Challenge Based Learning: Innovative Pedagogy for Sustainability through e-Learning in Higher Education

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Abstract: Challenge-Based Learning (CBL) is an innovative teaching methodology that engages students to resolve real-world challenges while applying the knowledge they acquired during their professional training. This article describes the results of the implementation of an online course on entrepreneurship that utilized CBL with a group of 20 undergraduate students from various disciplines in a university in Mexico. During the course, challenges related to the Sustainable Development Goals of the United Nations were presented to the participants, making it possible to observe the students' interest in resolving these problems. This research uses a case study methodology and seeks to determine the CBL elements in the e-learning modality. The results showed that the participants generated sustainable business ideas aimed to resolve local, national, and global problems. The recommendations are to continue the formation of the businesses proposed in the project. These ideas can become real ventures that connect various actors in the entrepreneurial ecosystem and will continue to strengthen transversal skills such as teamwork and communication.

Keywords: challenge-based learning; education in sustainability; e-learning; educational innovation; higher education; sustainable development goals

1. Introduction

There is no doubt that the development of Information and Communication Technologies (ICT) has generated transformations of all fields of society, including education [1]. The internet and the use of network-connected devices [2,3] have penetrated traditional teaching and learning methods. As a result, different educational modalities have arisen, reflecting these changes and raising new scenarios that shape training processes [4].

Among the new modalities of online education is e-learning, which uses ICT to provide educational content and facilitate learning to multiple segments of the population [5]. The advantages of this modality include its flexibility and the possibility that it can be utilized remotely and at different times, thanks to synchronous and asynchronous processes [6]. Also, its potential for communication and the possibilities for ubiquitous learning (anytime, anywhere) promote lifelong learning and interactions among participants [7,8]. The disadvantages are that if there are no such interactions in a course, a student's motivation decreases. Furthermore, evaluations are difficult to do online in disciplines that require applied practices [9].

Through education, people can improve their quality of life. Using technological tools, they can develop innovative solutions to the most significant problems of society [10]. So, ICT-based modalities such as e-learning are considered mechanisms that can improve access to education. They have great potential to accomplish the objectives set for sustainable development. For this to happen, there must be an appropriate pedagogical model that incorporates self-regulated learning and a multidisciplinary approach [11–13].

According to UNESCO [14], education for sustainable development aims to give people the skills and knowledge to find solutions to economic, social, and environmental problems. It encourages students to reflect on excess consumption, poverty, the stimulation of solidarity and cooperation, and to recognize that current economic development trends are not sustainable; therefore, programs that promote these are required [15].

In 2015, the international community proposed the Sustainable Development Goals (SDGs), including 17 objectives and 169 challenges that proposed to eradicate poverty by the year 2030 [16]. To achieve the goals of the 2030 agenda, citizens must have a world economy that is environmentally sustainable and inclusive. Therefore, lifelong learning and education should prepare citizens to develop the skills that make production and consumption sustainable [13,17]. A better-educated workforce will nurture inclusive economic growth and a focus on human well-being [18].

According to Alcalá and Gutiérrez [19], interest in sustainable education focuses on students and the innovative pedagogies that bring them closer to social reality and its main conflicts. The goal is for the students to better understand the environments of their intended professions. A university must be a driving force that trains students to remain aware of sustainability and the changes it implies. Therefore, it is a priority in education to work on values that lead to reflection and critical thinking, and to integrate the themes of sustainability into the contents of subject materials [19].

Takala and Korhonen-Yrjonheikki [20] defined the main competencies for sustainable development to be holistic understanding, communication, collaborative skills, critical thinking, reflection, creativity, innovation, and entrepreneurship. To achieve these competencies, one must keep sustainability in mind as an ongoing process. Teachers should encourage their students to understand their roles in sustainable development and collaborate in multi-disciplinary ways to share knowledge. Curricular content must be integrated, teacher training promoted, and there must be public funds for research.

Environmental, social, and economic changes make the issue of sustainable development more pressing than ever. However, training in universities remains technocratic and does not promote reflection on these problems [21]. Also, education for sustainable development is still not integrated into the programs, so most courses do not raise concerns about this issue [20]. The development of active pedagogical activities that help strengthen the vision of education in this society thus become a challenge [22–25].

