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Preserving World Cultural Heritage: Social Justice and Sustainability Competencies via Socially-Oriented Interdisciplinary Education

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Abstract

The world's cultural heritage (customs, practices, places, objects, artistic expressions, and values that signify a legacy of the history of humanity) provides identity to communities. In Mexico, the case of the World Heritage City of Xochimilco involves a sustainable agroecological system designed by its ancient inhabitants more than 500 years ago. Currently, the biodiversity and the chinampas (floating agricultural gardens) are at risk due to inconsistent government oversight and the lack of incentives for communities to carry on with the culture of agricultural production on Lake Xochimilco. Through a Challenge-Based Learning, a culturally relevant academic experience for university students was designed to involve them in preserving biodiversity while developing research and problem-solving skills. Satisfaction surveys and course evaluations indicated that this didactic methodology encouraged students to consider their connection to social justice issues and prompted them to expand their knowledge in their different disciplines. Socially-oriented experiential learning is an effective pedagogy that fosters a sense of social responsibility in students.

Keywords: Axolotl, challenge-based learning, educational innovation, higher education, higher-order skills, socially-oriented education, STEM education, sustainability, Tec21

Introduction

Socially-Oriented Interdisciplinary Education

Interdisciplinary education, very broadly, is a pedagogical approach that allows educators to integrate content from various academic fields into a particular learning experience (Jones, 2010; Rover, 2002; Spelt et al., 2009). Some of the potential advantages of interdisciplinary education are the advancement of academic learning (Repko, 2009), gains in critical thinking skills and growing appreciation for social and ethical concerns (Marlatt & Korang, 2020). However, instructors may face various challenges in higher education since there is a tradition of siloed academic field organization and learning. This is particularly true in science, mathematics, and engineering. These subjects are often taught as separate content units that are not connected to context and often do not carry clear cultural relevance for the learner. Yet the more significant the challenge, the more influential the impact. Thus, interdisciplinary education's potential is more effective in positively supporting student learning and motivation while connecting their developing understanding of content and social context.

Social Justice Through STEM

In an era of growing awareness of inequities across marginalized groups worldwide, social issues motivate solutions and contributions from all kinds of professionals, not only the traditional social workers. Engineers and Scientists find themselves in positions of influence that will allow them to influence social justice. In a study at the University of Texas at Austin (Madkins et al., 2020), researchers found that more than 50 % of under-represented students of color noted that working for social change was either "essential" or "very important" to their career goals. Frameworks that realize the potential of Social Justice Driven STEM Learning (Madden et al., 2017) offer hope and support for increasing students' critical consciousness and success in college.

World Cultural Heritage

A fundamental social role of education is its power to guide understanding and action towards considering issues in our immediate physical and cultural environments. STEM (Science, Technology, Engineering, and Mathematics) education helps us frame and understand complex phenomena uniquely surrounding us. Combined with integrating certain aspects of the social sciences, such as History, we are better equipped to understand the causes of our present and consider how society's evolution may require updated designs that promise a more sustainable and prosperous future.

For example, new communication technologies and social networks have created unexpected realities for the future of society. But along with this progress, the obvious problem of the loss of identity, cultural values and potentially those very elements that encompass cultural heritage has come. Specifically, for digital natives belonging to the Z generation (Caratozzolo et al., 2021), technological advances allow them to have an identity or virtual world with avatars, a parallel life, or an identification with imported values, often leaving aside the heritage values that characterize a community or a nation itself. UNESCO, in its Convention on the protection of the cultural world and natural heritage (United Nations Educational, Scientific and Cultural Organization (UNESCO), 1972), established that the following should be considered cultural heritage:

Monuments: works of architecture, works of sculpture and monumental painting, elements or structures of an archaeological nature, inscriptions, caves, and combinations of characteristics that have outstanding universal value from the point of vision of history, art, or science.

Building groups: groups of separate or connected buildings that, due to its architecture, homogeneity, or place in the landscape, are of outstanding universal value from the point of view of history, art, or science.

Sites: works of man or the combined works of nature and man, and areas including archaeological sites that are of outstanding universal value from the historical point of view, aesthetic, ethnological, or anthropological point of view.

The International Council on Monuments and Sites (lCOMOS) also defined cultural heritage as "an expression of the ways of living developed by a community and passed on from generation to generation, including customs, practices, places, objects, artistic expressions, and values" (Hartmann, 2020). In this way, what is considered world heritage has an essential characteristic: it is exceptionally unique, and as such, if it were to be lost, part of the history of humanity would be lost.

Since 1950, UNESCO and other government organizations have developed treaties to protect cultural heritage, following the destruction of many monuments and works of art during World War II (Blake, 2000). However, today, many world heritage sites are in danger of disappearing due to lack of care or budget. Much of what heritage sites suffer is from the UNESCO maxim: "No one cares for what they do not know", which makes preservation programs essential.

In recent years, entire cities have been considered world heritage. Therefore, the economic and social benefits of preserving cities as world heritage have acquired great importance. In sustainability, the term "cultural heritage" has evolved from the conservation efforts of some places, even to the strategic planning of cities' growth (Guzman et al., 2018). Preservation of cultural heritage produces indirect benefits for urban

