

Article

Research and practice of sustainability in Mexican higher education: The case of university of Sonora

Blanca Silvia Fraijo-Sing*, César Octavio Tapia-Fonllem, Melanie Moreno-Barahona, Daniela Borbón-Mendivil

Programs of Master and Doctorate in Psychology, University of Sonora, Hermosillo 83000, Mexico

* **Corresponding author:** Blanca Silvia Fraijo-Sing, blanca.fraijo@unison.mx

CITATION

Fraijo-Sing BS, Tapia-Fonllem CO, Moreno-Barahona M, Borbón-Mendivil D. (2024). Research and practice of sustainability in Mexican higher education: The case of university of Sonora. *Journal of Infrastructure, Policy and Development*. 8(9): 8321. <https://doi.org/10.24294/jipd.v8i9.8321>

ARTICLE INFO

Received: 9 March 2024

Accepted: 15 April 2024

Available online: 12 September 2024

COPYRIGHT



Copyright © 2024 by author(s).

Journal of Infrastructure, Policy and Development is published by EnPress Publisher, LLC. This work is licensed under the Creative Commons

Attribution (CC BY) license.

<https://creativecommons.org/licenses/by/4.0/>

Abstract: This work presents a review of Mexican Higher Education during the decade of education for sustainable development and how today it faces the commitments made for the Sustainable Development Agenda 2030. By portraying the agreements that support the UN's Development Program in advising higher education institutions, the SDGs which can be served through universities and their by-products, the success stories of some universities are shown. This case study addresses the theoretical value of quality of life and harmony of the environment, remarking on how different universities in Mexico have approached this matter as a key part of their curricula, policy, and research. Showcasing a special emphasis given to the work carried out by the University of Sonora, specifically for their institutional practices for sustainability and the study of sustainability from the perspective of Environmental Psychology.

Keywords: higher education; sustainability research; practices for sustainability

1. Background

Sustainability is a topic of pivotal importance to most higher education institutions, since sustainability as a whole and as a science itself, can be approached from different academic disciplines, including from natural to social sciences. It's goal of developing concepts, competencies, perspectives, and values that could enable people from different generations to accept the duty of creating sustainable lifestyles in order to thrive, should require higher education institutions around the globe to reconstruct their entire curriculum. From rebuilding their courses and research communities to the way they manage and operate their campuses. Sustainability must be embedded in the mission and the activities performed by the institutions as a way to mold and prepare their students to transform into citizens and professionals able to make educated decisions taking the environment into account. This then, represents the active and significant role that universities play into designing and building a future considered more sustainable, via education, research, and involvement with the other spheres of human activity (Yarime et al., 2012).

Around the globe, multiple universities and their research groups have worked diligently to provide different reflections about sustainability and its implementation. For example, renowned research works from Southern Europe have sought to explain how students, faculty, staff, and stakeholders in public Higher Education Institutions perceive both the concepts of sustainability and the different challenges posed by implementation initiatives in their local universities (Aleixo et al., 2018). On these same grounds, other studies have toiled with different tools to assess Education for

Sustainable Development implementation programs and their applicability, recognizing Higher Education institutions as some of the most notable “agents of change” pertaining their sustainability performance (Caeiro et al., 2020). Similarly, other research products have focused on the conceptualization and analysis of curriculum developments, pedagogical approaches, and their impact on competencies in education for Sustainable Development (Cebrián et al., 2020). Within the vast literature on sustainability, we may also find larger multinational studies. For instance, Leal Filho and collaborators (2018), present a revision of qualitative studies from Higher Education Institutions in Brazil, Latvia, Serbia, South Africa, Spain, Syria, and the UK, regarding the engagement of faculty and students towards the transformation in learning in education for sustainability. Although their findings reveal that this concept has not been adequately integrated into Higher Education Institutions, their work provides great insights on how sustainability can be enhanced in curricula by the appreciation and pursuit of the epistemology and multicultural perspective of sustainability.

However varied and illustrative these findings have been, they don't fully depict the complete picture of Higher Education Institutions around the world and how they contribute to the practice of sustainability in their origin countries. This makes the case for the present review about Higher Education Institutions in the Mexican context, representing a country that is less examined in existent literature, but has produced valuable findings for the field of Sustainability.

To date, Mexico is not a country known for remaining at the forefront with respect to environmentalism, energy efficiency or sustainability policies and practices. But in the light of the efforts being conducted during the last decade, Mexico has now taken a leap forward into both environmental and economic development. In this political and economic climate, more Mexican companies have developed a growing interest in hiring professionals trained in sustainability awareness and praxis, as well as environmental performance and competitiveness. Special reports have confirmed that of the five hundred largest companies in Mexico (located in two of the most important economic centers, the northern and central regions of Mexico), 68.4% include elements of environmental sustainability in their mission or vision statements, and 77.1% of companies take environmental sustainability into account when developing their business strategies. While these companies were actively committed to their sustainability oriented actions, they were still in the early phases of the learning process, given that it has also been reported that the use of sustainability practices is not widespread in important economic activities such as the production of transportation equipment and other manufacturing activities, two of the most important industrial activities in the Mexican economy (Aigner and Lloret, 2013; Acolt et al., 2019).

Examples such as the aforementioned, make Mexico a good illustrative example of the need for the formation and training of high-level human capital, educated in institutions that use sustainability as a form of education and that guide professionals both in the development of policies and initiatives, as well as in the actions in favor of them.

1.1. Sustainability in Mexico's higher education system

Up to 2018, the information about Mexico in the ranking of evaluation of compliance and impact on the Objectives for the Sustainable Development Agenda 2030 placed this country in the 84th place out of 156 countries evaluated, with a total score of 65.2 points, that is, a 65% of improvement regarding the best possible outcome. Other Latin American countries surpassed Mexico's score: Costa Rica (33rd place), Chile (38th place) and Cuba (42nd place). The figures on the position of Mexico in these metrics were not entirely satisfactory, which required a diagnostic evaluation and an urgent implementation of greater and better intervention strategies directed towards key aspects of sustainability, meaning resources, public policy, economy and of course, education. This meant an open call for all Mexican higher education institutions to consider sustainability as a priority and to incorporate it as a part of their daily teachings and campus life.

