mainly on the mining history of copper from La Higuera (1840-1930) and of iron from El Tofo (1913-1972) during the local minerals boom.

These investigations addressed the origins, rise and fall of the mineral deposits, means of exploitation, forms of socialisation, etc. For the study of the copper cycle, we find several examples, namely, the works *Aguinaldo a la Liga Protectora de La Serena* ('Bonus to the Protective League of La Serena'; Protective League of La Serena, 1876); *La Industria del Cobre en las Provincias de Atacama y Coquimbo* ('The copper industry in the provinces of Atacama and Coquimbo'; Aracena,

2011); *El Libro del Cobre y del Carbón de Piedra* (‘The history of copper and coal’; Mackenna, 1883); and the *Informe Sobre la Provincia de Coquimbo* (‘The report on the Province of Coquimbo’; Chouteau, 1887), among others. Such sources have served as support for the publications *Cuentos de mi Terruño Bajo La Higuera* (‘Tales from my homeland under the Higuera’; Alfaro & Villalobos, 2012), *Mineral de La Higuera*, ‘*Tierra de Zainos y Promeseros*’ (‘Mineral de La Higuera, “Land of Zainos and Promeseros”’; Alfaro & Villalobos, 2012), *Cultura Minera en la Historia de La Higuera* (‘Mining culture in the history of La Higuera’; Paéz, n.d.), *Imágenes del Mineral de La Higuera en el Siglo XIX* (‘Images of the minerals of La Higuera’; Moraga, n.d.). Regarding the iron cycle, we found useful the books *Tofinos en la Niebla* (‘Tofinos in the Fog’; Valdivia, 2016) and *El Tofo: Historia de un Extraordinario Pueblo Minero en el Norte de Chile* (‘El Tofo: History of an extraordinary mining town in the north of Chile’; Cleary, 1999).

Other ‘day-to-day’ topics like fishing, agriculture and goat raising were not deeply addressed. This changed in 2012 when the attention turned from the Andes mountains to the coast. The work of archaeologists, anthropologists, sociologists and historians allowed for the coastal Indigenous peoples, the work of fishermen, shellfish divers, seaweed collectors, ranchers, farmers and miners to be placed again on the map and as part of the history of the Coquimbo region, beyond ‘mining’ solely. Books such as *Historias Ancestrales de los Choros y Punta de Choros* (‘Ancestral stories of the Choros and Punta de Choros’; Gutiérrez et al., 2014), *Caleta Los Hornos: Images, Memory and History* (‘Caleta Los Hornos: Images, memory and history’; Aguilera, 2018), *Archipiélago Humboldt: Patrimonio natural y cultural del borde costero de la comuna de La Higuera* (‘Humboldt archipelago: Natural and cultural heritage of the coastal edge of the commune of La Higuera’; Villarroel, 2019), *Abrí los Ojos Bajo el Mar* (‘I opened my eyes under the sea’; Rivera et al., 2020) and *Comuna de La Higuera* (‘La Higuera commune’; Aguilera, 2022) have helped broaden and deepen views on this territory. The above has also been motivated by the various conflicts that have arisen in the commune of La Higuera and that are related to the coast and the installation of mining and energy megaprojects. These have entered into conflict with environmental groups and neighbours who ensure the safekeeping and protection of the Humboldt penguin reserve that covers the archipelago made up of the islands of Chañaral, Choros, Gaviota and Damas, the latter three located in the commune of La Higuera. These islands are in front of the Punta de Choros cove area that has had a historical root related to goat farming, fishing and mining, tracing its origins back to the pre-Columbian period and the occupation of the coastline by Indigenous groups. Likewise, the megaprojects have instrumentalised the mining history of La Higuera and El Tofo, as a sign that projects of this type can be developed given the ‘success’ and ‘progress’ they can deliver to the commune and its people, providing a ‘wrong view and perspective’ of the real scope of the copper and iron cycles in the local territory.

Recent research has made it possible to relocate communities that feel and are of Chango origin. Although much of the colonial period the coast was unoccupied, it was during the 19th century that it gradually began to be inhabited. The sea lion skin rafters appear on the scene in the local areas of Apolillado, Punta de Choros, Chungungo Viejo and Cruz Grande. These rafters were fishermen, but, above all, ranchers or muleteers settled in sheepfolds. Families such as the Moya, Álvarez, Vergara and Aguirre traded with the port of Totoralillo and the mining towns of San José de Los Choros, La Aguada, Mineral de La Higuera and El Barco, selling, directly or through garroteros, fresh and salted fish and seafood. These families were called 'changos' by the local inhabitants and surrounding communities, although it must be clarified that they did so in a derogatory and pejorative way. This will change at the end of the 20th century when they are gradually recognised and felt that they were made part of the Chango Indigenous people, an official recognition that was reflected on October 17, 2020, in Law no. 21,273 (Rivera, 2020). This has earned them a prominent position, both in Punta de Choros and Chañaral de Aceituno, where the Álvarez and Vergara Chango communities revitalised and consolidated their position and identity on the coastal edge of Freirina and La Higuera. The latter has been built and reaffirmed because of various research and publications, i.e., Rivera et al. (2017) and Rivera et al. (2020).

From the point of view of cultural heritage, in its material and intangible dimensions, La Higuera keeps sites and knowledge that evoke its pre-Columbian, mining, fishing and agricultural past (see Figure 2). There are the archaeological sites of Los Pajaritos, Los Morros, La Silla, Quebrada Honda, Apolillado, Punta de Choros, Chungungo Viejo, Temblador, Tilgo, Yerba, Caleta Los Hornos and El Molle, where Animas, Molles and Diaguitas communities lived. For the 19th century, we can find the material remains of La Higuera Alta in La Higuera, the cemetery and mining-port establishments of Totoralillo, the church of El Maray, and the stone walls and landmarks ('empircados') that are scattered along the coastal edge and in the middle and upper part of the Los Choros ravine. Contemporary are the remains and memories of El Tofo, the Cruz Grande camp and dock, the El Molle mining establishment, the Punta Colorada, Tres Cruces and Piritas railway stations, and the El Galpón seafood processing factory in Caleta Los Hornos with its old charcoal ovens, maray, sugar mills and mills to extract water. All of this, which has incalculable historical value for the communities and inhabitants of La Higuera, is totally abandoned, exposed to looting and disappearance (Aguilera, 2022). An exceptional case is the Maray church, which is regularly protected and 'repaired' by the Godoy family, owners of the El Maray ranch.

Figure 2
El Maray and its environs

Note. The collage includes, on the top from right to left: a mechanical traction sugar mill, maray, the 19th-century church of El Maray and the rock art of Los Morros, and, below, from left to right: an oven to make charcoal, an artisanal mill to extract water, a mural alluding to the Chango Indigenous people and animal action mill (Aguilera, 2022). By the authors. Copyright the authors 2024.

This is why it is essential to seek new instances of dissemination and education about this cultural and natural heritage. We need citizens and communities who can take ownership of their history and who feel that those spaces, buildings, artifacts, knowledge, etc., are part of their stories and identities. This is where formal training institutions are strategic allies; we require schools, kindergartens and colleges in which the concept of heritage is embedded in all sciences and disciplines and is not only exclusive to history and social sciences. Institutions that make part of their curricular planning those works and publications that address our heritage and can link with those who are always in dialogue with the territory. In this endeavour, the sum of new digital platforms and technological tools that are thought and rethought from a heritage perspective must be considered, technologies in line with the demands, needs and projections of the 21st century.

