

Education for Sustainable Development: Curriculum Approaches and Competence Assessment in a Multidisciplinary Undergraduate Course

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Abstract— Sustainable development is a concept that has been introduced at different academic levels. Professors seek more ways to promote the students' understanding and awareness about the importance of taking care of the planet, and the implications of the excessive growth in the world. Committed to Sustainable Development, Tecnológico de Monterrey has developed different strategies (including challenges and cases) for higher education students to get involved in this area of concern and to develop sustainability outcomes. This work aimed to implement different activities and tasks related to sustainable development, in two groups of the Fundamentals of Biological Systems course, in order to include and develop education for sustainable development throughout the course. These activities were implemented for the first time as educational innovation actions. The obtained results involved the students' vision and engagement in the topic. Furthermore, this work displayed the level of outcomes reached by the students and their awareness and contribution to a better future world.

Keywords—Educational Innovation, Higher Education, Sustainable Development, Sustainable Development Goals.

I. INTRODUCTION

As a response to traditional development models and their harmful effects on the environment and its resources, sustainable development has emerged as a global concept that considers environmental, social, and economic aspects of fulfilling our needs, while preserving and protecting the provision for future generations [1]. From the global efforts to transform the world into a place with stable and prosperous social, economic, political, and environmental structures; the

2030 Agenda for Sustainable Development appears as the most notorious reference for achieving this transformation. Through the recognition of protecting the planet, while developing human potential, the 17 sustainable development goals (SDG) tackle several problems and challenges affecting the present and future of human beings and the place we inhabit [2]. This fight is currently occurring at many levels, areas, and fields, where education has been regarded as an ideal moment for intervention, by means of its role in building human capital and shaping adulthood [3]. As noted by Goal 4, there is a necessity for providing quality education with an inclusive and equitable scope, where the promotion of sustainable development and a sustainable lifestyle must be ensured [2].

UNESCO has set the guidelines to provide Education for Sustainable Development (ESD) where it outlined the need for redesigning the purpose, use, and application of the skills, values, and attitudes that are developed through learning. For those reasons, ESD promotes an immersive approach where learning occurs through living while promoting a sense of responsibility in the students to ensure a better present and a safer future for upcoming generations. This should be considered not only in education policies but also when training teachers and designing curricula. A key aspect of this action is addressing climate change towards the generation of transformative actions [4].

Even though pedagogues and educators commonly address the role of early childhood and primary education for shaping individuals, universities are optimum spaces where the SDG can be applied to collaboratively solve the current problems and needs of society, while innovating in different disciplines with a social, scientific, economic, environmental, or political impact [5].

As one of the main actors in this transformation, educators should consider the sustainable development goals and link them with local realities [4]. ESD has an impact on the perception of sustainability among the students, which could set

the scenario for changes towards the achievement of the SDG [6]. In this work, the integration of different innovative activities focused on the development of sustainability consciousness and the improvement of the perception of the role of human beings in climate change was assessed in a higher education course from the Bioengineering department at Tecnológico de Monterrey, Mexico. The particularity of this course is its multidisciplinary, as it gathers students from the six exploration areas at Tecnológico de Monterrey (Built environment, Bussiness, Law, economy and international relations, Creative studies, Health and Enginnering) .

II. METHODOLOGY

A. Sample

Two groups from the Fundamentals of Biological Systems at Tecnológico de Monterrey (Monterrey Campus, Mexico) were selected during the semester of August-December 2023. This class was an elective class offered by the School of Bioengineering, which meant that students from different semesters and from all the schools and departments could be enrolled. Both groups, aged 18-23, were taught in English and included international students. The details from both groups are indicated in Table 1.

TABLE I
SELECTED GROUPS FROM THE FUNDAMENTAL OF BIOLOGICAL SYSTEMS CLASS

Group	Number of Students n	Gender		Origin	
		Male	Female	Mexico	Overseas
601	33	15	18	29	4
602	38	20	18	35	3
Total	71	35	36	64	7

B. Investigation of the acknowledgment of environmental affairs through the dimensions of wellness.

The exploration of the relevance given by the students to the environment and environmental issues was conducted by presenting 8 of the 9 dimensions of wellness during the class (physical, emotional, financial, intellectual, social, creative, spiritual, and environmental) [7]. This specific session was followed by a reflective video from the students, in which they selected one to three dimensions to be prioritized and worked on,

during the semester. The videos were uploaded on Flipgrid (Codes: 84e8bfaf, 092348cf), and the responses were analyzed.