In this context, educational innovation contributes to the design and presentation of programs that address these challenges [26,27]. However, for there to be educational innovation, we must introduce new technological tools that are used correctly and appropriated to the various actors that need them [2]. Additionally, digital learning environments must be created where a student can contribute directly to improvements, experiments, and shared experiences. All these actions occur through new forms of teaching [28].

Along these lines, Challenge-Based Learning (CBL) is an innovative pedagogy that actively engages students in relevant real-world problems that exist in their environments and that require a solution [29,30]. This pedagogy has its roots in experiential learning. It incorporates the use of technology, teamwork, self-directed learning, and solutions to real problems that extend from the classroom to the community [31].

This pedagogical approach leverages students' interests to give practical meaning to education. It develops competencies such as multidisciplinary teamwork, decision-making, leadership, and communication [32,33]. The challenge consists of an activity or situation that involves sincere effort from the student and triggers him/her to obtain new knowledge through the proposal of a concrete solution [34]. Content is presented that builds on students' previous knowledge, and is structured so that feedback can occur between students and instructors [30]. Therefore, the involvement of students in the creation of knowledge, both individually and cooperatively, is considered an essential characteristic of active methodologies [35].

According to Edutrends [30], CBL consists of the following elements:

- The general idea: There is a topic presented to students with importance to society.

- The essential question: The general idea starts with a problem that reflects the interest of the students and the needs of the community.
- The challenge: Students must create a solution to the problem posed in the essential question.
- Questions, activities, and guide resources: Students identify elements that are convenient for developing innovative solutions to problems.
- The solution: Each challenge permits a variety of solutions. These must be concrete and feasible to implement in the community.
- Implementation: Students test the solution in a real environment.
- The evaluation or assessment is carried out through the challenge process, which confirms the learning results and supports the decisions made during the implementation.
- Documentation and publication: Students find ways to publish their ideas, blogs, videos, and other tools.
- Reflection and dialogue that consider the content and the students' learning and experiences.

Previous studies on CBL like the one by Rådberg et al. [32] have indicated that this multidisciplinary approach encourages students to work actively with their peers and teachers to identify complex challenges, ask relevant questions, and take action favoring sustainable development. The three-year case study involving 38 students was conducted in the Chalmers University Challenge Laboratory. The results showed that the students developed skills in the formulation of problems and sustainable development. Although few projects reached their implementation, they had the potential for social impact. Hence, the authors suggested complementing other projects within the career with this type of program.

Another study by Malmqvist et al. [33] compared four experiences of CBL in universities in Australia, the United States, Denmark, and Sweden. The similarity among them was that this methodology was presented throughout the courses with topics related to social and environmental sustainability. In one of the universities, the course was positioned in the first year, setting the stage to continue with subsequent courses and projects based on that initial course, which made planning go further. The authors concluded that multidisciplinary courses placed new demands on teachers who may not know about the topics, causing students to feel a lack of support; this implies a need to have teachers from different disciplines. Students need to develop transversal skills such as communication, decision-making, leadership, and teamwork, in addition to those in a socio-technical domain. Soft skills remain outside the regular curricula, but they must become part of them.

In an experience carried out by Azeteiro et al. at a Portuguese university [12], the authors found that education in sustainability through e-learning can be highly relevant for sustainable development. However, the authors concluded that students had problems developing some competencies, and that more studies would be necessary to evaluate the appropriate pedagogical model. In the case of the e-learning modality, Racovita-Szilagyi et al. [6] conducted research in Spain and the United States with 400 university teachers in the social work field. The authors inquired about their perceptions on the opportunities that the e-learning modality creates for their teaching. The participating professors believed that, through this modality, students in rural areas could have greater accessibility, and that the students could learn at their own pace and have a mentor. Finally, the authors mentioned that for future studies, more research should focus on the integration of technology and its impact on training processes.

According to the literature consulted, these new strategies are necessary to develop more active learning oriented toward problem-solving [32,36]. However, the programs of higher education are still more theoretical than practical. There is a gap between what students learn and what they can apply in their lives [32–37]; therefore, methodologies that promote active learning and learning by doing [33,38] must be incorporated.