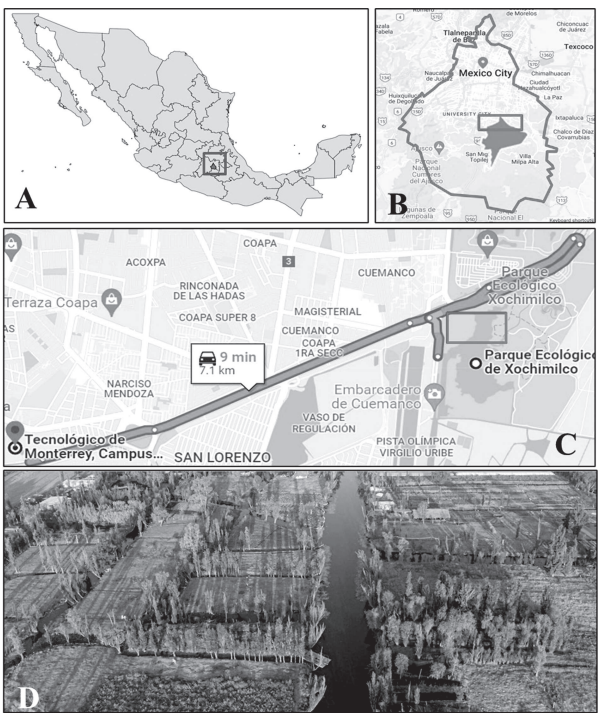
economies. Richard Florida (2002) argues that the main economic driver of cities is the creative class that works in the knowledge economy. Therefore, cities must be proactive in maintaining and creating new amenities that attract and retain such a creative class, such as historical neighborhoods or promenades. Classic authors in urban sociology consider that the urban space and places are a social construction. Sustainable urban development depends on traditional planning tools and soft institutions (Lefebvre & Nicholson-Smith, 1991; Brenner, 2000). The cultural assets in the urban space that foster the creation of culturally shared values are important for creating social capital in the city, which impacts economic growth and innovation (Yigitcanlar & Inkinen, 2019). Tourism associated with cultural heritage represents a financial sector of great significance at the local and regional levels (Hartmann, 2020). However, this relationship between heritage conservation and the environment has been poorly studied in urban development and today is a challenge for local governments (Guzman, 2020).

Xochimilco, a World Heritage City Inside Mexico City

In this regard, the lacustrine landscape of Xochimilco (Figure 1), located 28 km south of downtown Mexico City, constitutes the only reminder of traditional pre-Hispanic land use in the lagoons of Mexico City basin.

Figure 1[1]

Location of The World Heritage City of Xochimilco in A) Mexico, B) Mexico City, C) Location of the Academic Institution of Higher Education and Distance Between the School and the Xochimilco Lake, D) Aerial View of the Chinampas in Xochimilco Lake



In the middle of a network of small canals, on the edge of the residual lake of Xochimilco (the southern arm of the great drained lake of Texcoco), some chinampas or 'floating' gardens can still be found. Parts of this half-natural, half-artificial landscape are now an ecological reserve. The City of Xochimilco was declared World Cultural Heritage in 1987. However, this treasure is at risk. One of the main reasons is the excessive urbanization in its surroundings (Onofre, 2005). In 1987, Xochimilco was awarded the title due to its preservation of more than 2,500 acres of chinampas; today (35 years later), only approximately 25 % of those have remained. The chinampas are a sustainable agricultural system used by the Aztecs; initially, they were made up of areas (islands) of 300 x 25 feet and consisted of a network of tree trunks, mainly Bonpland willows (*Salix bonpladiana*, an endemic tree of the region, Ahuejotes in the ancient Nahuatl language), filling of land, mainly from the bottom of the lake, which increases the organic matter and therefore, the richness and fertility of the small island.

The problem detected for this heritage site is clear. Each year, fewer and fewer people are dedicated to the agricultural activity of the chinampa because the children of the chinamperos have redirected their vocational or career interests and now tend to be encouraged to pursue university studies and dedicate themselves to other professional activities that have removed this generational continuation of knowledgeable chinamperos. The current median age of the chinamperos ranges between 60–90 years, and there is no program for substituting these aging farmers. To maintain cultural heritage alive, knowledge must be passed from generation to generation, and the ancient agroecological activity of the chinampa must be kept alive as a legacy of the ancient inhabitants of Xochimilco. If we do not act today, tomorrow, the chinampas will be just houses, urbanization without the heritage value that distinguishes the site.

The chinampa agroecological landscape is at risk. The biodiversity that the chinampas entail their endemic species with their cultural and social values is of extreme sustainable importance for the identity of a community that refuses to lose its roots. That is why there is an enormous need for awareness of the conservation, protection, and actions to preserve the heritage. The research question is: To what extent can socially-oriented education (SOE) impact STEM student learners to raise their awareness of social justice issues and creatively engage them in team problem solving that might prevent chinampas from being lost and affecting the emblematic biodiversity of Xochimilco?

The Axolotl: A Piece of Culture and Identity

A Xochimilco endemic species occupying a special place in Aztec mythology is the Axolotl (*Ambystoma mexicanum*), which is a very ancient amphibian (which for the Aztecs was considered the misbehaved brother of the God Quetzalcóatl [the feathered snake]; his penalty was to stay in the lakes like a monster of the fluttering waters) and has the peculiarity of regenerating specific organs and entire limbs of its body (legs, tail, and half brains), for which it has attracted the interest of researchers in many areas of study (Kragl et al., 2009; Nowoshilow et al., 2018; Schreckenberg & Jacobson, 1975). Scientific understanding of multiple aspects of this biological process could one day help develop therapies for pathologies related to aging in humans (Vieira et al., 2020). Its genomic sequence was released in 2018, which might provide greater knowledge to branches of medicine such as neoteny (Nowoshilow et al., 2018).

The Axolotl has always been a symbol of identity and culture for the inhabitants of Xochimilco and Mexico (in fact, since 2020, a drawing of the Axolotl can be found on the 50 Mexican pesos note). We must go back to the Aztecs to find the first records of the history of the Axolotl, which was documented in several Spaniard codices. In the scientific literature, it appeared in 1615 in a natural history book, but it was not until two hundred years ago that it received a scientific name. Since then, this species has been present in the Mexican culture since it has been used as food and for medicinal uses without a scientific foundation. The Axolotl (Figure 2) is usually black or mottled brown, although albino and white varieties are relatively common, especially among captive-bred specimens. It differs from most salamanders in that it lives permanently in the water. The Axolotl has a relatively long life span, reaching up to 15 years of age, feeding on mollusks, worms, insect larvae, crustaceans, and some fish.