The Role of Digital and Non-Digital Technology

Traditional and novel digital and non-digital technology has revolutionised the way we can engage with our cultural heritage. From capturing, documenting, mapping, scanning and recording to 3D interactive modelling, reconstructing, storytelling and re-generating it using Artificial Intelligence (AI) prompts, we can explore and bring along the past to the present, or at least what we get to access from it. Such use of digital and non-digital technologies can help local individuals, groups and

communities to (re-)gain a profound sense of belonging and identity within communities. Digital platforms, including websites, social media and online forums, have become interactive spaces where individuals and groups can discuss, share experiences and explore their roots, leading to an augmented cultural consciousness. This heightened engagement not only aids in the preservation and dissemination of cultural values, practices and traditions but also can nurture a deeper sense of being from the place, connecting with cultural heritage in unprecedented ways.

The preservation and documentation of cultural heritage are critical aspects in ensuring its longevity and accessibility to future generations. Digital technology offers innovative solutions, such as for example LiDAR scanning now available on smartphones, which not only allows for the creation of accurate digital replicas of historical artifacts, monuments and cultural sites but also the interactive and immersive visualisation of them utilising virtual reality (VR), augmented reality (AR), mixed and/or extended reality (XR), digital video storytelling, 360 tours and more. These digital replicas act as safeguards, protecting tangible heritage from physical degradation, climate change and human-made disasters. Furthermore, AI algorithms play a crucial role in the analysis and interpretation of extensive datasets, contributing to the possibility of a more nuanced understanding of cultures and their evolutionary trajectories. Modern non-digital technologies like 3D printing, from a range of organic to plastic materials to generating new biomaterials, permit a more tangible and haptic access to the past, engaging the body beyond a digital screen. Both digital and non-digital technology provide unique possibilities for cultivating and fostering cultural heritage and belonging.

In addition to preservation, digital technology revitalises and reconnects communities with their cultural heritage, particularly those facing endangerment. Language preservation and revitalisation apps or cultural knowledge and practice learning platforms empower groups and communities to learn their roots, languages and ways, all vital components of their heritage. Moreover, immersive technologies and experiences offer the possibility to virtually visit the past, or a version of it, and connect with historical events, practices and wisdom, bringing together generations and their collective history. Digital platforms, therefore, become the means to facilitate a continuous and dynamic relationship between individuals and their cultural heritage.

Digital technology today can be accessed practically from anywhere. This offers a link to cultural heritage for those away from their lands and places of origin and belonging, yet still able ‘to be there’ virtually. And vice versa, people from abroad can learn and engage with others’ cultural heritage and sense of belonging, to appreciate it and many times seek inspiration from it for their own. This has given us the possibility to promote a profound impact on the dissemination and access of cultural heritage to a global audience. Such dissemination and inspiration transcend geographical constraints and cultural barriers, enabling individuals and communities from diverse backgrounds to access and appreciate the cultural heritage of others.

Virtual online tours and on-site exhibitions and interventions sharing cultural practices and events fostering intercultural understanding and appreciation can engage the feelings and the senses, providing tangible and memorable experiences of the past. The critical engagement with multimedia presentations and digital storytelling provides engaging narratives that captivate a diverse audience, encouraging exploration and understanding of various cultures. Digital and non-digital technology, thus, can transform the way we interact with and appreciate the richness of local and global cultural diversity.

From fostering a sense of belonging through interactive online spaces to revolutionising preservation efforts and facilitating a broader understanding of diverse cultures, the impact of technology is profound and far-reaching. As technology continues to advance, it is essential to critically, ethically and equitably harness its potential, ensuring that our belonging and cultural heritage remains accessible, engaging and deeply integrated into our lives.

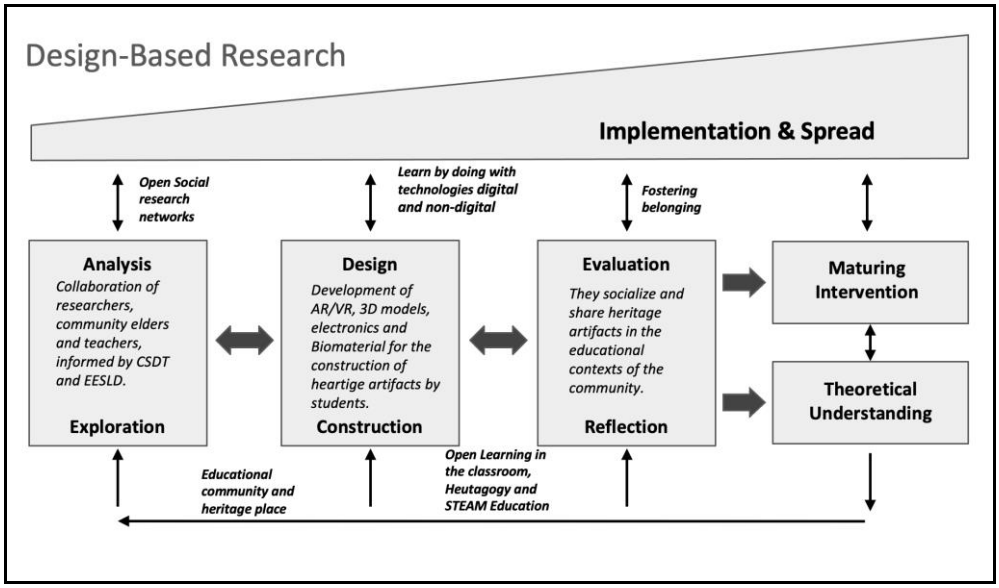
Exploring Digital Technology in Practice: A Case Study from La Higuera

Here, we present a one-year study following a design-based research (DBR) methodology (The Design-Based Research Collective, 2003) based on a case study at La Higuera Commune, Coquimbo Region in Chile. The fundamental purpose of DBR is to provide practical solutions to real-life problems through research, co-design with end users and experts, prototyping solutions in context and producing design principles for best practices, implementation and transferability to other similar contexts and environments (Figure 3). With this methodology, we address the following question from the design of cultural heritage artefacts and learning experiences with different technologies to foster belonging: how can we cultivate cultural heritage that germinates the past of places and promote belonging using digital and non-digital technologies in the 21st century? Our response is through the design of educational resources that can combine diverse experiences during the prototyping of heritage artefacts using non-digital technologies, such as the use of biomaterials and digital ones, such as 3D modelling and manufacturing, electronics with Arduinos, augmented and virtual reality.

To avoid an extractivist logic of heritage value that occurs in stark educational practices, we draw on the design principles derived from the Culturally Situated Design Tools (CSDT) (Bennet & Eglash, 2023), as well as Ethical Enactivism for Smart Learning Design (EESLD) (Aguayo et al., 2023). A crucial aspect of CSDT and EESLD is that students can use them to pursue their interests using different materials, tools and technologies. This freedom and independence allow students to delve deeper into their own cultural identity during hands-on learning, whether to recreate or create something completely new, prompted by the stories and heritage artefacts of their own places. To shape this project, we worked with representatives of the Commune of La Higuera, both local elders who preserve the heritage of the place and the local historian José Aguilera, who has described in his books the invaluable historical value of the cultural heritage of the commune. Subsequently,

some heritage artefacts are selected that could be designed, built and used by the local population, especially students and teachers of the commune, to learn about the place from an interdisciplinary approach, as is the case of generative STEAM education and ethical responsibility.

Figure 3
Design-Based Research



Note. In design-based research, through interdisciplinary collaboration, the abandonment of the material heritage of the Commune of La Higuera and its low valorisation and inclusion in educational processes are problematised. Then, in iterative cycles of design and evaluation with the community, a set of heritage artefacts was selected and built with digital and non-digital technologies. Subsequently, and through the active participation of community members and researchers, the heritage artefacts created were socialised and shared with the local people to improve them, considering the validation of the local elder and the educational practice of fostering belonging and valuing their own community by applying them in their educational processes. By the authors. Copyright the authors 2024.