Over the past decades, there has been sustained knowledge production activity regarding sustainability as well as changes in operations for campuses all across Mexico. According to Ramirez and Gómez (2018), there has been a 36% increment in sustainability knowledge production regarding theses, chapters and books compared to previous decades. Some authors have mentioned we are fortunate to find research work and academic activity on a variety of themes related to sustainability, such as environmental education and its outcomes, protected natural areas, climate change with an educational focus.

When speaking about Mexico's achievements in terms of sustainability, we can put forward the support provided by universities and government agencies, for instance, guidance and funds provided by the Ministry of the Environment and Natural Resources (often referred as SEMARNAT in Spanish). Research has also pointed out some of the difficulties and improvements of addressing environmental education on sustainability taking place in Mexico under its current political and ecological circumstances. Positive advances include expansion and consolidation of existing research groups, Increase in the number of articles and other publications in prestigious magazines and publishers and the continuing presence of postgraduate programs in environmental education. Propounded difficulties are mainly related to academic isolation and institutional networking, but also improving socioenvironmental quality and relevance, urging, and encouraging our research communities to deepen into topics related to environmental risks and phenomena directly related with social vulnerability and other social attributes (Ramirez and Gómez, 2018).

In the face of this challenges and advantages we have found, we must recognize that locally, regionally, or internationally, human beings are members of the natural systems, and therefore, we are to be held responsible for the use, management, and conservation of the resources in our planet. Education as an aid in the construction of global citizenship has the challenge of integrating and interrelating the integral formation of the human being, its values and sustainability (Valero and Briceño, 2019).

1.2. Current state of sustainability research in Mexico

Nowadays, research in the sustainability area is of great interest and with a very

active research community. Sustainability is laboriously taught and intently pointed as a main focus in research across disciplines in many universities across the Mexican territory. Some of the main topics of work and research in this country are sustainability in educational practice, sustainability perspectives from teachers and students, the concept of sustainable universities, the roles of education and entrepreneurship in conservation, different kinds of learning and pedagogy for sustainability, and the social and psychological components of sustainable and pro-ecological behavior.

Considering the topics related to sustainability and the work carried out by Mexican researchers in the field, most of the topics concern the mere indicators of sustainability in universities and other education dedicated institutions, for instance Brito et al. (2018), proposed sustainability indicators for different education levels: high school, bachelor's degree, and postgraduate. The indicators were developed by carrying out 2 different surveys to teachers and students in the aforementioned educational levels. The assessment of the indicators in their study concluded that students in these institutions show great socio-environmental concern while teachers are devoted to work and show less concern about other substantive functions in their schools. A second publication from Brito et al. (2018), pointed out that most teaching functions in terms of sustainable education and different institutional processes related to in-campus sustainability awareness and integration need to be strengthened. Here describing the particular situation of the Universidad Autónoma de Guerrero (Autonomous University of Guerrero), but also identifying what could be a reality in other Higher Education institutions, touching on the need of regular assessment of sustainability indicators.

Other authors have focused on different assets such as pedagogy of sustainability, the value teamwork and collaboration, and entrepreneurship skills for the ecosystem. As illustrated by Portuguez Castro et al. (2019), their conclusions have described how teaching methodologies that allow the creation of technology-based enterprises and entrepreneurial skills in students. Entrepreneurship teaching methodologies are able to support the development of science, technology, and sustainability, portraying a well-recognized association between the role of higher education and the students as part of the innovation ecosystem that strengthens social, environmental, and economic growth. More research work from these authors has proposed Challenge-Based Learning as another teaching methodology related to sustainability. One of their case studies describes the interest of their students in solving challenges related to the Sustainable Development Goals of the United Nations in an online course. These recent findings show how the participants were purposefully able to generate sustainable business ideas aimed to resolve local, national, and global problems (Portuguez Castro and Gomez Zermeño, 2020). This suggests how different approaches to pedagogy and teaching methodologies can enable our students to develop creative solutions for the ecosystem in the economic and technological fields.

While we have mentioned studies that depict the situation of Mexican institutions, some Mexican researchers from the Tecnológico de Monterrey University have taken international insights, worldwide views into their works with literature reviews. Lozano et al. (2013), carried out a revision that shows that universities may be “falling behind”, presenting lag, compared to companies and the industry when providing

solutions, or helping societies to become more sustainable. Their analyses pointed out this could be happening due to multiple reasons such as relying on what they call “reductionist and mechanist paradigms”. Furthermore, their recommendations land on how such issues may be solved by making sustainable development part of the institutional framework of universities, creating sustainable development on campuses, trans-disciplinary work, and inter-institutional collaboration.

Along with this idea, Lozano et al. (2015), presented a study with a survey answered worldwide by respondents from 70 different institutions. The survey included categories such as institutional framework; campus operations; research; outreach and collaboration and on-campus experiences. The main finding of this study showed different examples of sustainable development implantation around the globe. The authors suggest strongly related links from institutions commitment to sustainability to the actual implementation of this commitment. Chiefly, more recommendations were provided by the researchers like working on a pledge or declaration in order to commit to sustainability (forming policies and strategies to follow) and making certain that sustainability is present and widely implemented throughout higher education institution systems.

On a latter work some of these authors worked on a literature review and framework proposal (Lozano et al., 2017). Said framework describes the connection of competences and pedagogical approaches for Higher Education for Sustainable Development. Amongst the competences mentioned we can find systems thinking, interdisciplinary work, justice, responsibility, and ethics, empathy and change of perspective and strategic action, to name a few.

Within the pedagogical approaches we can find some of them with different emphasis (such as the environmental approach). Listed here are, lecturing, concept maps, project- or problem-based learning, community service learning, eco-justice and community, place-based environmental education, and traditional ecological knowledge. All of these come together in a matrix structure to explain the prior mentioned framework, which is intended to aid teachers and educators into designing and updating their course ideas in order to provide an integral view on sustainability. On a last note, the authors have highlighted the seriousness of better teaching, developing the sustainability competences and mind-sets of our learners who will be our future decision makers and change agents (Lozano et al., 2017).