Figure 2

Two Axolotl (Ambystoma mexicanum) Specimens



Photos were taken during the i-Week.

According to the red list of the International Union for the Conservation of Nature (IUCN), this unique amphibian is in critical danger of extinction due to habitat loss, and the introduction of invasive species in its habitat, overexploitation, pollution, and its consumption as food. Its population is declining since the demand from nearby Mexico City has led to the draining and contamination of much of the water in the Xochimilco lake complex. It is also very commonly used in the aquarium trade, which has reduced their numbers. Some actions to help its conservation are focused on restoring the balance of Lake Xochimilco and its natural habitat through education and ecological tourism and the implementation of habitat restoration works. In addition, its reproduction is carried out in captivity to recover its population because this species is also used in biomedical and physiological research. Due to its popularity in laboratories and as pets, Mexican Axolotl breeding farms have been established internationally since 1989. The most important is still on the site, near the Xochimilco Ecological Park, hoping that this "ancient monster of the fluttering waters" recovers its natural habitat one day.

The need for workforce diversification in the industrialized world, the government's negligence of cultural identity and the environment, and the lack of incentives to continue

cultivating chinampas have put the Xochimilco cultural identity at alarming risk. The cultural and biological significance of the Axolotl is essential. One proposed approach that will both seek to enrich STEM student learning while promoting the care of cultural heritage may be attained through the implementation of pedagogical strategies of a Socially-Oriented Education (SOE). Using techniques such as challenge-based learning (CBL), we may be able to guide students to gain empathy and skills towards the sustainability and cultural care required to maintain world heritage (Membrillo-Hernández et al., 2021a; Membrillo-Hernández et al., 2018; Membrillo-Hernández et al., 2021b).

The *i-Week* and the New Model Tec21

Our university has recently implemented its Educational Model Tec21, based on four key elements: 1) Challenge-Based Learning (CBL); 2) Flexibility; 3) A memorable university experience; 4) Inspiring and up-to-date faculty. The Tec21 Educational Model focuses on developing students' disciplinary and transversal competencies by engaging students in relevant and current problems (Membrillo-Hernández et al., 2021a). The challenges may be generated inside the university by a local faculty or external training partners. These partners are usually representatives from industrial companies, social organizations, and other organizations that open up their doors to collaborate with students and faculty to immerse them in a real context that enhances the learning experience (Membrillo-Hernández et al., 2021b).

An essential component of the CBL experience is the *i-Week* (interactive, innovation, and imagination week). The entire undergraduate programs at our campuses across the country are paused for one week so that students and faculty can engage in a completely different activity. The *i-Week* is an immersive learning experience linked to the environment, in which students strengthen their transversal skills such as leadership, entrepreneurship, innovation, critical thinking, problem-solving, ethics, citizenship, global perspective, intellectual curiosity, passion for self-learning, collaborative work, communication, mastery of foreign languages, and management of information and communication technologies (Lara-Prieto & Flores-Garza, 2022). In *i-Week*, students face real-life challenges through interactive and multidisciplinary activities with colleagues from different generations, campuses, and undergraduate programs (Lara-Prieto & Flores-Garza, 2022).

The following research-based report will describe a particular student experience during *i-Week*: "Axolotl Challenge: Saving Biodiversity through Engineering". This challenge was designed to sensitize students to the relevant role of the chinampas in preserving the universal heritage site through activities that allowed them to meet a living being that represents a whole tradition in the original town of Xochimilco: The Axolotl. If we are successful, this strategy could be scalable to other sites and thus replicate the process of caring for the constituent elements of world heritage.

Materials and Methods

The theoretical framework that supports the inclusion of experiences of recognition and appreciation of cultural heritage is based on the principles of education for sustainable development (ESD) of UNESCO, according to which sustainable development is an ethical challenge as well as a scientific concept (Membrillo-Hernández et al., 2021b). We based our research on the following premises: First, STEAM education (STEM +

Arts) is an approach that responds to the imperative need to prepare young people to develop innovation and creativity skills to positively and productively face the global challenges of the 21st century that are affecting the economy, the natural environment, and our diverse cultural heritage. Second, the inclusion of transversal priorities in the syllabus of the Higher Education curriculum subjects (sustainability, pre-Hispanic histories, and cultures, cultural heritage of the country's indigenous peoples) provide compelling contexts for students to understand the worldviews of other culturally different people and develop civic awareness of the impact of their planetary footprint (Taylor, 2018). Third, the management of cultural heritage resources in urban contexts must become the nexus of interdisciplinary research on biodiversity, ecosystem services, and human well-being challenges in the changing social, economic, and environmental conditions of the 21st century (Liu et al., 2021).

The Axolotl Challenge for Higher Education Students

We designed an academic strategy based on the theory of challenge-based learning (CBL), taking the World Heritage City of Xochimilco as a pilot study. The strategy consisted of presenting the Axolotl as an endemic species whose value in the sustainability of the place and the chinampa agroecological landscape is fundamental. The learning objectives of the challenge to be solved for higher education multidisciplinary students can be described at various levels:

1) To sensitize higher education students to learn about and establish conservation strategies for a world heritage city.
2) To establish multidisciplinary strategies to improve the conditions of the Axolotl farms, which are today the only reproduction and conservation system for the *Ambystoma mexicanum* species. Many of them are precarious due to a minimal budget and the evident presence of a gap between society and education.
3) To establish SOE strategies based on STEM to create a more responsible, sustainable population with work skills to protect the environment and cultural heritage.
4) To take the learners out of the traditional school setting and out to a relevant culture-rich societal setting and bring society into the school where different topics of global interest can be discussed to preserve the cultural heritage of humanity.

Research Hypothesis

The design and implementation of rapid immersion learning experiences in the community for students in the STEM areas and SOE via CBL contribute to the student awareness of the cultural richness and their will to preserve cultural heritage.