To implement heritage artefacts in educational contexts with the participation of students and teachers, we use the generative STEAM approach that promotes the use of active methodologies, curricular integration and the development of 21st-century skills, as is the case of education. STEAM (Science, Technology, Engineering, Art and Math). We ascribe to the cultural approach of generative STEAM proposed by Eglash (2019) to reveal the knowledge of generally under-represented Indigenous peoples through project-based learning with digital technologies. Likewise, we adhere to the curricular innovation challenges of the Chilean Ministry of Education MINEDUC (2023), which promotes STEAM as an interdisciplinary approach based on projects and oriented to belonging and

educational inclusion. We set down STEAM education, assuming that the evidence at hand shows a decreasing interest among students in learning new content from conventional methodologies that preserve memorisation over learning by doing in projects with digital technologies (Jenny, 2023). Consequently, there is a lack of active methodologies that revitalise the experience of learning by doing together, such as project-based learning, above all, because colonising educational myopia privileges dualism and subject tourism, promoting the teaching of the subject of history and geography with arid texts that inhibit students' interests in learning about cultural heritage by getting physically involved (Ibarra, Bonomo & Ramírez, 2014).

DBR Phase 1: Analysis and Exploration of Cultural Heritage

In Phase 1, at the beginning of 2022, the first approaches to La Higuera Commune began through a local historian and a defender of the cultural heritage of the place. The aims were to explore the territory geographically and delve into the history of the commune, considering the available findings and books published to date. Subsequently, visits were made to the towns of Maray, where permission was requested from the local elder 'Don Jorge' to enter the place where he preserves the material heritage of 'Trapiche' or 'Maray,' which refers to an artefact like a mortar, which allowed the origin of the 20th-century mining of the commune. The local elder provided us with invaluable accounts of the place, as well as explanations on the use of the artefacts with physical demonstrations of the mechanisms that allowed us to identify technology, mathematics, science and art. We also visited the elders 'Los Vergara' of Punta de Choros, who are originally from the coastal Indigenous people called 'Los Changos,' who currently protect and conserve cultural artefacts that are part of the heritage of La Higuera. One of the characteristic artefacts of Los Changos is the sea lion-hide raft, the original version of which is found in the Gabriel Gonzalez Videla Historical Museum of La Serena. Los Vergara provided historical narratives that allowed us to expand our understanding of Los Changos, as well as illustrative explanations about the 'Wolf Hide Raft.'

The most immediate approach to the Chango Indigenous communities was with the local historian José Aguilera, specifically in the development of the research and book *I Opened My Eyes Under the Sea* (Rivera et al., 2020), where he was able to socialise with the Vergara family and feel the feelings and practices that they try to preserve. Likewise, working with Felipe Rivera, a descendant of the 'monkey Robe' (Roberto Alvares), the last builder of wolf skin rafts in Chañaral de Aceituno, prompted him to investigate the presence of rafters in the commune of La Higuera. This research was presented in the 'Coastal development of the commune of La Higuera, history and cultural heritage 1821-1970 online seminar: Humboldt Archipelago, hope for the sustainable development of Chile, 2020,' and 'Between direct sales, the garroteros and the Vileños: trade and transformations of the coves of the commune of La Higuera (1870-1980),' developed in the II Version of the Seminar on Protected Coastal Marine Areas for Multiple Uses North Central Zone:

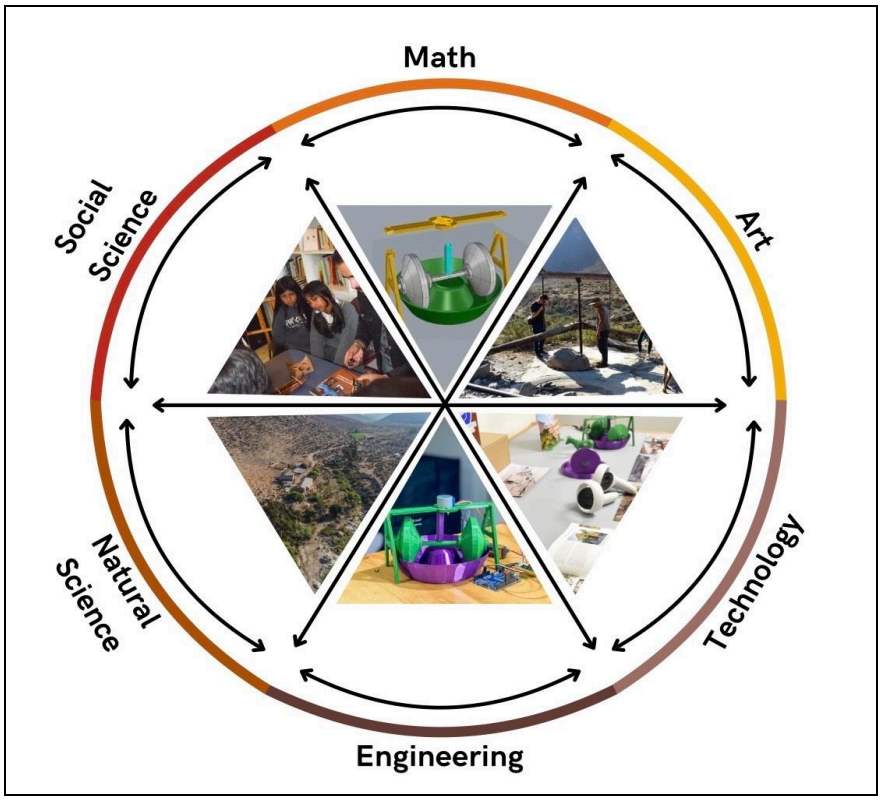
Advances and Challenges of the AMCP MU Bi-Regional Humboldt Archipelago 2022 and in the book *Commune of La Higuera, its People and its History* (Aguilera, 2022). Based on conversations with the community of La Higuera, represented by the local historian José Agulera and the elders who preserve the cultural heritage, it was decided to start the digital and non-digital co-design of the artefacts 'Trapiche' and 'Wolf Hide Raft.'

DBR Phase 2: Design and Construction of Artefacts with a STEAM Approach

The STEAM educational approach fosters culturally-based socio-material environments that cultivate curiosity, creativity and learning by makers using digital and non-digital technologies applied to real situations that catalyse problems of sustainability, inclusion and dis-identity (Videla, Veloz & Pino, 2023). From this generative and decolonising approach, the projects are framed as 'an educational system in which value is not extracted, but rather circulated in unalienated forms, via science, technology, engineering and mathematics (STEM) learning and innovation, back to the communities in which it was generated' (Eglash et al., 2019, p. 1570). In our case, we refer to the generative STEAM approach that incorporates art as a discipline that expands the restrictive field of STEM, opening up unsuspected opportunities for the incorporation of design, literature, sculpture, architecture and dance, among other disciplines (as represented in Figure 4). In this way, we break with the fallacy of teaching and learning in superficial and linear disciplines, in which one hopes to acquire one knowledge to begin another, ignoring the invaluable wealth of the complexity of informal, practical and culturally situated educational processes. Based on our research in STEAM (see Videla, Aguayo & Veloz [2021], Videla et al. [2023] and Aguayo et al. [2023]), we have identified in fieldwork with students and teachers that forms of tacit knowledge emerge that guide attention and motivation on artefacts and organisms, allowing them to articulate the disciplines with reference to contexts, designs, utilities, components and mechanisms. This offers an inclusive didactic opportunity for STEAM educational designers who wish to encourage the participation of all their students inside and outside the classroom, as well as building a didactic sequence integrated with the curriculum, based on the ethical and aesthetic complexity of things, through learning by makers working together. For example, Eglash et al. (2020) describe how students learn STEAM knowledge and skills synergistically through mathematical and computational exploration and modelling of animal horns, plants, trunks, arches and ritual dances.