There exists very extensive literature on the topic of Sustainable behavior and Sustainable behavior models. Mexican scientists and researchers have stayed avant-garde on this theme. We can find a diversity of approaches and variables alluded in different models explaining psychological or psycho-social views for sustainable behaviors (we will mention more of them in the next section too). Corresponding with this idea Juárez-Nájera (2015), from the Autonomous Mexico State University (Universidad Autónoma del Estado de México) has published a compilation where she gathers her results and ideas about different frameworks for sustainable behavior, socio-psychological attitude-behavior models and factors explaining sustainable behavior. Her research aimed to propose an integrated model for sustainable behavior, retaining different variables proposed before by multiple authors, as in Gardner’s cognitive theory in addition to Corral-Verdugo and Pinheiro’s (2004) psychological dimensions of sustainability. The Juárez-Nájera (2015), model of requirements for

sustainability included variables of regulatory requirements of social groups (conventions, norms for environmental protection and public policies), challenges imposed by the environment (lack of resources, climate adversity, environmental opportunities), also variables from individual dispositions models (attitudes, beliefs, perceptions, and values). The final model propounded the unification of the selected latent variables, in order to deeply elucidate sustainable behavior with an integrated model. Similar work carried out by García Lirios et al. (2017), sought the specification of a consensus sustainability model, which considered concepts related to development, migration, and participation. The authors conducted a documentary study based on civic participation and sustainability, collecting a selection of indexed sources and national repositories within the period from 2010 to 2017. Their conclusion showed limited findings given the context and study sample. Authors suggested further research and work based on similar methodologies and concepts that could impact comprehensive policies in sustainability.

The review we have made so far describes the current state of sustainability research in Mexico, which is undoubtedly varied and promises great advances for the future. Assuredly, at the University of Sonora, researchers, academic staff, and research by-products also play a significant role in Mexico's endeavor. This university has developed various plans, institutional strategies, and curricula that intentionally touch on some of the Sustainable Development Goals of the 2030 Agenda. Such as improving institutional policies, increasing research on well-being (Goal #3), designing sustainability and environmental psychology courses that include topics such as environmental management and sustainable development, responsible consumption (Goal #12), climate change and climate action (Goal #13).

Since its institutional establishment in 2009, the Sustainable Development Plan of the University of Sonora has sought to strengthen the integral education of students, including the sustainability dimension, as well as to improve the institutional response and that of the university community to reduce the environmental impact in the fulfillment of their daily tasks and functions. It also seeks to strengthen relationships and promote exchange networks and institutional collaboration with a multidisciplinary approach in all essential activities, and positively influence critical issues of the environmental agenda and sustainable development of the country. According to this plan and its guidelines, the University adopts a sustainability policy that promotes in the University population a culture aimed at preventing, eliminating and/or reducing environmental and occupational risks and negative impacts generated in the performance of its substantive functions of teaching, research, and administration, as well as the direct example shown to citizens by putting these principles into practice in their own spaces (University of Sonora, 2012).

Therefore, we present here the case of the University of Sonora and some of the progress it has made in recent decades, in an attempt to provide a picture of the embodied research and practice of sustainability in Mexican higher education.

2. Research methodology

2.1. Aim of research

This research examined various documentary sources and observations with the

aim of describing how research and policies designed at the heart of a higher education institution can contribute to innovative practices in sustainability within this educational level.

As an in-depth single case study, this work followed the standard procedures of case definition, case selection, data collection, and case conclusion, constructing a descriptive case that led to the development of a detailed review of several studies and research projects carried out at the University of Sonora, thus presenting a narrative of the phenomena with reference to existing literature in the field of sustainability.

2.2. Methodology

Our study employed the qualitative approach of the case study. Case studies are used in a variety of situations to enhance our understanding of individual, organizational, social, and political phenomena. Case study research is often defined as empirical inquiry that examines contemporary phenomena in their real-world context. It uses multiple sources such as interviews, secondary open data, documents, and observations, among others. Cases are composed of multiple dimensions and are assembled from various observations from which an understanding of a larger class or category of observed phenomena can be constructed (Turnbull et al., 2021; Yin, 2009).

Within the traditional framework of case studies, documents on the policies implemented, secondary open data and web pages on the institution's sustainability policies, as well as institutional reports and research works for the years 2013 to 2023 were the primary data sources. For the documentary analysis carried out, the researchers established the criteria for analyzing the quality of the data and subsequently categorized the information into two groups:

Institutional practices for sustainability.

Research as a form of sustainability.

3. Case study: The case of the university of Sonora

This article addresses some of the work revolving around sustainability implemented and accomplished by research teams in the University of Sonora because of its particular characteristics as an autonomous higher education institution of public nature, committed to the training of professionals who participate with society in its transition to sustainable lifestyles. Given some of the substantive aspects that are being discussed at the national level to assess the environmental difficulties and condition of the state of Sonora (such as problems with the management of water resources, the ecoregions of the state are home to a high proportion of endemic species that require protection, soil degradation and pollution is another of the serious problems that affect this state), the University of Sonora has fully assumed the commitments included in the Decade of Education for Sustainable Development. This institution also follows the guidelines provided by the National Association of Universities and Institutions of Higher Education (Acronym in Spanish, ANUIES: Asociación Nacional de Universidades e Instituciones de Educación Superior) for the formulation of institutional action plans for sustainable development in Higher Education Institutions. As a form of commitment and in the spirit of collaboration, the University of Sonora has also been part of the trilateral consortium between Universities of Mexico, the

United States and Canada: Sustainable Development for Rural Communities: Social, Economic and Environmental Advances (University of Sonora, 2012).