Sample

The *i-Week* project took place over three days during the fall semester, with the participation of 31 students from the second to the fourth year of different undergraduate academic programs. A non-probabilistic, non-intentional sample (Sheppard, 2020) was employed, consisting of 31 participants. Demographics of the students enrolled in the *i-Week* can be seen in Table 1. The sample size is small because it corresponds to a diverse

group of students participating in the *i-Week* that belong to different schools. Students from the School of Engineering and Sciences in the following programs took part: Biotechnology, Sustainable Development, Telecommunications, Mechatronics, Mechanical Engineering, Industrial Engineering, Innovation and Development, Computer Technologies, Biomedical Engineering, and Business and Technology. From the School of Business, there were students from International Relations, International Business, and Business Administration. From the School of Arts, Architecture, and Design, there were students from Architecture, Industrial Design, and Digital Music Production. Table 2 shows the learning sequence of the *i-Week*.

Table 1

Demographic Data of the i-Week Enrolled Participants

Gender	School of the enrolled program	Semester
15 female (48.39 %) 14 male (45.16 %) 2 fluid (6.45 %)	Engineering and Sciences: 15 (48.39 %) Business: 9 (29.03 %) Arts, Architecture, and Design: 5 (16.13 %) Other: 2 (6.45 %)	5th: 1 (3.23 %) 6th: 4 (12.90 %) 7th: 11 (35.48 %) 8th: 4 (12.9 %) 9th: 11 (35.48 %)

Table 2

Learning Sequence of the i-Week

Day 1	Plenary talk: Xochimilco Mayor's Office Challenge description Plenary: Biodiversity in Xochimilco by an expert from the National University of Mexico Organization of teams Teamwork on assignment document No. 1
Day 2	Visit to the Michmani Community where an Axolotl farm is in Xochimilco Lake (4 km east of the campus) Visit to the Chinampas (floating gardens) at Tlilac lagoon inside Xochimilco Lake Teams' collaborative work for assignment document No. 2
Day 3	Visit to the Children's Museum of Mexico City (24 km up north from the campus) where there is a Xochimilco exposition room with several axolotls on display, also visiting an artificial chinampa made by experts on sustainability Work in teams for assignment document No. 3 and preparation of the final project
Day 4	Challenge resolution presentation

Methodology of the Analysis

This work employed a mixed-methods approach. The transversal competencies to be developed in the *i-Week* were as follows: collaborative work, oral and written expression, critical thinking, and the disciplinary competencies: sustainability, resilience, and biodiversity. Students' competence acquirement was evaluated through three text documents and a final report consisting of both a video and a document text. The method for analyzing these assignments was based on descriptive analytics (Loeb, 2017). In addition, an analysis of the keywords of the documents was carried out using the Sketch

Engine computer software (Lexical Computing, Brighton, United Kingdom) to appreciate the terms that the students used the most. To extract the terms, the software uses 16.9 billion words (European Spanish Web, American Spanish Web, whole Spanish Wikipedia) with topic classification for the most significant web domains based on a semi-manual check of sample texts. Afterward, it uses simple math for keywords method to assign a score to each keyword (Kilgarriff, 2009). Keywords were ordered from higher to lower scores. All students were asked to complete their assignments considering a minimum of formatting and technical requirements.

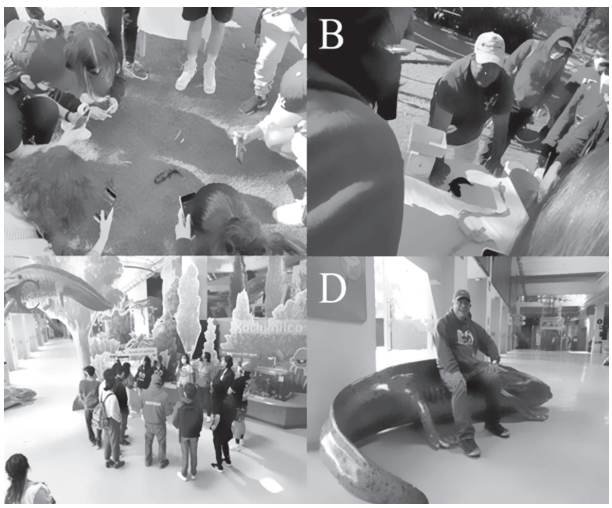
The final student report was presented in class in a video presentation of less than 10 min and in written form. The expected information required for the first three document tasks and the final project can be consulted in Appendix (Tables A1 and A2). A questionnaire regarding the experience during the *i-Week* was designed (Table A3), and students were asked to answer in a non-anonymous form through Google Forms. The ECOA (teacher satisfaction and evaluation survey) was carried out at the end of the experience.

Results and Discussion

It may seem challenging to find activities within the study programs of STEM careers that have to do with understanding of the value of World Heritage. However, world heritage and the potential loss of it are all around us in the society in which students live. Thus, we developed a SOE program using the Challenge-Based Learning technique to establish a conductive line of knowledge-reasoning-sensitization-appropriation-design of solution strategies. Students were asked to produce four documents (three during well-defined stages and a final project) to identify the Axolotl as an essential part of the World Heritage City of Xochimilco identity (Figure 3).

Figure 3

Images of the i-Week Experience



A and B were taken in Michmani, and C and D were taken in the Children's Museum.

When monitoring concept development, in the analysis of the assigned task documents, between 300 and 600 keywords were detected; more than 900 keywords were found in the final task document. Only those words with a score above 100 were selected. Around 100 keywords were analyzed for each assigned task. The analysis was performed for those terms other than Xochimilco, chinampa, Axolotl, or Michmani (where the study was carried out), which were in the top 5 of the terms extracted for all the documents, with scores above 1000. Three groups were found in all four assignments. Most terms were characteristics of the Axolotl and those related to its reproduction, history, and tradition. Another large group of terms was the flora, fauna, and geography, whether being characteristic of the region, endangered fauna of Xochimilco, or crops that can be grown in chinampas and their respective pests. Likewise, some localities close to the geographic area of study, such as lakes, wetlands, and sinkholes, were also included in this group. A third group of words was related to Mexican cultural icons, such as Quetzalcóatl, Náhuatl, and Guadalupana.