Figure 4

Representation of Interdisciplinary Education Based on a Pedagogy of Place



Note. In interdisciplinary education based on a pedagogy of place, the use of technologies enriches the conceptual understanding of cultural heritage through learning by doing framed in the CSDT, which assumes that STEAM education is already integrated into knowledge systems, cultural and vernacular designs. By the authors. Copyright the authors 2024.

Likewise, and following Bateson (1979), the incorporation of art in scientific understanding highlights aesthetic education, which consists of sensitivity to the pattern that connects everything. In this way, the course of actions with the materials opens a field of unprecedented and interdisciplinary possibilities for understanding by exploring the lines, shapes, textures, indentations, mechanisms and colours of the artefacts that are intended to be reconstructed with digital and non-digital technologies. The patterns usually emerge from contingent relationships that occur when students participate in projects motivated by their own interests, in which autonomy, collaborative work and learning with different types of technologies and materials lead to greater material engagement (Malafouris, 2013).

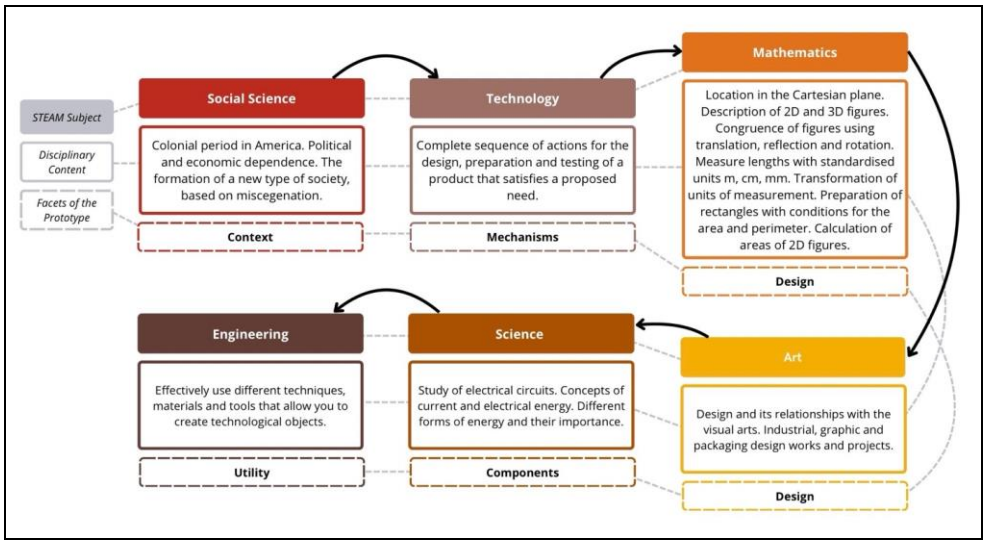
Penny (2023) argues that the embodied cognition with artifacts and materials germinates in dynamic learning processes characterised by chance, accidents and surprises that are generally invisible to a Western/transmissive pedagogy that relieves the world's immaterial understanding in symbolic. The cognitivist imperative of an intellectualism incorporated the body of educational processes, kidnapping perception and senses by virtue of symbolic processing. In this way, the dualism mind/body or thought/action characteristic of cognitivism that has permeated the formal curriculum with Western pedagogy has perpetuated forms of bank education harmful to the revindication of the educational praxis of the peoples (Ryle, 1949; Freire, 1978). Cognition has roots in sensorimotor dynamics, because it is intimately linked to biological-cultural systems; therefore, knowing is doing and doing is knowing (Varela et al., 1991; Villalobos & Videla, 2023). This dynamic loop of perception, cognition and action allows us to open new ways of understanding educational practice with digital and non-digital design. From a 4E contemporary approach, the construction of artifacts or the generation of designs imply different multiscale interactions, which involve cerebral plasticity, proprioception and narrative exchanges, providing a holistic understanding of learning with digital and non-digital technologies.

The knowledge cultivated in material engagement that encourages heritage and cultural identity to emerge from the dance of agencies through the flow of skills, materials, tools and people derived from condensed stories (Pickering, 2024). Skills such as creativity and serendipity that are distributed as a performative process by designing with different materials and technologies contribute to shaping cognition through action (Ross & Arfini, 2023). This provides to fruitful frame for a skilful practice field to explore the cultural and experiential wealth of decolonising pedagogy when designing and building heritage artifacts with digital and non-digital technologies.

In our study, students and teachers participate in the design and construction of heritage artefacts using different technologies that constitute sociomaterial, culturally based environments. In this context of learning based on generative STEAM projects, students first become aware of their experiences and the stories of the community, as is the case of Don Jorge from the town of Maray, where the co-design of the artefact is conceived as the heritage of the 'Trapiche' and, in the case of Los Changos, provided by the Vergara elders of the town of Punta de Choros. Once students and teachers participate in these informative activities, they develop more complex skills during the process of designing and building prototypes related to cultural heritage to foster belonging (Figure 5). To ensure that the project activities were amalgamated with the curricular coverage of the regular study plan, the contents of the STEAM disciplines and the learning objectives of a fifth year of primary education were selected (see Table 1 below).

Table 1

Curricular Integration of STEAM Disciplines



Note. Curricular integration of STEAM disciplines that are part of the interdisciplinary educational project creates heritage artifacts applied to formal education. From each STEAM discipline, learning objectives were selected that are declared in the study plans to be implemented in integrated lessons.

Once the heritage artefacts corresponding to the 'Trapiche' and 'Wolf Hide Raft' were selected, curricular integration was carried out to be able to incorporate the digital and non-digital design construction project into formal educational processes through project-based learning. The idea is that students could participate in co-design and project development processes for each of the two artefacts. In the case of the digital technologies of the 'Trapiche,' 3D modelling and manufacturing, electronic technologies with Arduinos and a 3D scanner were used to generate augmented reality elements with the Polycam App. Likewise, an immersive tour of the territory where the Trapiche heritage is located was carried out through 360º filming and later incorporation into Oculus Meta Quest 2 virtual reality glasses. Below are the digital and non-digital designs corresponding to the heritage artefacts of the 'Trapiche' (Figure 5) and 'Wolf Hide Raft' (Figure 6).

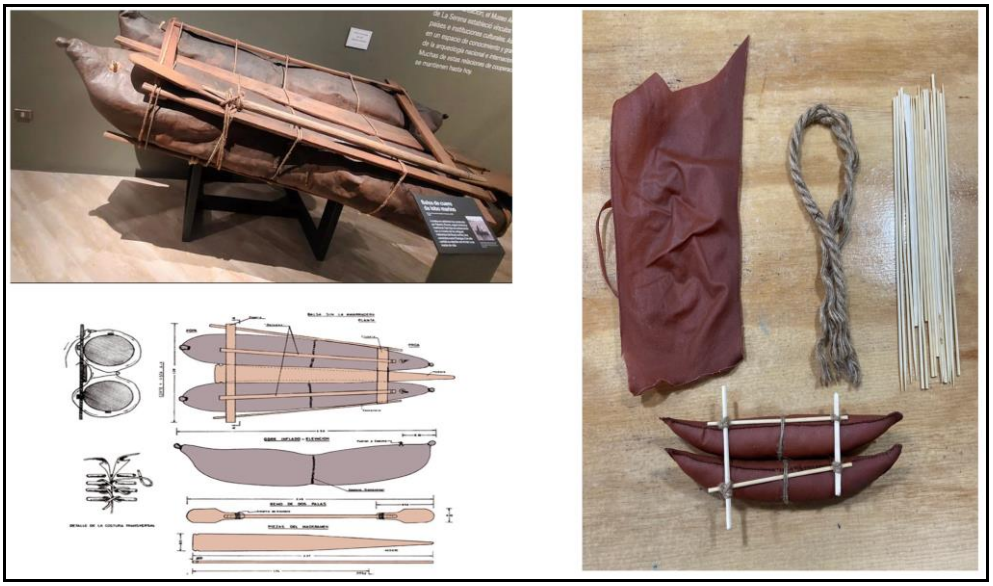
Figure 5

The 'Trapiche'

Note. Digital 3D modelling and manufacturing technology, electronics with Arduinos and virtual reality were used to represent the 'Trapiche' that corresponds to the cultural heritage of the Commune of La Higuera. By the authors. Copyright the authors 2024.