Also, as online education continuously evolves, research should focus on the good practices that favor its implementation so that the learning mediated by technologies continues [39]. However,

although CBL has been shown to be positive for students interested in sustainable development facilitated by the active methodologies used in the courses, some courses are not yet part of the curricula. Therefore, there is not continuity of the projects. More research is required to learn how to continue developing sustainable development skills in students [6,12].

The research of this project was carried out in a university in northern Mexico. This institution is currently implementing an educational model based on active methodologies, so this study sought to generate knowledge about the results of its implementation related to sustainable education. The study was carried out in an extracurricular course taught to students from different careers. The courses ere optional and taken by students interested in this topic of study; they sought to develop transversal competencies in students, including personal and professional skills for achieving life and career goals and comprehensive health.

Therefore, this study aimed to implement CBL as an innovative pedagogy through online education in this particular study group. It had the objectives to determine its results and opportunities for improvement and to guide students toward solutions for sustainable-development problems. The study sought to answer the following research questions:

- Q1. How to implement CBL to strengthen education for sustainable development in an e-learning course in the study context?
- Q2. What was the perception of the enrolled students in the e-learning course about the contribution they can make to resolving local, national, or global problems?
- Q3. What elements of CBL contribute to providing solutions to local problems through an e-learning course?

2. Method

To answer these research questions, we used a case study methodology. The approach was qualitative. In such research, the investigators explore a case or several real-life cases, collecting data from multiple sources of information such as observations, interviews, audiovisual materials, documents, and reports [40]. This research developed an e-learning course with training activities and challenges in which the students solved sustainability problems through entrepreneurial proposals. The research analyzed a unique case of a class that was participating in an online course.

The evidence obtained describes the intervention and the context in which it occurred [41]. By analyzing the educational experiences that promote active learning, such as CBL, one can discover how to use active teaching methodologies to generate solutions to local, national, and global problems. Research such as this can lead to the construction of education for sustainable development.

2.1. Participants

The sample consisted of 20 undergraduate students from a university in northern Mexico. The participants were selected by convenience, and they agreed to be included in the study [42]. The study aimed to have students from different careers (curricula) in the sample. The most frequent careers studied by the participants were strategy and business administration, marketing, psychology, civil engineering, chemical engineering in sustainable processes, mechatronics, and biotechnology. Table 1 shows the number of students and their gender, career, and average age percentages.

Table 1. Distribution of the sample.

Total Students	Men	Women	Average Age	Career
20	8	12	23 years old	
	40%	60%		
12	5	7		
6	2	4		Engineering
				Business administration
1	1	0		Industrial design
1	0	1		Clinical psychology

During the first week, 20 students participated. In the second week, six groups were formed according to the interests of the students; each group was made up of three to four students. Twelve students completed all the activities. Students who did not finish indicated that they did not have time to carry out the activities due to other academic obligations and withdrew from the course. Of the eight students who withdrew, five withdrew before working on the proposals, while the other three started with their proposals but did not present them.

2.2. Procedure

This study consisted of the implementation of an e-learning course that followed the CBL methodology. The course was held as an extracurricular activity in a workshop to develop skills for life and work; it was directed to students of different careers (multidisciplinary). It was optional and intended for those interested in the topic of entrepreneurship and social innovation.

The main objective of the course was for the students to seek solutions to social problems by proposing products or services that could become entrepreneurial businesses. The specific objectives were for the students to (1) describe concepts related to entrepreneurship and innovation for use in solving problems in their environments; (2) analyze problematic situations in their environments that can be resolved through innovative and entrepreneurial proposals; (3) propose innovative solutions to problems collaboratively, and (4) prepare pitches to publicize their proposed solutions.

The course duration was five weeks with synchronous and asynchronous activities and content related to CBL and entrepreneurship, hosted on a Moodle platform. Synchronous activities were those related to meetings or chats to organize the group work, and asynchronous activities were forums and blog interventions. Also, during the last week, some groups presented their pitches face-to-face at the university. The teacher evaluated using a checklist and rubrics of assessment. Table 2 shows the contents and activities of the e-learning course.

In the course, the students had a series of challenges related to community problems that had to be solved collaboratively with peers and teachers. The challenge was to choose one state problem out of the 10 defined as priorities by the *Strategic Plan for the State of Nuevo León 2015-2030* [43], and that was aligned with the SDGs, as shown in Table 3.