In assignment task No. 1, a group of terms was related to problems such as marginalization, illiteracy, biodiversity, and ecosystem, and another group of words was used during the plenary sessions that day. It was found that more than 80 % of the key terms extracted from the documents on the first day were related to these topics. In assignment task No. 2, a group of words associated with the activities carried out on day two was observed and grouped with words related to the problems of the Axolotl, the term *ecotourism*, and a group of words corresponding to the activities of the day. Finally, a specialized group of words was observed, which was only presented in the document from a specific team, related to the potential characteristics of the Axolotl for its medical properties. The words "marketing" and "philanthropy" were only observed in the documents handed in on the second day. In assignment task No. 3, "raise awareness" was repeated constantly. Also, other words like "purify", "multidisciplinary", "biomass", "experimentation", "diversify," and "architects" were mentioned in different teams. In the final task document, a group of terms referring to governance and standardization, such as ISO4001 and SDG (sustainable development goals), were repeated. A group of words referring to the genomic area was observed in all the documents, as well as a repetition of the terms: "panels" and "photovoltaics", "reorientation," and "enlist" were grouped into repeated words. Finally, different words were observed, referring to solutions clustered into another group, such as "donations", "engineers", "digital", "influencer", "alliance", "community", "technification", "SWOT", "volunteers", and "sensors". Table 3 shows the percentage of keywords of each assigned task catalogued in the large thematic groups that emerged from the word analysis.

After the final evidence was delivered by means of video, all students obtained a passing grade in the challenge. Figure 4 is a compilation of the term connections observed in the documents students delivered.

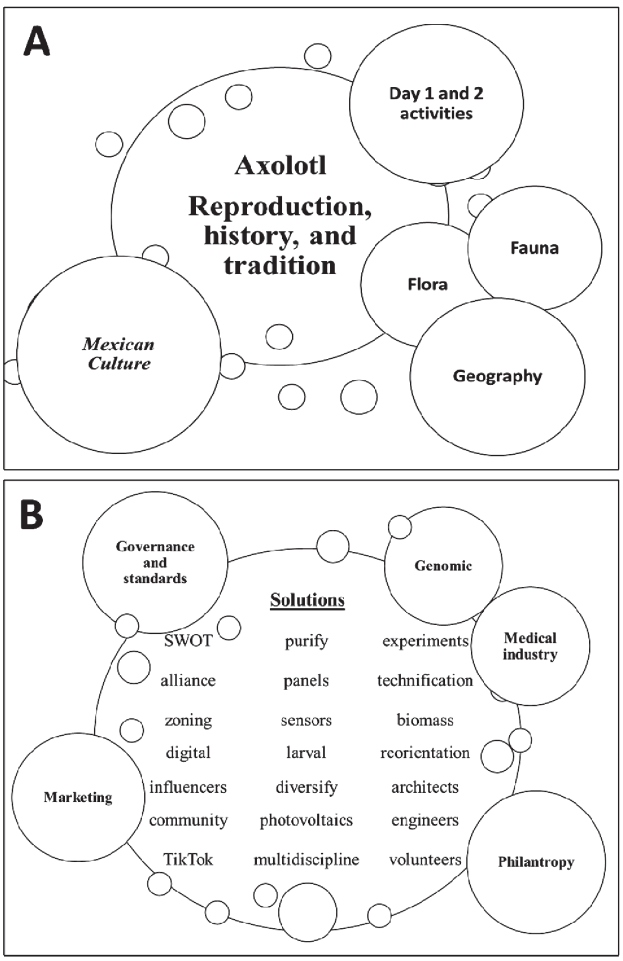
Table 3

Percentage of Terms Found in the Handed-in Documents by Each Team That Concern the Conceptual Groups of Terms Observed in This Work

Team	Assigned Task			
	1	2	3	Final
1	96.77 %	87.80 %	84.44 %	93.88 %
2	93.33 %	82.93 %	81.82 %	97.87 %
3	85.94 %	84.31 %	86.36 %	91.80 %
4	93.68 %	79.49 %	84.00 %	96.15 %
5	88.71 %	87.76 %	83.33 %	90.63 %
6	96.84 %	81.58 %	84.62 %	90.91 %

Figure 4

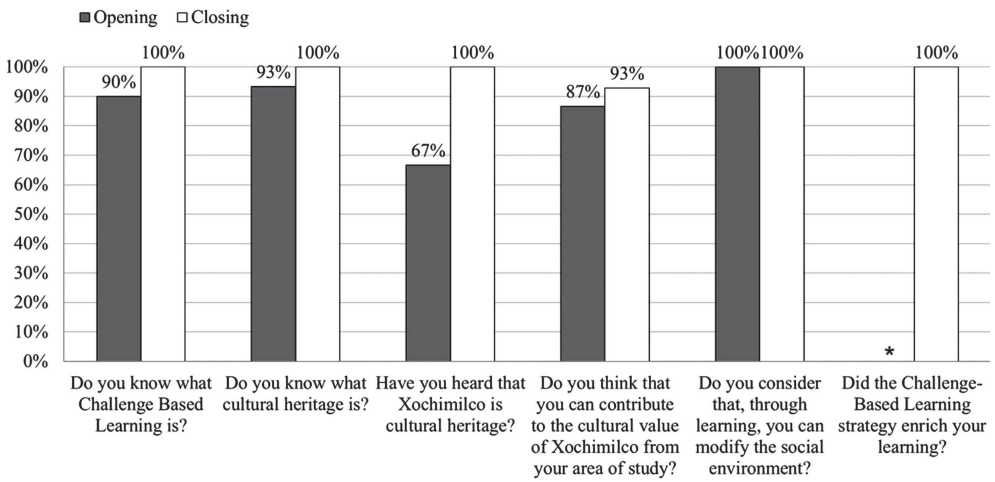
Keywords and Groups That Were Identified in the 24 Documents Delivered by Students in This i-Week. A. Documents 1 to 3. B. Final Document