Figure 6

The 'Wolf Hide Raft'



Note. Non-digital biomaterials were used to represent the 'Wolf Hide Raft' that corresponds to the cultural heritage of the Commune of La Higuera. By the authors. Copyright the authors 2024.

The artefact prototypes were co-designed and built based on knowledge of the place and incorporated digital and non-digital technologies to provide new ways of learning about the cultural heritage and fostering belonging of the La Higuera community. The idea of providing various technologies to scaffold the understanding and abstraction of the cultural heritage of the commune beyond books and images, consists of designing cognitive activities that do not exploit the world in search of disembodied colonialist knowledge but rather provide technological material environments, cumulatively generating local skills, artefacts and knowledge that arise from action through things.

DBR Phase 3: Participatory Evaluation and Reflection of the Artefacts

In this phase of design and construction of non-digital and digital prototypes, we used the symbiosis of selected design principles from Culturally Situated Design Tools (CSDT) and Ethical Enactivism for Smart Learning Design (EESLD) for a generative and ethical STEAM education of the cultural heritage artefacts. For this, the design and development involved a continuous cycle between the following DBR elements.

1. Collaborative refinement of practical problems:

a. design through early participatory processes of consultation with the community in all stages of the project

b. realise ethnographic, sociocultural and cultural-historical partnership-driven research to understand the larger context and give contextuality to educational projects, programs and interventions

2. Development of solutions based on existing theory and technological innovation:

a. incorporate identified problems and needs of the communities into the design challenges

b. wherever possible, have members of the local 'target audience' working closely with the design team, ideally leading design processes where appropriate

c. consider the natural and cultural heritage expressed in symbols, artefacts, tacit and intangible knowledge of local communities, such as the flora and fauna of the place and more

3. Iterative cycles of testing and implementing solutions in practice:

a. promote an ethical, enactive approach that promotes critical learning by doing among all, through recursive prototypes that offer

b. allow for multiple perceptual possibilities to unfold their experiences

c. co-design the prototypes with community representatives involving continuous content-context iteration to reaffirm relevance

4. Reflection to produce design principles and improve solution implementation:

a. validate the final prototype until reaching the majority consensus of the community, achieving acceptance and transferability.

The incorporation of these design principles starts with the understanding of the context, participatory design with the La Higuera community and the exploration of digital and non-digital materials and tools to create and revitalise cultural heritage. The objective is for students to use different technological tools to authentically learn what Eglash et al. (2016) call 'legacy algorithms.' In this sense, students and designers creatively use the integration of materials and tools to generate their own innovations. Our examples suggest that educational processes based on authentic learning by doing together do not require the Western canon on which colonial and oppressive teaching is based in which teachers fill students' heads with content. Rather, these types of approaches and methodologies help teachers to 'educate perception' through continuous and generative doing, so that ontology grows with practice.

Figure 7

The 'Trapiche' and the 'Wolf Hide Raft'

Note. This representation of the 'Trapiche' and the 'Wolf Hide Raft' using digital and non-digital technologies corresponds to the cultural heritage of the La Higuera Commune. By the authors. Copyright the authors 2024.

From this perspective, students commit to the natural course of their actions as the heritage artifacts of the place are embodied and recreated, considering new technologies that allow them to combine actions and materials to better understand their structure, design, mechanics and worldview of the place. Designers, teachers and students see new possibilities for understanding the cultural heritage of the commune by using digital and non-digital technologies that open up an indefinite potential for authentic, ethical and responsible learning in promoting cultural identity with, in and through the things.

DBR Phase 4: Design Principles for Digital Preservation of Cultural Heritage

In the maturation, intervention and theoretical understanding phase of our Design-Based Research (DBR) methodology applied to La Higuera Commune, we addressed the nuances of digital preservation of cultural heritage. The key considerations for digital heritage projects encompass a comprehensive approach to capturing, modelling and disseminating cultural artefacts and narratives through digital means. The integration of 3D scanning, augmented reality and virtual experiences offers an immersive way to preserve and share the rich history and culture of La Higuera. These technologies not only facilitate a vivid representation of artefacts like the 'Trapiche' and 'Wolf Hide Raft' but also ensure the longevity of cultural narratives against the erosion of time. Our methodology underscores the importance of fidelity in digital reproductions, ensuring that they are not just mere replicas but carry the essence and stories of the original artefacts. By leveraging digital platforms, we enable global access to La Higuera's cultural heritage, thus broadening the impact and understanding of its historical significance.

Addressing ethical and cultural sensitivity in digital preservation is paramount. Our approach is rooted in respectful collaboration with the local community of La Higuera, involving them in every step of the digitalisation process. This collaborative effort ensures that the digital representations of cultural artefacts are created with a deep understanding of their cultural, historical and social contexts. Ethical considerations include the consent and active participation of local knowledge holders, the accurate representation of cultural artefacts and the mindful use of these artefacts in educational and public domains. This process respects the community's autonomy over their cultural heritage and avoids the commodification of their cultural assets. It emphasises the role of digital heritage projects as a bridge between generations, enabling the transfer of knowledge and the preservation of cultural identity.

Lastly, the principle of accessibility and inclusivity in sharing digital cultural heritage ensures that the resources developed are available to a diverse audience, including those with disabilities. Our project adopts universal design principles in the creation of digital interfaces and experiences, making sure they are user-friendly and accessible to individuals with varying physical and cognitive abilities. This inclusivity extends to the linguistic and cultural adaptation of content, ensuring that it is engaging and informative for both locals and the global community. By prioritising accessibility, we aim to democratise access to cultural education, allowing for a wider appreciation and understanding of La Higuera's unique heritage. This commitment to inclusivity not only enriches the learning experiences of individuals but also fosters a deeper, more respectful global engagement with the cultural heritage of communities like La Higuera.

Discussion and Conclusion

Summary of Findings

The general objective of this study was to promote the belonging of the educational community through the co-design of digital and non-digital technological resources based on the local cultural heritage. For this, a research methodology based on design was carried out, which allowed for exploring, designing, prototyping, building, evaluating and transferring knowledge of the cultural heritage of the commune of La Higuera. This process considered the integration of design principles inspired by Culturally Situated Design Tools (CSDT) and Ethical Enactivism for Smart Learning Design (EESLD) to promote cultural belonging in local students and teachers, through project-based learning with a generative STEAM approach. All this with the purpose of involving members of the educational community through the integrated design of STEAM disciplines that promote creativity, collaboration, critical thinking and computational thinking skills by incorporating the cultural heritage of the place to promote the circulation of value in the community from a decolonising pedagogical practice.