C. Understanding the role of humans in environmental changes.

Through an activity titled “My own ecosystem” the students considered their hometowns as big ecosystems. Based on their childhood memories and recent observations, they reflected on the changes that their ecosystems suffered throughout the years. Depending on their reflective process, the students answer the following questions:

- 1) How has your ecosystem changed throughout the years?
- 2) What is the cause of those observed changes?
- 3) How are humans related to those changes?

All the responses were subsequently categorized for analysis.

D. A Global Ecosystem Perspective through 7Vortex

The 7Vortex platform was utilized by the students to create a global ecosystem regarding different environmental topics and their relation to human beings. For this purpose, each student selected a topic with environmental relevance and included a bubble about it in the designated virtual space. Then, each bubble was connected by the students according to its symbiotic relation with any applicable bubble within the 7Vortex ecosystem. The ecosystem can be found at <https://www.7vortex.com/ecosystems/a80faeaf-e6d3-46d9a560-4dd240a0464c/view>

E. Assessment of the Education for Sustainable Development through the Evaluation of a Wellness-related Competence.

For assessing the conscious development of sustainability as a priority for the students within their lifestyle, a final project, consisting of an infographic about how their lifestyles in a big city such as Monterrey help prevent any chronic disease while positively impacting on a sustainable way of living. Through answering this final project, the degree of achievement was assessed for an applicable sub-competence, according to a four achievement levels rubric (incipient, basic, solid, and outstanding), as indicated in Table 2.

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TABLE II
ASSESSED SUB-COMPETENCE AND RUBRIC FOR ITS LEVELS
OF ACHIEVEMENT.

Sub-competence			
Systematically implements relevant physical, emotional, mental, and economic self-care strategies; that allow the student to flourish in a changing environment, in accordance with a personal and professional well-being project.			
Level of Achievement			
Incipient	Basic	Solid	Outstanding
<i>The student implements suitable physical, emotional, mental, and economic selfcare strategies, by establishing viable goals in which he/she/they make(s) optimal use of his/her/their personal resources and those from the environment.</i>	<i>The student implements appropriate physical, emotional, mental, and economic selfcare strategies, by establishing appropriate goals in which he/she/they make(s) convenient use of his/her/their personal resources and those from the environment.</i>	<i>The student implements basic physical, emotional, mental, and economic selfcare strategies, by establishing limited goals in which he/she/they make(s) acceptable use of his/her/their personal resources and those from the environment.</i>	<i>The student implements inadequate physical, emotional, mental, and economic selfcare strategies, by establishing basic goals in which he/she/they make(s) deficient use of his/her/their personal resources and those from the environment.</i>

III. RESULTS AND DISCUSSION

The results for the dimensions of wellness selected by the students are presented in Figure 1. From the received answers, it was clear that most students were committed to working on their physical, emotional, and social dimensions. Unfortunately, the environmental dimension was only selected by three students, which denotes how this aspect is commonly overlooked as an important dimension of wellness. In fact, the current state of the environment could be related to the worldwide development of many diseases, hence recognizing our responsibility in preserving, protecting, and remediating the environment should be promoted in the students at different levels. Not only individually but as a social commitment that has a positive impact on other dimensions (physical, social, etc.) [7]. The students that selected the environmental dimension, indicated in their videos that were willing to gradually change to recycling and generating less waste, as well as modifying consumption patterns, and merging the physical and environmental dimensions, by doing activities such as exercising in the green areas offered by the city.

This first examination of the status of both groups was crucial to understanding the need to include activities and tasks that allowed the integration of SDG, along with climate change topics to develop the conscious acknowledgment of the impact that the human lifestyle and human activities have on the

environment, and how individual actions can improve the collective wellbeing.