A pre- and post-questionnaire were administered to gauge students' insights concerning their learning and appreciation of *i-Week*. Only one student did not answer the initial survey, while three students did not answer the closing survey. Figure 5 compares the student's answers to questions with a binary response (yes or no). As can be seen, the students understood what CBL was, the term for cultural heritage, and that Xochimilco was a world heritage city. It was reaffirmed that through these learning experiences, students could connect with and impact their social environments and that CBL was useful for such learning. Half of the students answered that their area of study did not usually include anything related to the cultural value of Xochimilco or any other world heritage.

Figure 5

Binary Survey on Specific Concepts Made by Students Prior the Survey (gray bars) and at the End (white bars)

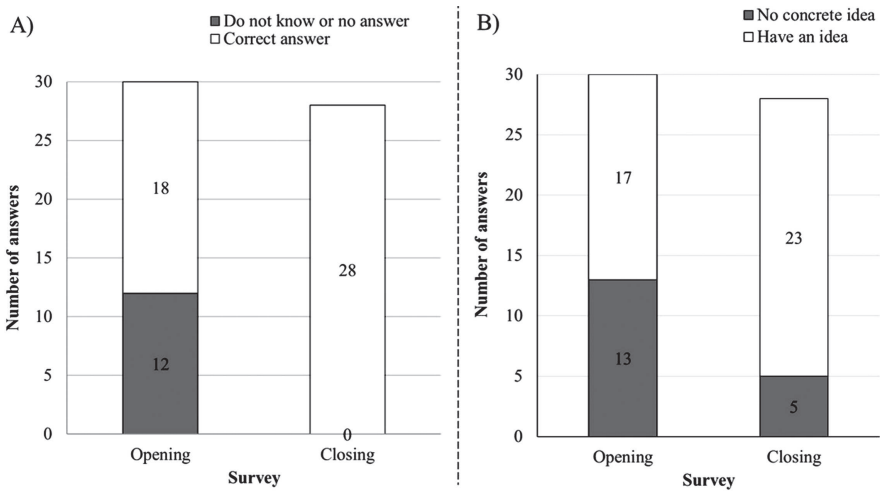


* This question was only asked in the opening survey.

Students were asked a question about the meaning of the word Xochimilco in the initial survey. Almost half of the students had no idea of the meaning, but in the end, all the students answered the question correctly (Figure 6). Similarly, some students did not have a concrete idea of the sustainable development goals (SDG) involved in designing the solution to the challenge. In contrast, in the end, more than half of these students had a clear idea of the SDGs involved (Figure 6) and could even indicate the number of SDGs. All the students, in the end, knew that a "chinampa" was an artificial island used for cultivation by the Aztecs, whereas at the time of the initial survey, 11 of the 30 students did not know what the chinampa was.

Figure 6

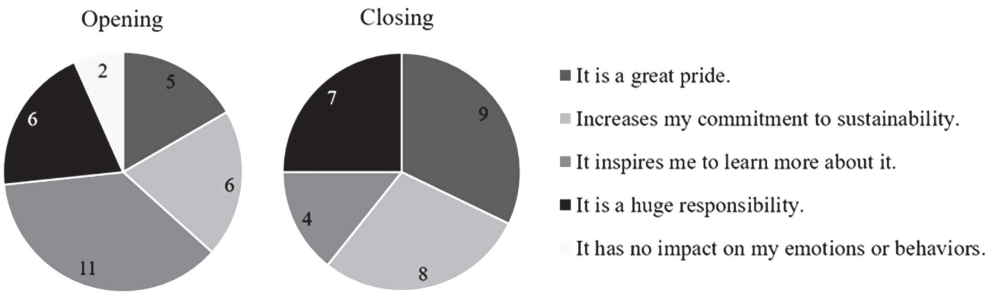
Comparison of Answers to the Questions A) "What does the word Xochimilco mean?", and B) "Knowing the description of i-Week, which SDGs (Sustainable Development Goals) do you consider will be involved in the development of the problem and the solution?"



In the closing survey, all the students responded that in the future, they would see Xochimilco as a heritage zone; likewise, the majority enjoyed the challenge, while two students considered themselves neutral. For most students, it became a great point of pride to get to know that Xochimilco was a world heritage, as shown in Figure 7.

Figure 7

Answers to the Question "Choose the option with which you most identify, taking into account that you live in a world cultural heritage city"



In the reflection questions, as observed in Table 4, it was detected that at the end of the challenge, the students exhibited a more mature and informed opinion of what it meant for Xochimilco to be a cultural heritage, the problems it bore, and how they, as students, citizens and future professions could contribute through the acquired knowledge in their respective careers.

Table 4

Analysis of the Responses to Open Reflection Questions. At the Beginning (opening) or End (closing) of the Survey

Survey	In a short sentence, what is the cultural heritage for you?	What problems do you consider to be present in Xochimilco?	How do you think your area of study can contribute to the preservation of the cultural value of Xochimilco?	How do you consider that education modifies the social environment?
Opening	Short answers related to an important site.	Short answers, mainly related to pollution.	Those who did respond gave general responses of short to medium length.	–
Closing	More detailed answers, considering elements such as "intangible", "valuable", "priority" and "irreparable".	More concrete and specific, "loss of biodiversity", "lack of responsibility", "economic system" and "ecosystem" were added.	More answers, more varied and specific for each area of study, were related to the proposed solutions.	The most repeated concept was "awareness" (in 14 out of 31 answers, 45.16 %).