A number of approaches to sustainability have been discussed within the literature, but for the case of the University of Sonora, the work in this area has been categorized in two main sub-fields; firstly, Sustainable good practices at institutional level; and secondly, the research and study of sustainable development, characteristically from the perspective of human behavior. The work in these areas generally concerns itself with higher education insights as in to describe more about the policies and norms surrounding this institution. The categories identified as the main approaches to sustainability taken by the University of Sonora can be defined as follows:

(1) Institutional practices for sustainability

The practice of sustainability observed in our case includes the concept of institutional sustainability, which is described as the way in which institutions structure and shape the behaviors, values, expectations, relationships, and decision-making of their communities, and thus their approach to and goals for sustainable development. This concept also considers all issues related to the accountability of the institution as a crucial element in the construction and evaluation of sustainability-oriented policies and policy instruments (Pfahl, 2005). Because the institution we studied is one that focuses on higher education, good practices for sustainability are based not only on policies and accountability, but also on how sustainability is embedded in the education that the institution provides. The concept of education as sustainability is added to this, which implies that education for sustainability requires more than the provision of competencies for professional activities, but also skills and qualities that are used to address the challenges of sustainability. Education as sustainability focuses on the processes of learning and what is learned, learning in these scenarios should be reflexive and participatory. According to several authors, this approach is somewhat difficult to be achieved by higher education institutions, as it may result in conflict with the prevailing structures and methods of universities (Sterling, 2010; Tapia-Fonllem et al., 2017; Wiek et al., 2011; Wals and Schwarzin, 2012). Institutions of higher education must implement practices that affirm their commitment to sustainability in the form of written statements of their mission, vision, and purpose, while also embedding sustainability concepts into their institutional programs, courses, and academic research to enable their community and students to analyze real-world environmental issues (Clugston and Calder, 2000).

(2) Research as a form of sustainability

This concept is fostered by the way sustainability research is conducted. Research as a form of sustainability is not only a matter of disciplinary knowledge or subject matter, but also the way in which scientists and institutions collaborate and share results in multinational and multidisciplinary efforts. The term also reflects the way in which research shapes both policy and curricula within the institutional context. According to Avelino and Rotmans (2011), sustainability research should also embrace the notions of interdisciplinarity and long-term dimension, while sharing the recognition that social reality is understood not only by academics, but also through the experiences and knowledge of students, practitioners, policy, and decision makers. In order to provide relevant knowledge for societal change strategies, sustainability

research and the people who contribute to it, both in basic and applied research, should be committed to the promotion of fundamental moral values such as equity, diversity, justice, respect for nature and for others, in an effort to meet the needs and conservation goals of all generations. Finally, sustainability research must serve the development of any social institution that conducts research and education in issue-oriented arenas (Hadorn et al., 2006).

3.1. Good institutional practices for sustainability at the University of Sonora

According to the GreenMetric World University Rankings Fact File Report prepared by the University of Indonesia in 2021 the University of Sonora was ranked 8th nationally and 172nd internationally as one of the most sustainable universities in the world (University of Sonora, 2019). The assessment, conducted by UI Greenmetric, ranks universities around the world based on their commitment and actions towards sustainability. This initiative evaluates the categories Setting and Infrastructure, Energy and Climate Change, Waste, Water, Transportation and Education according to the university's policies and actions in favor of sustainable development, where the University of Sonora received scores ranging from 60 to 80 percent of the maximum score points in each category. While also notable in the 4th place nationally in the items of transportation and infrastructure. Some of the highest scoring indicators were "University budget for sustainability effort", "University budget for sustainability effort", "Smart building program implementation", "Recycling program for university waste", "Inorganic and toxic waste treatment" and "Pedestrian policy on campus" (UI GreenMetric World University Rankings, 2021).

Velazquez-Contreras et al. (2018), portray the University of Sonora as "One of the most successful efforts in Latin America to transform a higher education institution into a more sustainable organization". Explaining how the institution has executed sustainability practices and functions since 1992 in order to educate students able to transform society into a more sustainable lifestyle. Some of the sustainable practices in this university (University of Sonora, 2012), pertain not only the inclusion of environmental issues in the study plans, but also the three guiding axes: Incorporating the dimension of sustainable development in the substantive functions of teaching, research, and outreach (See **Table 1**); Sustainable administrative management (This includes the efficient use and management of water and energy, comprehensive management of non-hazardous and hazardous waste, Sustainable Administration and responsible consumption); and finally, Communication to improve our environmental awareness (mostly alluding to awareness in matters of sustainability, diffusion and editorial production for sustainability). The aforementioned authors mention education, research, and partnership as key aspects in the development of a sustainable institution, they continue to further explain that sustainable universities are actively involved in the mitigation or elimination of economic, social, and environmental damages that may occur in their use of resources needed to execute their main functions in order to guide society into attaining sustainable lifestyles. Conclusions on this note mention that the University of Sonora has compelling and well-founded credentials such as the environmental management standard (ISO 14001), while also obtaining a sustainable

development certificate offered by the National Council of Science and Technology in Mexico (CONACyT for its abbreviation in Spanish).

Table 1. Major University of Sonora sustainability practices and projects.

Time	Project/Document	Sustainability Practices Covered
September, 2012	“Sustainable Development Plan of the University of Sonora”	General sustainability policy, Key areas, programs, and lines of action
September, 2012	“Internal guidelines for the efficient use of institutional resources”	Guidelines for the management of electricity, water, paper, plastic bottles and disposable polystyrene products, toners, and inks
May, 2018	“Zero Garbage: Program for the effective management of solid waste and special handling waste”	Implementing sustainable waste and disposal practices while ensuring the efficient use of institutional resources and assets.
January, 2020	“Institutional Sustainability Program Training Manual”	Implementation of measures to strengthen the efficient use of the University of Sonora’s resources and installation of the recycling stations program.
December, 2021	“UI GreenMetric World University Rankings Assessment”	Assesses the institution’s commitment and actions towards sustainability regarding Education, Transportation, Water, Waste, Energy and Climate Change, Settings, and Infrastructure.