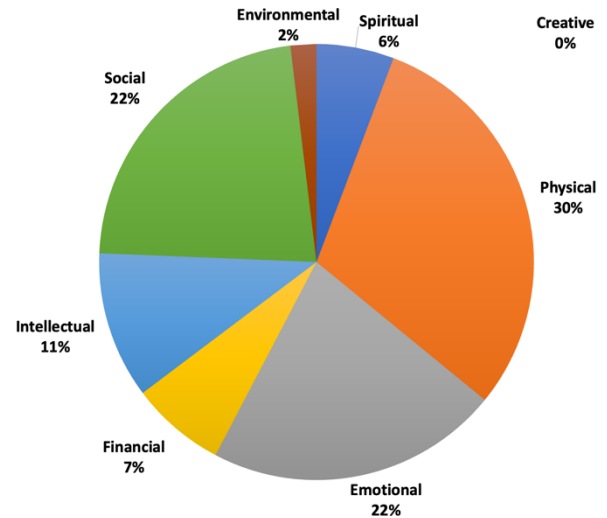


Figure 1. Dimensions of wellness prioritized by the students for the semester August-December 2023 (n=156).

As shown in Figure 2, from the 55 participants in the “My own ecosystem” activity, 52.72% were originally from Monterrey, Nuevo Leon, Mexico; other participants had their origins in cities from varied states of Mexico such as Puebla, Tamaulipas, Veracruz, State of Mexico, Mexico City, Yucatan, Tabasco, Coahuila, Durango, Guanajuato, Chiapas, Campeche, Jalisco, Hidalgo, Sinaloa, and Baja California Sur. This activity was a good opportunity for exploring different experiences and perspectives on the same topic, while addressing the multiculturalism occurring in the classroom. Furthermore, some international insights were provided by students from Honduras and France, yet, in all the cases the students observed substantial changes in their ecosystems, which resulted in a reflection on the possible causes for this overtime transformation and its relationship with human beings.

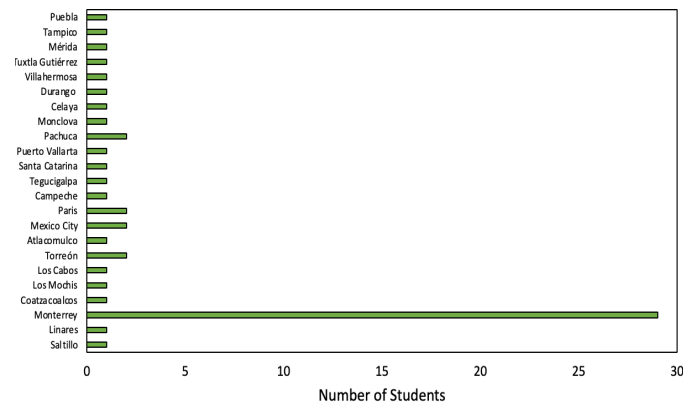


Figure 2. City of origin from the students who answered the “My own ecosystem activity” (n=55).

The answers to the question: How has your ecosystem changed throughout the years?; were categorized and are presented in Figure 3. The main identified change throughout the years was the weather, which was described by the students as longer drought periods, increments in the overall temperature, absence of snow events in some cities, extreme temperatures during the day (colder nights and warmer days), and modification of the seasonal patterns. An important event that impacted the perception of change in the students was the water shortage period that took place in Northern Mexico in 2022, specifically in the Monterrey metropolitan area [8]. Hence, it is necessary to consider the implementation of sustainable water use contents in the curricula, that could permeate in the creation of supporting technologies, better urbanization plans, and structured agriculture activities, that could be potentially implemented by the young professionals currently shaped through undergraduate education [9].

Other observed changes included the increment of air pollution in different cities, which modifies the daily landscape of urban areas. In close relation to this issue, urbanization was mentioned as a modification of the architecture, as well as a response to deal with overpopulation, where the invasion of green and natural areas in combination with increased traffic, were also acknowledged by the students. In accordance with the urbanization of natural areas, some places like Monterrey are constantly subject to animal encounters as in the case of endangered bears due to anthropogenic activities [10], while other cities have shown a decrease in their animal populations, as in the case of the marine life (gray whale) in Los Cabos, Baja California Sur [11]. Opposite to water scarcity, places like Mexico City and Villahermosa are suffering from flooding, which represents economic losses and requires investments in flood protection [12]. Although migration has been identified as an important event by the students, the case of Coatzacoalcos, Veracruz was notorious because of the emigration of citizens due to insecurity reasons, this corresponds to the perception of insecurity indicated by the citizens, triggered by the kidnap rates observed 14 to 10 years ago in the Coatzacoalcos region [13].