In the survey applied at the end of the challenge, 94 % of the students answered their belief that their areas of study could contribute to the cultural value of Xochimilco compared to only 86 % expressing this sentiment in the initial survey. Another significant aspect of the initial survey was the generic way in which students described an application of their skills and career towards cultural heritage as very general with phrases such as dissemination of heritage or application of technology. This was in contrast with the answers in the survey at the end of the week, which contained specific ideas about how their STEM discipline could contribute to the cultural value. Specific answers are: environmental management plan, plantation and cleaning logistics for prevention and improvement, design of natural filters for the lake, bioclimatic techniques that allow for the development of the area, and buildings with low environmental impact to improve the conditions to shelter the species, apply technology to clean the water, to mention a few.

Finally, 22 students (70.97 %) evaluated the course and role of the professor in the survey (ECOA). The scores are shown in Table 5.

Table 5

Course Evaluation Questions (ECOA) Applied to the Students of the i-Week (N = 22)

Description	Max. score	Score
The teacher clearly established what was expected of me in developing the activity.	10	9.95 ± 0.21
The teacher clearly explained to me how I was going to be evaluated.	10	9.95 ± 0.21
The teacher provided me with guidance and advice during the activity's learning.	10	9.76 ± 0.42
Everything you did in the activity allowed you to learn new knowledge or apply what you already knew.	10	9.90 ± 0.42
I had access to clear and precise explanations. Learning techniques or technological tools that facilitated the activity were included.	10	9.71 ± 1.27
In the activity, there were spaces for reflection on the learning acquired.	10	9.86 ± 0.46
Through the activity, I realized the valuable contribution I can make to the community, organization, or society in general.	10	9.90 ± 0.39
The activity represented a different challenge than my classes.	10	9.95 ± 0.20
I consider that my attitude played a very important role in the result of the activity and the learning that I acquired.	10	9.81 ± 0.66
I consider that the learning acquired can be applied in other situations.	10	9.57 ± 0.79
I developed the skills that the teacher said we would address through the activity.	100 %	95 % ± 0.19
How satisfied do you feel to have participated in this *i-Week*?	5	4.59 ± 0.55
Would you recommend this activity to your classmates?	5	4.73 ± 0.48

As can be seen, all the questions received a high score. Some answers provided by the students in the ECOA open question section about the course were as follows:

> *"It is a very different challenge from those offered in the classes and an opportunity to explore other areas of knowledge".*
>
> *"Is a great opportunity to get to know a different species that is in danger of extinction and apply knowledge of your career and learn a little about other jobs through the proposed solution".*
>
> *"It is a unique experience in life; I loved having the opportunity to see such a particular species as the Axolotl up close".*
>
> *"It is a lot of fun, and you learn a lot; it also helps you understand a problem that needs urgent attention".*
>
> *"I recommend the activity because it makes you aware of the symbol of Mexican biodiversity, its ecosystems, and how interdisciplinary solutions can be proposed through collaborative teamwork with the effect of preserving an endangered species, the Axolotl".*
>
> *"It is a good project; multidisciplinary teams always help broaden your perspective of a problem; it is also essential because it is aimed at a species in danger of extinction".*

"Without a doubt, it's the best i-Week I have ever been to. It allowed me to learn more about Mexico from another perspective; the teachers are amazing and genuine. That was my favorite part; the passion and knowledge they transmit are what I take the most. Having unique opportunities like meeting the Axolotls, I would not trade it for anything".

"It is a very valuable way to raise awareness about the situation in which the Axolotls live".

"I would recommend it because getting to know this species makes people understand its importance and fall in love with these small animals suffering from the exploitation and destruction of their habitat".

"It has a real value for me personally and for the community. A complete professional challenge".

"It is a unique experience".

"It exceeded my expectations; I learned a lot and learned much more about the environment surrounding us in the city".

Since the surveys applied were anonymous, we could not conclude that only students who studied careers in the STEM areas became aware of cultural heritage, according to the hypothesis of this study. However, almost all students who lived this experience gave a positive opinion. In some cases, the expectations they had for the theme of *i-Week* were even exceeded. In addition to the above, the null hypothesis of this study was fulfilled according to the following statements:

1) In the four assigned task documents requested, a marked tendency was observed toward the preservation of proposing solutions to the problem of the loss of biodiversity in the Lake of Xochimilco.
2) There was a clear increase in knowledge of the World Heritage according to closing survey answers, for example, regarding the meaning of the word Xochimilco, chinampa, and the SDGs associated with the topic of *i-Week*.
3) The ECOA surveys and the closing survey of the course repeatedly highlighted the keywords of awareness, reflecting the importance of preserving the cultural heritage that exists, in this case, in the city of Xochimilco.
4) A high level of response (greater than 70 %) was obtained in the educational evaluation measurement tools, getting high scores in the qualitative tools.

Additionally, it was shown that the students became aware of their opportunity to contribute to environmental preservation by applying the knowledge obtained in their respective areas of study. This can be verified by the diversity of solutions exemplified in Figure 4, which, in turn, can be taken to plan future challenges.

The objective of this *i-Week* was to get students to know Xochimilco's natural and cultural richness and engage in proposing innovative solutions to some of the complex problems it faced not only to maintain but to improve and promote this cultural identity through the next generations. Through this CBL experience, students appeared to understand the potential power of impacting their communities positively when they increased their knowledge and perspectives in culturally relevant ways.

At the beginning of *i-Week*, a certain level of awareness of cultural heritage was observed in students and an awareness that their discipline might contribute to preserving

and improving the current state of cultural heritage. By contrast, at the end of the *i-Week*, all students identified a sense of either pride, commitment, inspiration, or responsibility in connection with the cultural heritage they were able to observe, learn about, and analyze up close. It is also interesting to observe how the actions they proposed using their field of study were more concrete and linked to their discipline.