On Prior work Velazquez-Contreras et al. (2015), reported on the design of a distance learning sustainability bachelor’s degree. Their article mainly describes the elements in the competence-based curriculum design, making it a distance learning program in order to comply with the broadening and boosting the quality of higher education for sustainable development in Mexico. The data from this study was obtained via focus group techniques, integrating the information from a committee composed by twenty-five professors from different higher education institutions with knowledge on the field of sustainability. The authors have stated that the program’s main goal is to face the difficult challenges posed by the early campaigns about the Decade of Education for Sustainable Development and the Education for all and the Millennium Development Goals from UNESCO (United Nations Educational, Scientific and Cultural Organization). Final notes comment on how a strong competencies curriculum can benefit sustainability graduates during the paths into becoming true agents of change who embrace sustainability in their professional futures and organizations.

The paper by A la Torre Islas, et al. (2016), details the results of the calculation of the indicators of education for sustainability of the University of Sonora, in order to examine whether the institution complies with the principles declared in the United Nations Decade of Education for Sustainable Development (2005–2014). The results of the analyses show that 100% of the programs of this university fully adhere to the environmental sustainability perspective, moreover, 33% of the faculties work within a system of environmental management, and finally, regarding the teaching and scientific dissemination of sustainable development, indicators showed that 51.1% of its undergraduate programs offer courses and subjects related to environmental care and sustainability. These results demonstrate the institution’s interest in contributing to the field of sustainability, but also how institutional policies can contribute to the betterment of the community and the environment in which it is constantly involved. This study also shows the intertwined realities of the scientific debate and the development of institutional policies in the field of sustainable development, where

the proposed goals and agendas must be understood in order to develop feasible policies.

Lastly, some academic groups along with researchers from the University of Sonora have also developed sustainable solutions to applied problems in the area of Hermosillo, Sonora (the city where the main campus of the University of Sonora is located). Such as different studies on integrating ergonomics and sustainability in Mexican Maquiladoras (word in Spanish for a specific kind of factory) and also research about sustainability strategies for the Hermosillo area coast aquifers (Munguía Vega et al., 2019; Quintana et al., 2018). This admirable work exemplifies how locally implemented solutions derived from investigation can impact sustainability in broader aspects such as health, labor, and economy for the benefit of their residents.

3.2. Research on sustainability in relation to human behavior: An ongoing quest at the University of Sonora

Research teams from the Psychology Department in the University of Sonora have dedicated several years of their career to the study of Sustainable Development from the Perspective of Human Behavior. Their vision integrates the multiple variables that relate or impact sustainability, explaining pro-social, pro-environmental human behavior. The key element in their work is adhering to the principle of human interdependence with the environment and integrating variables that remain relevant to the study of this binomial of physical and social environment and how they enable or empower pro-sustainable behavior. Earlier work on this matter by Tapia-Fonllem et al. (2017), describes the influence of sustainability at improving quality of life. Authors remark on the importance of guaranteeing satisfaction of human needs and environmental conservation by the means of active sustainable behaviors. Sustainable behaviors here refer to pro-ecological, frugal, altruistic, and equitable behaviors which facilitate the protection of our societies and natural environment. Further explanations on sustainable behaviors then lead to declaring their effects in positive psychological dispositions or consequences such as satisfaction, self-efficacy, psychological wellbeing and restoration, happiness, and pleasure. All of these consequences, also represent improvements or positive impact in quality of human life, which could be noted as a positive outcome or aftermath of manifesting sustainable behavior. Concluding marks in this chapter, recommend the continued study of sustainable behaviors in the different scenarios of human life and evaluation their impact on positive social practices.

On a second publication from 2017 by Tapia et al. (2017), pointed out that the role that higher education plays in the promotion of sustainable development outstands in the declarations on Education for Sustainable Development, besides being a research priority in higher education. These authors carried out a study where different measurement scales were applied to 360 students from 4 Mexican universities and compared the data of new students and students in advanced semesters, testing the Construct of Orientation towards Sustainability. When comparing the results by group of progress in the studies, it was shown that there were no significant differences in the results between students, the conclusion was that the university was not impacting

with their training in pro-sustainable behavior, in any case, other exogenous variables not studied would explain the behavior of the students.

Shortly after this publication, the passage from the Decade of Education for Sustainable Development into the Objectives for Sustainable Development in the 2030 Agenda (starting in 2020) was fairly noticeable. The goals in the agenda were well received by scientific and institutional communities, and thus, gave the opportunity for a better introduction and fitting in the different component of society concerned with sustainability: government, individual actions, economy, and education. In the scenario of higher education institutions these goals were welcomed and endorsed as a form of commitment.

The aforementioned would explain a difference in the new findings, as reported in a recent study by Perez et al. (2020) where, under a similar logic to studies carried out between 2010 and 2017, 417 students from 6 public universities were evaluated. This study confirmed the existence of psychological predispositions towards sustainability: considering emotions towards the environment (affinity for diversity, feelings of indignation due to ecological deterioration and appreciation for nature), environmental actions (environmental deliberation, self-presentation and perception of environmental norms) and socio-environmental (equity, altruism and pro-ecological behavior), as well as a scale to measure environmental identity. In some way it can be inferred that the observed results are a consequence of the training and curricular process of the universities, the study findings suggest that the presence of certain psychological characteristics in people would promote a closer relationship with nature, which could then promote participation and caring for the environment.

Table 2. Some of the seminal works carried out in the University of Sonora researching variables related to Sustainable Development from the Perspective of Human Behavior.