This research also applied a protocol that considered the ethics of educational research to maintain the privacy, confidentiality, and integrity of the data, as well as the privacy and consent of the participants. To accomplish this, the considerations were:

1. To clearly explain the objectives of the study, telling the participants that the course was a research project.
2. To allow researchers to personally visit the class and explain the work to be done, answer any questions, and explain the time involved and procedures to be followed during the research.
3. To emphasize that participation was voluntary, and that all data would remain confidential.
4. To explain to the participants that they could decide not to participate in the research at any time. An online form was sent to them with the terms requesting their acceptance in the study.

Table 2. Contents and activities of the e-learning course.

Learning Objectives	Week	Activities	Assessment
To describe concepts related to entrepreneurship and innovation for use in solving problems in their environment.	1. Introduction to the course	Forum: What do you think is the importance of entrepreneurship and innovation in our country?	Participate in the forum and comment on at least two interactions by partners. Checklist.
To analyze problematic situations in the local environment that can be resolved through innovative and entrepreneurial proposals.	2.Presentation of the challenge	Presentation of the challenge: individually, students reviewed the challenge, and one of the priority areas to be solved was chosen.	Participate in the team forum by choosing a topic and proposing a possible solution to the problem. Checklist.
To propose innovative solutions to problems collaboratively and with the help of a mentor.	3. Preparation of solution proposals	Brainstorming forum to coordinate the group work and define a solution proposal collaboratively. Meet with partners to solve the challenge (through videoconference/chat/forum).	Participate in the group forum to coordinate the activity and propose the solution. Checklist.
To prepare a pitch to publicize the proposed solution	4. Final pitch	Present the final pitch following the instructions of the evaluation rubric.	Present a pitch that includes the problem to be solved, the proposed solution, and a conclusion. Rubric.
	5. Final evaluation	Final Reflection: Write a personal story by answering questions about the experience.	Publish your entrepreneurship story on your blog. Checklist.

Table 3. Priority areas proposed to be resolved by the students.

Priority Areas	Relationship to SDG
Eradicating extreme poverty with particular emphasis on nutrition	Objectives 1 and 2: End of poverty and zero hunger
Ensuring coverage and effective access of the population to healthcare for priority health conditions	Objective 3: Health and well-being
Ensuring the employability of young people in the productive sector	Objective 8: Decent work and economic growth
Generate training programs in reading, written culture, and development of artistic skills	Objective 4: Quality education
Encouraging physical activity and sports	Objective 3: Health and well-being
Improving air quality	Objective 11: Sustainable cities and communities
Facilitating the opening and operation of businesses	Objective 8: Decent work and economic growth
Identifying and eliminating causes, conditions, and factors of corruption	Objective 16: Peace, justice, and strong institutions.
Promoting energy security and a transition to lower-impact fuels	Objective 7: Affordable, non-polluting energy
Strengthening and promoting community and neighborhood cultures to generate social cohesion and citizen coexistence	Objective 16: Peace, justice, and strong institutions

2.3. Instruments

The information was collected through the discussion forums, questionnaires, observation guides, the evaluation rubrics for the challenge activities, and the solutions proposed by the students.

The discussion-forum-content analysis was used to understand the initial perceptions of the students regarding the contributions they could make through entrepreneurship to resolve local, national, or global problems. The students answered the questions from their perspectives and commented on the responses of at least two classmates.

Observation guides were used during the course to describe how the participants resolved the challenges. The students answered a few questions about their experiences in the course, namely: "What did you learn during the course?" "How did you handle the problems or complicated situations presented to you?" and "How will these lessons that you learned help you in the future?" The responses were posted on a blog that the students used during the course.

To evaluate the final projects, we developed an evaluation rubric that included the elements listed in Table 4. The students presented a final pitch that highlighted the essential points of the proposal to be shown to potential users or clients of the venture.

Table 4. Evaluation rubric of the final projects.

Name of the Product or Service	Score (1–5)
Teamwork	
Included research on the subject	
Included statistics on the problem	
Defined the number of users	
Validated the idea with potential users	
Elaborated a final pitch	
Presented interesting data or information	
Presented the benefits of the product or service	
Presentation of the pitch	
Points earned	

2.4. Data Analysis

To perform the data analysis, we followed the process suggested by Creswell and Poth [40], providing the description, analysis, and interpretation of the information generated. In the first phase, a content analysis of the participants' discussion forums was conducted to identify categories arising from the perceptions of the students of the contributions of entrepreneurship and the innovations to resolving national problems. To carry out the analysis, we identified passages within the data. We categorized them to determine the intentions of the participants within the context of the study [44].