The study begins with the characterisation of the location and the context of the cultural heritage of the Commune of La Higuera to provide relevant historical, geographical and cultural background of the place. For this, emphasis was placed on the cultural and material heritage of the Commune, such as the 19th-century church of El Maray and the rock art of Los Morros, the oven to make charcoal, the artisanal mill to extract water, the mural alluding to the Indigenous Changos and authentic replicas of their 'Wolf Leather Raft' and animal action mill and automated plants called 'Trapiche.' The Commune of La Higuera has an invaluable wealth of heritage that has unfortunately been abandoned, left in the voluntary care of local elders who fight to preserve the local heritage and foster belonging. Subsequently and with the purpose of encouraging this fight, we proposed to discuss the theoretical, epistemological and methodological foundations that highlight the preservation of heritage and belonging in the communities of the Global South. To this end, we argue for ethical, embodied and culturally situated digital and non-digital design of heritage artifacts that are co-constructed within the framework of generative pedagogical perspectives such as STEAM education and postcognitivist approaches. In particular, we discuss the implications of education based on interdisciplinary decolonising projects that place heritage as an inexhaustible source of historically condensed knowledge, from which teachers and students draw and circulate cultural value. This process, in turn, occurs through material engagement with technologies, expanding new emergent learning opportunities that result from embedded interactions enabled by culturally settled sociomaterial environments in the form of dances of agency.

With the objective of fostering belonging through learning hands-on with digital and non-digital technologies in which cultural heritage is incorporated from a generative STEAM educational approach, we reflect on the potential of digital

innovation based on research based on Culturally Situated Design Tools (CSDT) and Ethical Enactivism Smart Learning Design (EESLD) for heritage preservation and fostering belonging. We integrated the principles of (CSDT) and (EESLD) during the design-based research (DBR) that we used, and that allowed us to propose practical solutions in a participatory and situated way based on the analysis of the context of the Commune of La Higuera. Heritage artifacts were chosen that were subsequently designed, co-constructed in a digital and non-digital technological way and evaluated and shared in the commune and by the school in the town of Caleta Los Hornos. The set of design principles (CSDT and EESLD) allowed us to safeguard the circulation of the cultural value of the place's heritage, in which the 'Trapiche' and the 'Wolf Leather Raft' of the Los Changos indigenous people were chosen. These technological artifacts were validated by students and teachers of the commune, where they had the opportunity to use them in classes and exhibit them at different events to disseminate local educational projects.

With the aim of delving deeply into the design principles for fostering belonging from the Generative STEAM approach and with an emphasis on learning hands-on, we set out to design digital and non-digital educational resources focused on cultural heritage that promote new ways of teaching and learning through of the postcognitivist 4E cognition approach. We take the 4E approach to mean that cognition is situated, anti-representationalist and based on the embodied experience of learning by makers. The digital recreation of the 'Trapiche,' which consists of the first mineral grinding mechanisms that gave rise to local mining, was done based on fieldwork at the site of the elder Jorge Godoy, who protects and preserves this artifact. After conversations and explanations with this elder about the operation of the 'Trapiche,' we decided to recreate it using 3D modelling and manufacturing, to later incorporate Arduino electronic boards and a servo motor that would allow us to automate the grinding mechanism through code programming. To introduce teachers and students to this topic, an interactive 360º immersive tour was developed in order to present and characterise the place, and allow all interested people to access it virtually. In the case of non-digital technology, the 'Wolf Hide Raft' of the Los Changos indigenous people was recreated through a brown 3D-printing biofilm that replaces animal leather, and to achieve its colour and texture, different components were used, such as algae, pigments, glycerine and recycled sticks, as well as cotton and sewing thread. The prototype of the raft was validated by the Vergara elders, who are descendants of Los Changos and who, after several conversations and invaluable historical narrations about the construction of rafts, allowed us to disseminate the recreated prototype with the aim of promoting their culture and fostering a sense of belonging. Finally, these technological products were incorporated into a Generative STEAM educational KIT that could be used by students and teachers through interdisciplinary projects that were generated to promote various forms of learning by makers with digital and non-digital technologies, demonstrating the embodied potential of enactive,

embedded and extended cognition by recreating the cultural heritage 'Trapiche' and the 'Wolf Hide Raft.'

Discussion

Our research based on the cultivation of cultural heritage and the fostering of belonging in lagging communities, which are far from the concentration of opportunities available in cities, provides new ways of thinking about heritage education using digital and non-digital technologies, following principles of design of culturally responsive pedagogy (Bishop et al. 2014). We oppose the exclusively encyclopaedist, monolithic and disembodied education of teaching the historical and geographical background of cultural heritage. Our proposal vindicates the emancipatory pedagogy of an anti-banking education based on praxis (Freire, 1985), as well as a generative STEAM approach. Eglash et al. (2020) highlight the circulation of cultural value over the extractive colonising logic with which the technological educational design of the heritage has been thought out. For this, in the Commune of La Higuera and, in particular, in the town of Caleta Los Hornos, through DBR and using the symbiosis of design principles (CSDT) and (EESLD), it was possible to co-design with elderly people who preserve cultural and material heritage. Students and teachers actively participated in the digital and non-digital recreation of the cultural heritage of their communities, connecting with their heritage from a bottom-up logic in opposition to the predominance of Western thought (Eglash et al., 2017).

In this framework, we borrow the 4E cognition approach to rethink 21st-century education (Videla et al., 2021), in which interdisciplinary approaches such as STEAM use project-based learning to promote learning by makers with technologies from an inclusive, sustainable and social justice perspective (Aguayo et al., 2023; Videla & Veloz, 2023). Unlike generally reproductive and instrumental STEAM approaches in which value is extracted from cultural heritage, our research fosters the circulation of value for the prevention of value alienation through embodied and situated practices with technological tools that shape cultural artefacts. Our study aligns with the evidence presented by Eglash (2019) regarding the invaluable opportunities to expand student agency that CSDT provides in developing Generative STEM projects that preserve indigenous culture. Likewise, our proposal adheres to the educational methodological approach proposed by Deng et al. (2022), in which the C-STEAM approach and project-based learning incorporate cultural heritage, reporting significant improvements in cultural identity and belonging. Likewise, our proposal adheres to the critical foundations of a counterhegemonic practice by using digital and non-digital technologies and artefacts in favour of projects that highlight learning in projects that highlight the culture of underrepresented communities.

Implications and Future Directions

Our research complements the emerging evidence on Generative STEM education from STEAM that includes art and postcognitivist approaches that celebrate the role of experience and culture. The future directions of this research are in the generation of a STEAM Educational Kit focused on the cultural heritage of the Trapiche and the Wolf Hide Raft with digital and non-digital technologies, to be disseminated in the different schools that are part of the Commune of La Higuera. Likewise, being able to incorporate other heritage artefacts and narratives from elders and community representatives to generate projects that foster belonging. Another future direction is to explore the transfer of the emerging design principles coming from this project situated in the commune of La Higuera in Chile into other localities within and beyond this target country. This could be done with the aim of confirming, consolidating, expanding and improving such design principles to foster a sense of cultural belonging based on digital and non-digital technologies and artefacts across the Global South and beyond.

Acknowledgements

We thank María Fernanda Aranda, Daniela Jorquera and Marcelo Chávez for their support in digital and non-digital technological design and development. We also thank Don Jorge Godoy and the Vergara brothers for supporting this initiative through their invaluable stories about the cultural heritage of La Comuna de La Higuera. We would also like to thank the management team, teachers, and students of Colegio Carlos Condell de La Caleta Los Hornos.