Variables related to sustainable development	Theme or title	Authors and year
Effectiveness, Future consequences, Austerity, deliberation, Fairness, Altruism, Diversity, Appreciation for nature	Orientation towards sustainability	Tapia-Fonllem et al. (2006).
Pro-environmental behavior, Intention to act, Feelings of indignation, Emotional interest in nature, Affinity towards biodiversity	Emotions and pro-environmental behavior. In Psychological Approaches to Sustainability	Tapia-Fonllem et al. (2010).
Environmental degradation and protection, Environmental Education, Environmental competency.	Designing environmental education programs: Modeling pro-environmental competency. In Values in Sustainable Development	Fraijo-Sing et al. (2010)
Education as sustainability, pro-sustainability orientation, Pro-environmental deliberation, Appreciation of nature, Pro-ecological behavior, Predispositions to act	Education for Sustainable Development in Higher Education Institutions: Its Influence on the Pro-Sustainability Orientation	Tapia-Fonllem et al. (2017)
Environmental Identity, Psychological predispositions, Perception of Environmental Norms	Psychosocial predispositions towards sustainability and their relationship with environmental identity	Pérez Ibarra et al. (2020).
Future Orientation, Sustainable Behavior, Pro-Ecological Behavior, Happiness, Self-Care.	Transcendental future as a determinant of sustainable behavior and the perception of happiness	Barrera-Hernández et al. (2021)

In the literature that comes from authors at the University of Sonora, sustainable behavior has been studied extensively in an attempt to deepen the explanation of

integrated models or a broader vision of how pro-sustainable behavior works, which variables could be strongly related to it, factors that may compose these behaviors in favor of the environment and which are the main situations or aspects of human life where these behaviors are developed and maintained. **Table 2** describes some of the seminal studies carried out in the University of Sonora, which shows the array of themes and variables studied across the years. All of these studies were carried out in the state of Sonora, during the last decade. In a broad sense, their purpose was approaching the concepts of orientation towards Sustainability and pro-environmental behaviors in this population, developing tools dedicated to the assessment of this variables and producing explanatory models of the reality observed on the dimension of sustainability in Sonora.

4. Conclusions

Through the examples and studies presented here, we have shown some of the most important work on sustainability in higher education in Mexico and talked about different topics and different approaches in this field. However, it is the growing interest in the study of sustainability that compels us to continue working in this area to make greater contributions, reevaluating and reviewing the educational opportunities we offer in our universities and higher education institutions. After much review, the special efforts of the University of Sonora were highlighted. Leading not only with institutional policies and standards for the improvement of its campuses, but also for the continued work on the study of sustainable development from the perspective of human behavior. The works, scales and concepts about sustainability that have been developed in the University of Sonora have been regarded as useful tools for other authors around the globe in countries such as Spain, Italy, Pakistan, Ukraine, Iran, and the United States (Bakhshi et al., 2019; Berejnoi et al., 2020; Cvitković, 2018; Giancola et al., 2021; Muñoz-García and Villena-Martínez, 2021; Rasool et al., 2019; Shahid et al., 2020). Future directions are related to the improvement of the methods employed to assess practice of sustainability or the orientation towards sustainability, by transcending traditional research and statistical modelling methods into applied knowledge. Several interesting aspects may be explored further by re-designing institutional policies in the light of findings coming from the field of environmental psychology and human behavior. A key strength of the research lies within the fact that investigating sustainability for Higher Education Institutions in Mexico is of novelty within the field of sustainability, but still, the replication and recognition of our work provides an extremely useful detailed description of how, aided by environmental sciences we have approached with a constitutive and broader view, the study of the very same aspects of the sustainable behaviors we seek to convey and install in the students and graduates in hopes for a brighter future and a smooth transition into sustainable lifestyles and organizations.

In the course of this work, we have concluded that higher education institutions can be agents of change and drivers of sustainable societies, as institutions that model sustainable practices for their local communities through the policies, guidelines and actions taken on their own campuses, building a bridge from how these actions change the everyday behavior of citizens and professionals, and thus modeling a way to

educate them about sustainable actions. In the face of new environmental challenges related to natural resource management, education, social justice, equity, and advocacy for well-being, higher education institutions have a responsibility to promote sustainable development research and practice in their communities (De Amorim et al., 2020).

Considering this responsibility as part of a cyclical process in which universities provide the knowledge and the environment suitable for the practice and research of sustainability, without neglecting the training of future sustainability scientists, who will be responsible for adapting and strengthening both actions and policies to meet the needs of their contemporaries. As Killion and collaborators (2018) mentioned, to address these needs, students, faculty, and researchers require frequent training and research opportunities, in order to experience contact across disciplines and working associations. Courses, seminars, workshops, special programs, and new research communities of sustainability practice could all incorporate these opportunities. The integration of social and natural components in sustainability research can be advanced by using these guidelines to help future sustainability scientists study emergent socio-environmental systems.

Author contributions: Conceptualization, COTF; methodology, BSS and DBM; formal analysis, COTF; resources, MMB; data curation, BSS and DBM; writing—original draft preparation, COTF and MMB; writing—review and editing, MMB; supervision, BSS and DBM; project administration, COTF and BSFS; funding acquisition, COTF and BSFS. All authors have read and agreed to the published version of the manuscript.

Conflict of interest: The authors declare no conflict of interest.