To determine the categories for analysis, we sought relationships in the participants' responses in the discussion forums. Once the categories were defined, we used inductive analysis to segment the text and gather the evidence for each category. We then reviewed this to identify quotes that were relevant to the research questions. The data from the participants' answers were compared to the codes we had established as links to the answers to the research problems. The course was conducted in Spanish, so the researchers translated the texts into English to present the results.

Subsequently, proposals made by students were analyzed to determine how the participants resolved the challenges. The final presentations were reviewed with an evaluation rubric, presenting tables and graphs to display comparisons of the results [40]. For the answers to the questions about their experiences, we analyzed each question individually, separated the texts by topic, and determined the most frequently mentioned responses.

3. Results

In this section, we first present a content analysis of the initial forum. Then, we continue with a description of the steps followed to resolve the challenge; next, we discuss the results of the solution proposals, and, finally, the responses to the questionnaires.

3.1. Forum Content Analysis

According to the responses obtained in the forum, the participants were very concerned about social and environmental problems. Most of them expressed interest in seeking solutions by developing ventures related to their careers. However, they stated that they did not know if they had the skills to develop the ventures or generate solution proposals. They hoped to learn these things in the course. The most frequently mentioned answers were divided into the following categories:

1. Opinion on entrepreneurship: Students related entrepreneurship to economic growth and job creation, as well as to the achievement of skills and capacities and personal development. Student comments from the forum included, *"for me, entrepreneurship is focusing on a problem that you consider important to solve"*, *"to improve people's opportunities and quality of life"*, and *"improvement of culture and way of thinking of society"*.

2. Difficulties: Studnets expressed their concerns about how they could contribute to solving social problems, improve peoples' qualities of life, and how, through their careers, they could generate ideas and propose businesses that could solve these problems. They indicated that they did not know how to undertake these things or if they had the skills. Also, they responded that entrepreneurship was not highlighted in their fields of study, that socially responsible production is a "pending" task in companies, and that they were not clear which businesses to start. They identified a delay in the country in developing ventures. Their comments included, *"I am not clear which business to start; I must know its advantages and disadvantages. I feel that I have not developed the abilities needed for entrepreneurship"*, *"I think it is necessary to know more about the subject in-depth and how to develop these skills in us better"*, and *"socially responsible production is a pending task in companies"*.

3. Interests: The students expressed great interest in undertaking social projects and interest in solving social problems. They mentioned issues such as pollution, the use of polluting materials in industrial applications, the insertion of older people into the workforce, the development of the best sustainable practices, and avoiding food waste and water and air pollution, among other issues. Their comments included, *"I want to undertake a social project whose objective is the reintegration of seniors into the work environment; I encourage that companies obtain a special badge that qualifies them as socially responsible companies"*, *"I want to create an environmental consultancy and an environmental remediation company in contaminated places"*, and *"I am interested in this course because, in the future, I want to launch a startup"*.

In summary, in this initial participation of the students, we observed that they had great concern about social and environmental problems. For the most part, they expressed interest in finding solutions through developing career-related ventures. However, they stated that they did not know if they had the skills to develop them or know how to generate the proposed solutions, so they hoped to learn these things in the course.