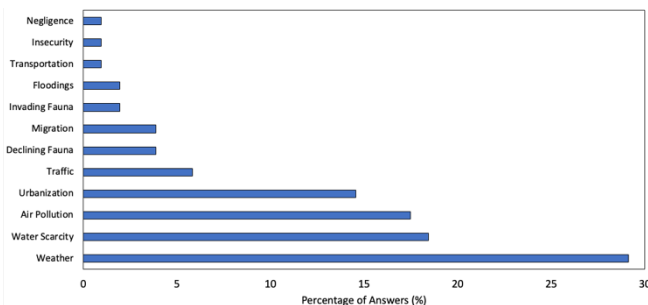


Figure 3 Changes and issues identified by the students in their ecosystems (n=103).

After responding to the question: “What is the cause of those observed changes?”, the answers were grouped into 6 categories. As noted in Figure 4, both climate change and industrial

activities were highly considered as the main causes for the changes in the described ecosystems.

As previously discussed, overpopulation was also mentioned by the students as one of the main reasons for the change in the overall panorama of urban areas. It is worth mentioning that all the students had the freedom to search for online information including newspapers and videos. Nevertheless, their own memories and perceptions were accepted as valid, as the main goal of this activity was to create environmental awareness by reflecting on the situations of a close, relatable, and local scenario. The fact that climate change was highly regarded is a positive point that corresponds with the relevance given to climate change in the Education for Sustainable Development Roadmap, where is considered as an emergency in which human beings are responsible for the global temperature change throughout the years [4]. For this reason, in order to discover if the students were aware of all the possible roles (responsible or solvers), that human beings can take within the context of a required global action, the third question was: How are humans related to those changes?

As displayed in Figure 5, the students recognized that many of those changes and the environmental issues generated throughout the years correspond with the lifestyles of human beings. As perceived by the students, when fulfilling the demand for resources, services, transportation, and infrastructure, human beings can ignore the importance of preserving nature. This was outlined by some students as the use of resources, which refers to the overexploitation of agricultural and fishing resources. An important aspect that was considered by some students was the role of human beings as part of government bodies, this not only reinforces the idea of political platforms as drivers for change and transformation but promotes an active role of citizens to promote policy changes and governmental programs. In fact, when government instances intervene and ensures equal access to education, health, and food systems, along with energy sources and urban development, transformations towards achieving Sustainable Development Goals can be accomplished [3]. The government has also a crucial role in including ESD in different education policies, as students can develop skills, reinforce values, and learn about sustainable development goals while applying them from an institutional framework [4].

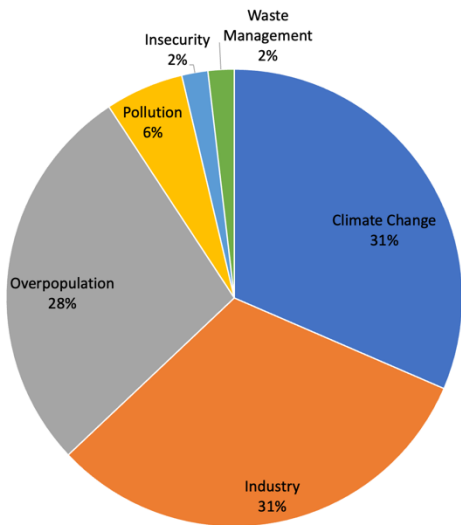


Figure 4. Causes of change identified by the students in their ecosystems.

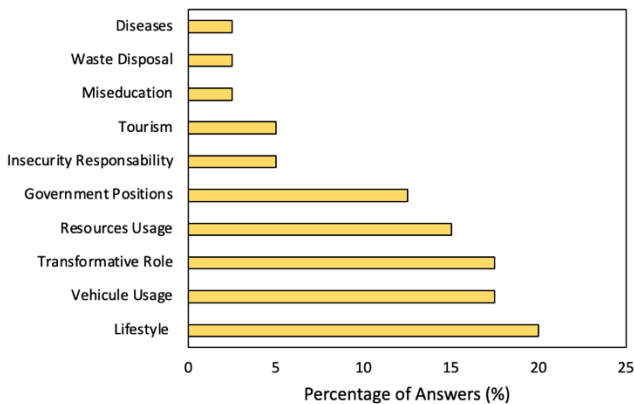


Figure 5. Perceptions of the students regarding the relationship between humans in ecosystem changes.