References

- A la Torre Islas, M. A., Zavala Reyna, A., Alvarado Ibarra, J., et al. (2016). The Decade of Education for Sustainable Development at the University of Sonora (Spanish). *Epistemus*, 10(20), 95–99. <https://doi.org/10.36790/epistemus.v10i20.29>
- Acolt, R. G., Rodríguez, J. C., & Boncheva, A. I. (2019). Environmental practices in transportation equipment manufacturing companies in Mexico (Spanish). *Revista Venezolana de Gerencia*, 2, 210–222.
- Aigner, D., & Lloret, A. (2013). Sustainability and competitiveness in Mexico. *Management Research Review*, 36(12), 1252–1271. <https://doi.org/10.1108/mrr-06-2013-0138>
- Aleixo, A. M., Leal, S., & Azeiteiro, U. M. (2018). Conceptualization of sustainable higher education institutions, roles, barriers, and challenges for sustainability: An exploratory study in Portugal. *Journal of Cleaner Production*, 172, 1664–1673. <https://doi.org/10.1016/j.jclepro.2016.11.010>
- Avelino, F., & Rotmans, J. (2011). A dynamic conceptualization of power for sustainability research. *Journal of Cleaner Production*, 19(8), 796–804. <https://doi.org/10.1016/j.jclepro.2010.11.012>
- Bakhshi, A., Khosravipour, B., & Ghanian, M. (2019). Assessing the sustainable behavior of agricultural water operators and its correlates in South Khorasan Province. *Environmental Sciences*, 17(2), 173–188.
- Barrera-Hernández, L. F., Corral-Verdugo, V., & Fraijo-Sing, B. S. (2021). The transcendental future as a determinant of sustainable behaviors and the perception of happiness (Spanish). *CES Psicología*, 14(1), 1–15. <https://doi.org/10.21615/cesp.14.1.2>
- Berejnoi, E., Messer, D., & Cloutier, S. (2020). Cultivating Spiritual Well-Being for Sustainability: A Pilot Study. *Sustainability*, 12(24), 10342. <https://doi.org/10.3390/su122410342>
- Brito, R. M., Rodríguez, C., Aparicio, J. L., et al. (2018). Indicators of Sustainability in Educational Practice: Perception of Teachers and Students of UAGro-Mexico. *Sustainability*, 10(10), 3733. <https://doi.org/10.3390/su10103733>
- Brito, R., Rodríguez, C., & Aparicio, J. (2018). Sustainability in Teaching: An Evaluation of University Teachers and Students.

- Sustainability, 10(2), 439. <https://doi.org/10.3390/su10020439>
- Caeiro, S., Sandoval Hamón, L. A., Martins, R., et al. (2020). Sustainability Assessment and Benchmarking in Higher Education Institutions—A Critical Reflection. *Sustainability*, 12(2), 543. <https://doi.org/10.3390/su12020543>
- Cebrián, G., Junyent, M., & Mulà, I. (2020). Competencies in Education for Sustainable Development: Emerging Teaching and Research Developments. *Sustainability*, 12(2), 579. <https://doi.org/10.3390/su12020579>
- Clugston, R. & Calder, R. (2000). Critical dimensions of sustainability in higher education. In: Walter, L. F. (editor). *Sustainability and university life*. Peter Lang, Germany. pp. 31–46.
- Corral-Verdugo, V., & Pinheiro, J. (2004). Approaches to the study of sustainable behavior (Spanish). *Medio Ambiente Y Comportamiento Humano*, 5(1), 1–26.
- Cvitković, E. (2018). Sustainable behavior of future teachers (Spanish) [PhD thesis]. University of Rijeka.
- De Amorim, W. S., Neiva, S. D. S., Castro, B. C. G., et al. (2020). Higher Education Institutions as Drivers of Sustainable Communities: A Case Study of The University of Southern Santa Catarina Empowering the Community. In: *Universities and Sustainable Communities: Meeting the Goals of the Agenda 2030*. Springer International Publishing, pp. 805–823.
- Frajio-Sing, B., Corral-Verdugo, V., Tapia-Fonllem, C., & González-Lomelí, D. (2010). Promoting pro-environmental competency. In: *Psychological Approaches to Sustainability: Current Trends in Theory, Research and Applications*. Nova Science Publisher.
- García Lirios, C., Rivera Varela, B. L., Limón Domínguez, G. A., et al. (2017). Specification of a consensus sustainability model. *Revista Internacional de Investigación En Ciencias Sociales*, 13(2), 201–224. <https://doi.org/10.18004/riics.2017.diciembre.201-224>
- Giancola, M., Pino, M. C., & D’Amico, S. (2021). Exploring the Psychosocial Antecedents of Sustainable Behaviors through the Lens of the Positive Youth Development Approach: A Pioneer Study. *Sustainability*, 13(22), 12388. <https://doi.org/10.3390/su132212388>
- Giannetti, B. F., Agostinho, F., Almeida, C. M. V. B., et al. (2020). Insights on the United Nations Sustainable Development Goals scope: Are they aligned with a ‘strong’ sustainable development? *Journal of Cleaner Production*, 252, 119574. <https://doi.org/10.1016/j.jclepro.2019.119574>
- Hirsch Hadorn, G., Bradley, D., Pohl, C., et al. (2006). Implications of transdisciplinarity for sustainability research. *Ecological Economics*, 60(1), 119–128. <https://doi.org/10.1016/j.ecolecon.2005.12.002>
- Juárez-Nájera, M. (2015). *Exploring Sustainable Behavior Structure in Higher Education*. Springer International Publishing. <https://doi.org/10.1007/978-3-319-19393-9>
- Killion, A. K., Sterle, K., Bondank, E. N., et al. (2018). Preparing the next generation of sustainability scientists. *Ecology and Society*, 23(4). <https://doi.org/10.5751/es-10395-230439>
- Leal Filho, W., Raath, S., Lazzarini, B., et al. (2018). The role of transformation in learning and education for sustainability. *Journal of Cleaner Production*, 199, 286–295. <https://doi.org/10.1016/j.jclepro.2018.07.017>
- Lozano, R., Ceulemans, K., Alonso-Almeida, M., et al. (2015). A review of commitment and implementation of sustainable development in higher education: results from a worldwide survey. *Journal of Cleaner Production*, 108, 1–18. <https://doi.org/10.1016/j.jclepro.2014.09.048>
- Lozano, R., Lozano, F. J., Mulder, K., et al. (2013). Advancing Higher Education for Sustainable Development: international insights and critical reflections. *Journal of Cleaner Production*, 48, 3–9. <https://doi.org/10.1016/j.jclepro.2013.03.034>
- Lozano, R., Merrill, M., Sammalisto, K., et al. (2017). Connecting Competences and Pedagogical Approaches for Sustainable Development in Higher Education: A Literature Review and Framework Proposal. *Sustainability*, 9(10), 1889. <https://doi.org/10.3390/su9101889>
- Munguía Vega, N. E., Flores Borboa, V. S., Zepeda Quintana, D. S., & Velazquez-Contreras, L. E. (2019). Assessing the effectiveness of integrating ergonomics and sustainability: a case study of a Mexican maquiladora. *International Journal of Occupational Safety and Ergonomics*, 25(4), 587–596. <https://doi.org/10.1080/10803548.2017.1419589>
- Muñoz-García, A., & Villena-Martínez, M. D. (2021). Influences of Learning Approaches, Student Engagement, and Satisfaction with Learning on Measures of Sustainable Behavior in a Social Sciences Student Sample. *Sustainability*, 13(2), 541. <https://doi.org/10.3390/su13020541>
- Pfahl, S. (2005). Institutional sustainability. *International Journal of Sustainable Development*, 8(1–2), 80. <https://doi.org/10.1504/ijsd.2005.007376>
- Pérez Ibarra, R. E., Tapia-Fonllem, C. O., Frajio-Sing, B. S., et al. (2020). Psychosocial Predispositions Towards Sustainability