Claudio Aguayo: https://orcid.org/0000-0003-1805-7737
José Aguilera: https://orcid.org/0009-0004-7081-8059
Maybritt Aros: https://orcid.org/0009-0003-0355-827X
Carola Cerpa: https://orcid.org/0000-0002-6180-5262
Camilo Ibacache: https://orcid.org/0000-0002-3152-0549
Paulina Valdivia: https://orcid.org/0009-0002-6154-4311
Ronnie Videla: https://orcid.org/0000-0002-1038-2968

References

Aguayo, C. (2023). Autopoiesis and 4E+ cognition in the design of digital learning affordances. *Constructivist Foundations*, *18*(2), 325-337. Retrieved from https://constructivist.info/18/2/325.aguayo

Aguayo, C., Eames, C., & Cochrane, T. (2020). A framework for mixed reality free-choice, self-determined learning. *Research in Learning Technology*, *28*. http://doi.org/10.25304/rlt.v28.2347

Aguayo, C., Videla, R., López-Cortés, F., Rossel, S., & Ibacache, C. (2023). Ethical enactivism for smart and inclusive STEAM learning design. *Heliyon*, *9*(9). https://doi.org/10.1016/j.heliyon.2023.e19205

Aguayo, C., Videla-Reyes, R., & Veloz, T. (2023). Entangled cognition in immersive learning experience. *Adaptive Behaviour*, *31*(5), 497-515. https://doi.org/10.1177/10597123231183996

Aguilera, J. (2018). *Caleta Los Hornos: Imágenes, memoria e historia [Caleta Los Hornos: Images, memory and history]*. ULS.

Aguilera, J. (2022). *Comuna de La Higuera: su gente y su historia [Commune of La Higuera: its people and its history]*. Marmor Graphic.

Aguilera, J. (2023). *Notas de viajes, historias de un recorrido por la comuna de La Higuera [Travel notes, stories and accounts of a tour of the commune of La Higuera]*. Marmor Graphic.

Alianza Humboldt Coquimbo Atacama. (2020, September 13). *Seminario online: Archipiélago de Humboldt, esperanza para el desarrollo sostenible de Chile*. YouTube. https://www.youtube.com/watch?v=AUdNI5i-V3o

Alianza Humboldt Coquimbo Atacama. (2022, November 11). *Seminario áreas marinas costeras protegidas de múltiples usos, zona centro norte.* Facebook. https://www.facebook.com/108251801397144/videos/494882652592626/

Bahho, M., Vale, B., & Milfont, T. L. (2023). An investigation into heritage, sustainability and place attachment: The Ōtātara case study. *Heritage & Society*, *17*(2), 239-257. https://doi.org/10.1080/2159032X.2023.2230832

Bateson, G. (1979). *Mind and nature: A necessary unity*. E. P. Dutton.

Bennet, A., & Eglash, R. (2023). *Heritage algorithms combine the rigours of science with the infinite possibilities of art and design*. School of Information University of Michigan. https://stamps.umich.edu/news/audrey-bennett-and-ron-eglash-explore-heritage-algorithms-in-new-op-ed

Bibi, S., Sari, D. S., & Putra, M. (2020). The design of multimedia storytelling. *English Language Teaching Educational Journal*, *9*(1), 1-12. https://doi.org/10.15294/elt.v9i1.34614

Biblioteca del Congreso. (n.d.). *Región de Coquimbo: Chile nuestro país.* https://www.bcn.cl/siit/nuestropais/region4

Bishop, R., Berryman, M., Cavanagh, T., & Teddy, L. (2014). A culturally responsive pedagogy of relations: Effective teaching for Māori students. In A. St. George, S. Brown & J. O'Neill (Eds.), *Facing the big questions in teaching: Purpose, power and learning* (pp. 165-173). Cengage.

Chouteau, E. (1887). *Informe sobre la provincia de Coquimbo presentado al supremo gobierno [Report on the province of Coquimbo presented to the supreme government]*. National Printing Office.

Cleary, E. (1999). *El Tofo: Historia de un extraordinario pueblo minero en el norte de Chile [El Tofo: History of an extraordinary mining town in the north of Chile]*. Eda Cleary.

Design-Based Research Collective, The. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher*, *32*(1), 5-8. https://doi.org/10.3102/0013189X032001005

Deng, H., Li, S., Gao, S., Li, Z., & Hong, C. (2022). Design and practice of a C-STEAM curriculum of intangible cultural heritage: Taking a key secondary school in Zhuhai as an example. In *Proceedings of the 6th International Conference on Education and Multimedia Technology (ICEMT' 22)* (pp. 245-251). Association for Computing Machinery. https://doi.org/10.1145/3551708.3551771

Dhonju, H. K., Xiao, W., Mills, J., & Sarhosis, V. (2018). Share our cultural heritage (SOCH): Worldwide 3D heritage reconstruction and visualisation via web and mobile GIS. *ISPRS International Journal of Geo-Information*, *7*(9), 360. https://www.mdpi.com/2220-9964/7/9/360

Eglash, R., Babbitt, W., Bennett, A., Bennett, K., Callahan, B., Davis, J., Drazan, J., Hathaway, C., Hughes, D., Krishnamoorthy, M., Lachney, M., Mascarenhas, M., Sawyer, S., & Tully, K. (2016). Culturally situated design tools: Generative justice as a foundation for stem diversity. In Y. Rankin & J. Thomas (Eds.), *Moving students of colour from consumers to producers of technology* (pp. 132-151). IGC Global. https://doi.org/10.4018/978-1-5225-2005-4.ch007

Eglash, R., Lachney, M., Babbitt, W., Bennett, A., Reinhardt, M., & Davis, J. (2019). Decolonising education with Anishinaabe arcs: Generative STEM as a path to Indigenous futurity. *Educational Technology Research and Development*, *68*, 1569-1593. https://doi.org/10.1007/s11423-019-09728-6

Eglash, R., Bennett, A., Babbitt, W., Lachney, M., Reinhardt, M., & Hammond-Sowah. D. (2020). Decolonising posthumanism: Indigenous material agency in generative STEM. *British Journal of Educational Technology*, *51*, 1334-1353. https://doi.org/10.1111/bjet.12963

Eglash, R., Bennett, A., Cooke, L., Babbitt, W., & Lachney, M. (2021). Counter-hegemonic computing: Toward computer science education for value generation and emancipation. *ACM Transactions on Computing Education (TOCE)*, *21*(4), 1-30. https://doi.org/10.1145/3449024

Feher, K., & Katona, A. I. (2021). Fifteen shadows of sociocultural AI: A systematic review and future perspectives. *Futures*, *132*, 102817. https://doi.org/10.1016/j.futures.2021.102817

Freire, P. (1985). *Pedagogía del oprimido [Pedagogy of the oppressed]*. México D. F. Siglo XXI Editores

Gutiérrez, F., Osorio, C., Arancibia, C., Orozco, P., & Monsalva, H. (2014). *Historias ancestrales de los Choros y Punta de Choros [Ancestral stories of the Choros and Punta de Choros]*. National Council of Cultures and Arts.

Hrebackova, M., & Štefl, M. (2022). Challenging intercultural discomforts: Intercultural communicative competence through digital storytelling. Journal of Language and *Cultural Education*, *6*(3), 78-88. https://doi.org/10.22363/2521-442x-2022-6-3-78-88

Ibarra, M., Bonomo, U., & Ramírez, C. (2014). El patrimonio como objeto de estudio interdisciplinario: Reflexiones desde la educación formal chilena. *Polis (Santiago)*, *13*(39), 373-391. https://dx.doi.org/10.4067/S0718-65682014000300017

La Higuera, Comuna, su Gente e Historia. (n.d.). Facebook group. https://www.facebook.com/groups/1517850908508130

Mackenna, V. (1883). *El libro del cobre y del carbón de piedra [The book of copper and charcoal]*. Cervantes Printing Press.

Malafouris, L. (2013). *How things shape the mind: A theory of material engagement*. MIT Press.