Furthermore, the students also acknowledged the transformative action from humans in a similar way proposed by the ESD towards 2030, where all positive changes start with each individual. This is a key reflection from the ESD, in which exposure to reality is important for developing transformative actions in the students [4]. Hence, the Ecosystem Activity, as well as this type of activity in general, aligns with the ESD approach.

The contributions from the students to the 7Vortex activity are illustrated in Figure 6. Once the individual cases were reflected by the students through their own ecosystems, the 7Vortex activity was focused on developing a global perspective regarding climate change and environmental issues triggered by humans and affecting humans. This was necessary for integrating a global citizenship education, where students (learners) are the active promoters of change for a better world, by tackling different global challenges and promoting a global and sustainable development [14]. In addition, this activity was also important to understand how different environmental

aspects, challenges, issues, and initiatives, can be symbiotically connected from a global and holistic perspective.

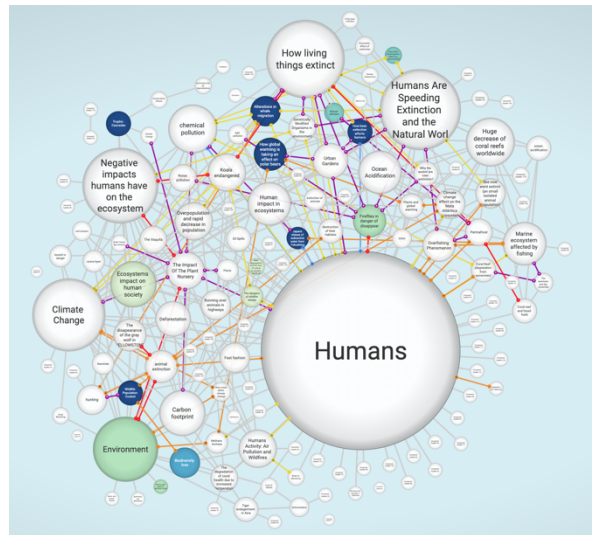


Figure 6. 7Vortex ecosystem generated by the students regarding the connection of human beings with different environmental topics.

The achievement levels for the assessed sub-competence are indicated in Figure 7. As noted, the majority of students (69%) accomplished an outstanding level, followed by a solid level (28%) which is desirable for the fulfillment and development of any sub-competence. Approximately 40% of the students who obtained basic and solid levels, did not complete at least one of the presented activities in this work.

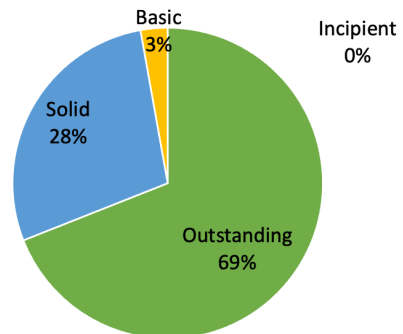


Figure 7. Sub-competence level accomplished by the students (n=71).

Those sub-competence levels denoted the student's mindset change, which started with a low consideration for environmental issues, and after the curriculum intervention was transformed into considering sustainable actions within their lifestyles, well-being, and future plans.

III. CONCLUSIONS

Although climate change and sustainable development are tangible realities and needs, their integration into different undergraduate curricula is still under debate by different actors in the education system. As indicated by the United Nations and several other authors, our world can be collectively transformed through individual efforts.

In this regard, undergraduate institutions represent an ideal platform for shaping the future, through the promotion and integration of sustainable development concepts into the curriculum from different programs. Elective subjects, such as the course from this work, represent a melting pot, where different disciplines come together to discuss topics such as climate change and sustainable development on transformative actions, which can result in the integration of such contents, skills, and values in a sustainable lifestyle. In this regard, the integration of innovative education activities could be a strategy for triggering changes in higher education institutions, towards the achievement of sustainable development. At the end of the implementation, all the curriculum modifications positively changed the overall consciousness of the students towards climate change, human responsibility, global development, and a sustainable lifestyle.

This also allows a more proactive approach, which differs from the common pessimist point of view, taken by educators and students when addressing these topics. So far, these efforts work as a seed that can be planted in students at different levels, however, it is necessary to monitor and confirm not only a conscious and perception change but the generation of changes and transformation by the intervened groups.

IV. ACKNOWLEDGMENTS

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