- and Their Relationship with Environmental Identity. *Sustainability*, 12(17), 7195. <https://doi.org/10.3390/su12177195>
- Portuguez Castro, M., & Gómez Zermeño, M. G. (2020). Challenge Based Learning: Innovative Pedagogy for Sustainability through e-Learning in Higher Education. *Sustainability*, 12(10), 4063. <https://doi.org/10.3390/su12104063>
- Portuguez Castro, M., Ross Scheede, C., & Gómez Zermeño, M. G. (2019). The Impact of Higher Education on Entrepreneurship and the Innovation Ecosystem: A Case Study in Mexico. *Sustainability*, 11(20), 5597. <https://doi.org/10.3390/su11205597>
- Ramírez, L. V., & Gómez, A. Y. B. (2018). An Investigation in Environmental Education and Sustainability in Mexico: A Study of Tendencies and Challenges. *European Journal of Social Sciences Education and Research*, 12(1), 237. <https://doi.org/10.26417/ejser.v12i1.p237-243>
- Rasool, S., Shakur, A., ani Mohammad, M., et al. (2019). Validating a measure for altruistic self towards the responsible plate food consumption: a mix method approach. *International Journal of Business & Society*, 20(1).
- Shahid, Z. A., Rasool, S., & Chen, Y. (2020). Exploring Altruistic Self in Socially Responsible Behaviors. In: *Proceedings of the International Conference on Modern Educational Technology and Innovation and Entrepreneurship (ICMETIE 2020)*. <https://doi.org/10.2991/assehr.k.200306.116>
- Sterling, S. (2010). Sustainable education. In: *Science, society and sustainability*. Routledge, pp. 127–140.
- Tapia-Fonllem, C., Fraijo-Sing, B., Corral-Verdugo, V., et al. (2017). Education for Sustainable Development in Higher Education Institutions. *SAGE Open*, 7(1), 215824401667629. <https://doi.org/10.1177/2158244016676295>
- Tapia-Fonllem, C., Corral-Verdugo, V., & Fraijo-Sing, B. (2017). Sustainable behavior and quality of life. In: *Handbook of environmental psychology and quality of life research*. Springer, Cham, pp. 173–184.
- Tapia-Fonllem, C., Corral-Verdugo, V., Gutiérrez-Sida, C., et al. (2010). Emotions and pro-environmental behavior. In: *Psychological Approaches to Sustainability: current trends in theory, research, and applications*. Nova Science Publisher.
- Tapia, C., Fraijo, B., Corral, V., et al. (2006). Validation of a sustainability orientation scale—Desert and sea (Spanish). Cd. Obregón, México: Instituto Tecnológico de Sonora.
- Turnbull, D., Chugh, R., & Luck, J. (2021). The Use of Case Study Design in Learning Management System Research: A Label of Convenience? *International Journal of Qualitative Methods*, 20, 160940692110041. <https://doi.org/10.1177/1609406921100418>
- University of Indonesia. (2021) GreenMetric World University Rankings Fact File Report—Universidad de Sonora. University of Indonesia.
- Universidad de Sonora. (2012). Sustainable Development Plan of the University of Sonora (Spanish). Programa institucional de Sustentabilidad.
- University of Sonora. (2019). Unison ranks in global sustainability rankings (Spanish). Available online: <https://internacionalizacion.unison.mx/se-ubica-unison-en-ranking-mundial-de-sustentabilidad/> (accessed on 10 February 2024).
- Valero, N., & Briceño, M. E. F. C. (2019). Environmental Education and Education for Sustainability: history, fundamentals, and trends. *Encuentros*, 17(2), 24–45.
- Velazquez-Contreras, L., Munguía, N., Zavala, A., & Esquer, J. (2018). Sustainable good practices in the University of Sonora, Mexico. *Global University Network for Innovation*.
- Velazquez-Contreras, L. E., Vega, N. E. M., Pulgarin, A. G. H., & Palencia, E. P. (2015). Designing a distance learning sustainability bachelor's degree. *Environment, Development and Sustainability*, 17(2), 365–377.
- Wals, A. E. J., & Schwarzin, L. (2012). Fostering organizational sustainability through dialogic interaction. *The Learning Organization*, 19(1), 11–27. <https://doi.org/10.1108/09696471211190338>
- Wiek, A., Withycombe, L., & Redman, C. L. (2011). Key competencies in sustainability: a reference framework for academic program development. *Sustainability Science*, 6(2), 203–218. <https://doi.org/10.1007/s11625-011-0132-6>
- Yarime, M., Trencher, G., Mino, T., et al. (2012). Establishing sustainability science in higher education institutions: towards an integration of academic development, institutionalization, and stakeholder collaborations. *Sustainability Science*, 7(S1), 101–113. <https://doi.org/10.1007/s11625-012-0157-5>
- Yin, R. K. (2009). *Case study research: Design and methods*. Sage. <https://doi.org/10.1080/10803548.2017.1419589>
- Zepeda Quintana, D. S., Loeza Rentería, C. M., Munguía Vega, N. E., et al. (2018). Sustainability strategies for coastal aquifers: A case study of the Hermosillo Coast aquifer. *Journal of Cleaner Production*, 195, 1170–1182. <https://doi.org/10.1016/j.jclepro.2018.05.191>