Marasco, A. (2020). Beyond virtual cultural tourism: History-living experiences with cinematic virtual reality. *Tourism and Heritage Journal*, *2*(1), 22-33. https://doi.org/10.1344/THJ.2020.2.1

Marsal, D. (2022). *Pensar patrimonios [Think heritage]*. UC Editions.

Marcial Aracena, F. (2011). *Apuntes de viajes: La industria del cobre en las provincias de Atacama y Coquimbo, los grandes y valiosos depósitos carboníferos de Lota y Coronel*

en la provincia de Concepción [Travel notes: The copper industry in the provinces of Atacama and Coquimbo, the large and valuable coal deposits of Lota and Coronel in the province of Concepción]. Pontificia Universidad Católica de Chile.

McKenney, S., & Reeves, T. C. (2012). *Conducting educational design research*. Routledge. https://doi.org/10.4324/9781315105642

MINEDUC. (2023). *Centro de Innovación Ministerio de Educación de Chile*. MINEDUC. https://www.innovacion.mineduc.cl/

Moraga, F. (n.d.). *Imágenes del mineral de La Higuera, siglo XIX [Images of the La Higuera mineral, 19th century]*. Serena.

Municipality of La Higuera. (2021). *Plan de desarrollo Comunal (2021-2024) [Communal development plan (2021-2024)]*. The FIG tree.

Ocón, D. (2021). Digitalising endangered cultural heritage in Southeast Asian cities: Preserving or replacing? *International Journal of Heritage Studies*, *27*(4), 355-370. https://doi.org/10.1080/13527258.2021.1883711

OECD. (2022). *Global plastics outlook: Policy scenarios to 2060*. OECD. http:// oecd.org/environment/plastics

Paéz, R. (n.d.). *Cultura minera en la Historia de La Higuera: Vida cotidiana de un pueblo minero del siglo XIX (1870-1900) [Mining culture in the history of La Higuera: Daily life of a mining town of the 19th century (1870-1900)]*. Municipality of La Higuera.

Parada, F. J., & Rossi, A. (2020). Perfect timing: Mobile brain/ body imaging scaffolds the 4E-cognition research program. *European Journal of Neuroscience*, *54*(12), 8081-8091. https://doi.org/10.1111/ejn.14783

Penny, S. (2017). *Making sense: Cognition, computing art and embodiment*. MIT Press.

Penny, S. (2023). Living in mapworld: Academia, symbolic abstraction and the shift to online everything. *Constructivist Foundations*, *18*(2), 188-198. https://constructivist. info/18/2/188

Petrelli, D., & Roberts, A. J. (2023). Exploring digital means to engage visitors with Roman culture: Virtual reality vs tangible interaction. *ACM Journal on Computing and Cultural Heritage*, *16*(4), 73. https://doi.org/10.1145/3625367

Pickering, A. (2024). What is agency? A view from science studies and cybernetics. *Biological Theory*, *19*, 16-21. https://doi.org/10.1007/s13752-023-00437-1

Protective League of La Serena (1876). *Aguinaldo a la liga protectora de La Serena: Publicación acordada en beneficio de esta Sociedad por su Directorio [Bonus to the Protective League of La Serena: Publication agreed for the benefit of this society by its board of directors]*. La Reforma.

Rivera, F., Zepeda, C., Díaz Plá, Aguilera, D., & Valdés, J. (2017). *Mar trabajo y memoria social de Caleta Chañaral de Aceituno [Sea work and social memory of Caleta Chañaral de Aceituno]*. Quiñe.

Rivera, F., Zepeda, N., Álvarez, C., Díaz Plá, R., Portus, V., Aguilera, J., Chamaca, G., & Valdés, J. (2020). *Abrí los ojos bajo el mar: Memoria de los changos del borde costero de la comuna de La Higuera en la región de Coquimbo [I opened my eyes under the sea: Memory of the Changos on the coastal edge of the commune of La Higuera in the Coquimbo region]*. Quiñe.

Rivera, F. (2020). *Process of revitalisation, recognition and organisation of the Chango people from the experience of the Changos of Caleta Chañaral de Aceituno*. https://www.cultura.gob.cl/wp-content/uploads/2021/04/folleto_proceso-de-revitalizacion-reconocimiento-y-organizacion-del-pueblo-chango.pdf

Ross, W., & Arfini, S. (2023). The role of serendipity in creative cognition. In L. J. Ball & F. Vallee-Tourangeau (Eds.), *Routledge handbook of creative cognition* (pp. 46-64). Routledge. http://dx.doi.org/10.4324/9781003009351-5

Swords, J., Nally, C., Rogage, K., Watson, R., Charlton, J., & Kirk, D. S. (2020). Colliding epistemologies, productive tensions and usable pasts in the generation of heritage-led immersive experiences. *International Journal of Heritage Studies*, *26*(9), 885-900. https://doi.org/10.1080/13527258.2020.1780462

Trichopoulos, G., Aliprantis, J., Konstantakis, M., Michalakis, K., Mylonas, P., Voutos, Y., & Caridakis, G. (2021). Augmented and personalised digital narratives for cultural heritage under a tangible interface. *SMAP*. https://dx.doi.org/10.1109/SMAP53521.2021.9610815

Thornton, I. (2023). A special delivery by a fork: Where does artificial intelligence come from? *Evolutionary Intelligence*, *178-179*, 23-32. https://dx.doi.org/10.1002/ev.20560.

Valdivia, B. (2016). *Tofinos en la niebla [Tofinos in the fog]*. Cubox.

Valencia, M. (2021). *La cuestión patrimonial: Resistencias barriales en la ciudad neoliberal Santiago de Chile (2007-2017) [The heritage issue: Neighbourhood resistance in the neoliberal city Santiago de Chile (2007-2017)]*. Ministry of Cultures, Arts and Heritage.

Varela, F. J., Thompson, E., & Rosch, E. (1991). *The embodied mind*. MIT Press. https://doi.org/10.7551/mitpress/6730.001.0001

Vicari, S., & Kirby, D. (2022). Digital platforms as sociocultural artifacts: Developing digital methods for cultural research. *Information, Communication & Society*, *25*(5), 609-625. https://doi.org/10.1080/1369118X.2022.2027498

Videla, R., Aguayo, C., & Veloz, T. (2021). From STEM to STEAM: An enactive and ecological continuum. *Frontiers in Education*, *6*, 709560. https://www.frontiersin.org/articles/10.3389/feduc.2021.709560/full

Videla, R., Ravanal E., Aros, M., & Ibacache C. (2023). Designing to transform educational practice: The art of inquiring and exploring from steam. *Constructivist Foundations*, *18*(2), 173-177. https://constructivist.info/18/2/173

Videla, R., Veloz T., & Pino, M. C. (2023). Catching the big fish: A 4E-cognition approach to creativity in steam education. *Constructivist Foundations*, *18*(2), 295-307. https://constructivist.info/18/2/295

Villalobos, R., & Alfaro, A. (2012). *Cuentos de mi terruño bajo La Higuera [Tales from my homeland under La Higuera]*. The FIG tree.

Villalobos, R., & Alfaro, A. (2014). *El mineral de La Higuera, tierra de zainos y promeseros [The mineral of La Higuera, land of zainos and promeseros]*. The FIG tree.

Villarroel, C. (2019). *Archipiélago Humboldt: Patrimonio natural y cultural del borde costero de la comuna de La Higuera [Humboldt archipelago: Natural and cultural heritage of the coastal edge of the commune of La Higuera]*. The FIG Tree.

World Bank (2023). *Building foundations for an inclusive digital future*. https://live.worldbank.org/en/event/2023/2023-annual-meetings-building-foundations-for-an-inclusive-digital-future