STEM fields of study can be helpful in contexts for the classification, maintenance, administration, and care of cultural heritage (Cuenca-López et al., 2021; Monteagudo-Fernández et al., 2021; Neves, 2018; Nicolopoulos et al., 2018). However, now, more than ever, in the face of the economic and environmental crises and contemporary challenges that affect today's world and threaten the diverse cultural heritage, studies have shown that STEM education coupled with social justice issues can offer a highly relevant synergy for the development of young people with higher-order skills who can contribute to the solution of current problems through different approaches (Bybee, 2018; Taylor, 2018). This idea has been reflected in political discourse, in which the impact of STEM fields and beliefs and values at the service of the development of society is recognized (Bybee, 2018; Eglash et al., 2020; Jigyasu, 2019; Sesana et al., 2021). The generation of educational experiences in the STEM areas focused on the care of cultural heritage can be helpful for the generation of stakeholder networks, which help in responsible and sustainable development (Moreno-Mendoza et al., 2019).

Sustainability becomes a relevant topic in the context of the future of education for global development, broadening the idea of sustainability to more holistic research frameworks, transversal to different disciplines (Salīte et al., 2019). Expanding disciplinary research to include a sustainability perspective is becoming more acceptable (Salīte et al., 2021). Some examples of this kind of research include the assessment of learning outcomes and transversal competencies for sustainability among students of different majors (Rekalde-Rodriguez et al., 2021), and the mapping of scientific production to suggest that the integration of the Sustainable Development Goals in universities (higher education) is recently becoming a field of study under exploration (Murillo-Vargas et al., 2020). Experiential learning is fundamental in Education for Sustainable Development to deepen students' awareness of their context, identifying the social, cultural, environmental, and economic needs (Ichinose, 2017). A challenge by itself is for teachers to adopt the role of coaches and change agents, guiding students in this learning process. As Rashidi and Meihami (2017) mention, there is a need *"to introduce sustainable teacher education program in general"*. As well, we believe, this case study is an example of how higher education researchers all over the world can work together, advocating for sustainable education, to answer questions like "*How to elaborate indigenous knowledge and school science in the science curriculum for the cultural sustainability?"* (Handayani et al., 2018).

Conclusions

Education is a valuable tool to guide and serve society positively. However, the dynamics of the evolution of social and environmental conditions have influenced how we teach. The sudden change from face-to-face education to distance education forced by the COVID-19 pandemic has been one of the most obvious. In this pedagogical study, a SOE strategy was tested to solve a specific social problem: The lack of attention and knowledge to preserve the World Cultural Heritage. The results indicate that SOE positively impacted students to gain greater insight and motivation to become better

and more responsible citizens. More studies will have to be carried out to establish the theoretical frameworks on which SOE is based and the scope of problems that can be solved with this approach, where STEM education plays an essential role.

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Note

(1) Figures 1 to 3 can be found in color at the following link https://drive.google.com/file/d/1Z3iWtl8ys64HR8Rglve6agfGp2S4v1IE/view

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Appendix 1

Table A1

Expected Content of the Assignment Documents of the i-Week

Document 1. Biology and cultural importance of Xochimilco	• Research: Carry out a diagnosis of the study area (Lake Xochimilco) where the biological, environmental, geographic, social, and sustainable characteristics are identified. • Summary of the plenary conferences
Document 2. The comprehensive structure of the Axolotl farm and agroecological environment at the Michmani local community	• Location description • Summary of the visit specifying the activities carried out • Data collected and analysis of information • Photographic evidence
Document 3. The comprehensive structure of the Axolotl farm and environment in the Children's museum	• Place description • Summary of the visit specifying the activities carried out • Data collected and analysis of information • Photographic evidence

Table A2

Expected Content of the Final Written Document of the i-Week

Introduction
- a. Establish the identified problem
- b. Define the challenge to solve
- c. Delimit the general objective and specific objectives
- d. What is the Axolotl? Why is the conservation of its natural habitat important?
- e. Write about the importance of the Axolotl from the team perspective

Developing
- a. Explanation of the sites: Axolotl farm and Children's Museum at the Xochimilco room
- b. Improvement proposals for both sites
- c. Scientific Areas used in improvement (Engineering, Design, Law, etc.)
- d. Feasibility of the proposal and approximate costs
- f. SDGs that could be involved to support their development

Conclusions
- a. Reflection on what you learned from the challenge
- b. Improvement recommendations for the challenge

Table A3

*Axolotl Challenge i-Week Survey**

1.	E-mail:
2.	Campus:
3.	Career:
4.	Semester you are currently studying:
5.	Gender: Female/Male/I prefer not to say/Other
6.	Do you know what Challenge Based Learning is? Yes/No
7.	Do you know what the cultural heritage of humanity is? Yes/No
8.	In a short sentence, what is the cultural heritage of humanity for you?
9.	Have you heard that Xochimilco is a cultural heritage of humanity? Yes/No
10.	What does the word Xochimilco mean?
11.	Choose the option with which you most identify. Living in a world cultural heritage city: It is a great pride/Increases my commitment to sustainability/It inspires me to learn more about your story/It is a huge responsibility/It has no impact on my emotions or behaviors.
12.	Describe what a chinampa is.
13.	What problems do you consider to be present in Xochimilco?
14.	Do you think that from your area of study you can contribute to the cultural value of Xochimilco? Yes/No
15.	If you answered yes, how do you think your area of study can contribute to the cultural value of Xochimilco?
16.	**In the future, you will see Xochimilco as: One more site/A heritage area/A turistic place**
17.	Do you consider that through learning you can modify the social environment? Yes/No
18.	**If you answered yes, how do you consider that learning modifies the social environment?**
19.	Knowing the description of i-Week, which SDGs (Sustainable Development Goals) do you consider will be involved in the development of the problem and the solution?
20.	**Was the Challenge-Based Learning strategy useful for you to enrich your learning? Yes/No**
21.	**Did you like this week's experience with Challenge Based Learning? I loved it/Neutral/ I did not like**

* Questions in bold (16, 18, 20 and 21) were asked only in the closing survey.