3.2. Participation in the Challenge

The first step for the students was to choose a challenge from possible alternatives according to their interests. Of the 10 topics presented, students chose the five that were the most acceptable to them (see Figure 1). The topic "improving the quality of the air" was selected by two groups. In the initial selection, the students made individual proposals for possible solutions. The solution proposal had to be a product or service that would solve the problem under study, define the potential users, and indicate how their proposal would address the problem.
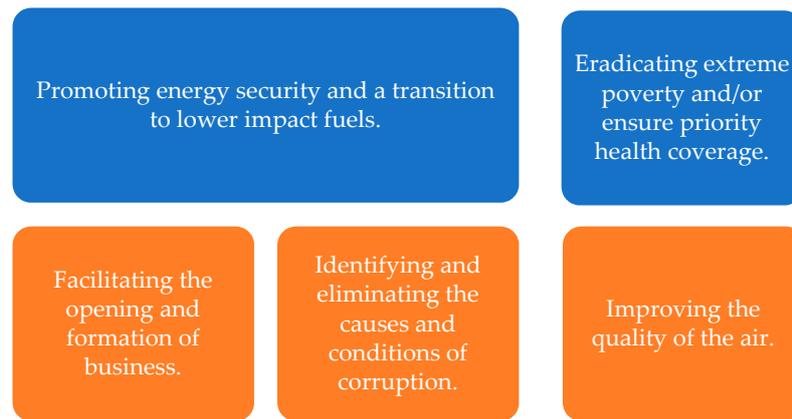
Figure 1. Challenges selected by the online course participants.

The initial proposals of the students included:

- A social enterprise that honors companies that adopt senior mentoring programs, that trains young people, and in which lack of experience is not an impediment for new employees.
- A platform to support the commercialization of products through employing young people remotely, and the digitalization of government information for greater transparency.
- A proposal to eradicate the extreme poverty of food in the state of Nuevo León and facilitate access to health services.
- A proposal to decrease carbon dioxide in the companies that emit it.
- A proposal for an environmental consulting agency that gives incentives to companies that reduce their emissions.
- A proposal to use plants to reduce air pollution.

As they worked on resolving the challenges, the students brainstormed and researched the data that would help them solve the problems. To work asynchronously, the students used discussion forums and Google Docs to upload their findings. They also had some meetings via video conferencing and chats to agree on what they were going to present.

In the data analysis, we found the following elements in the strategies of the work teams:

1. Projects resolving problems related to the students' careers, theoretical research, and statistics they collected to establish the magnitudes of the problems, as well as analyses of the impacts of the solutions.
2. Research on the problems using interviews and the applications of the business model canvas to determine the people affected.
3. Consultations with people affected by the problems and feasibility analysis of each solution's implementation.
4. Presentation of a proposal defining a product or service, the benefits of the solution proposed for the priority area, data related to the impact of the solution, and a value proposition.

The process followed by the participants to resolve the challenge is shown in Figure 2.
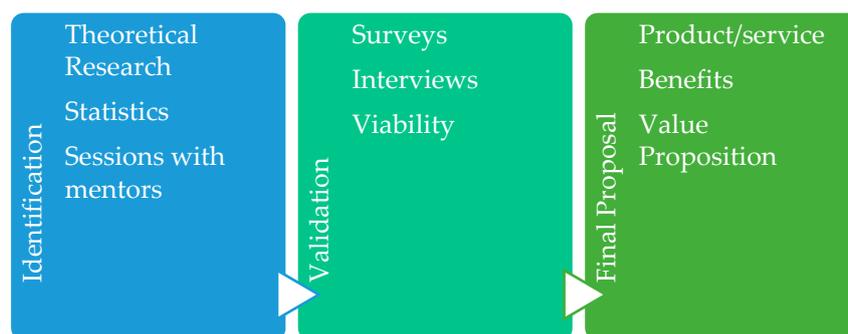
Figure 2. The process followed by the participants to resolve the challenge.

3.3. Solution Proposals

The proposals for solutions to the different problems encountered by the students are shown in Table 5. Five teams presented solutions to the problems. One of the six groups did not present the final work, which consisted of three students who indicated that they did not have time to complete the activities and withdrew from the course. The proposed solutions included a biogas producer to produce clean-energy fuels, an educational program to promote healthy eating, a rewards program for companies that used a mentoring program, a design of vertical gardens, and an algae-based filter to reduce pollution.

Table 5. Solution projects proposed by the students.

Problem	The solution that Addresses the Problem
Promoting energy security and a transition to low-impact fuels	Biodigestor to produce biogas
Eradicating extreme poverty and ensuring priority health coverage	An educational program focused on healthy alimentation
Facilitating the opening and formation of businesses	Various mentors
Improving the quality of the air.	Vertical gardens
Identifying and eliminating the causes and conditions of corruption	The final proposal not presented.
Improving the quality of the air	The capture of contaminants in chimneys by a microalgae biofilter

Of the five proposals submitted, 100% of the teams made a final pitch in which they presented their projects. The items scoring the highest in the rubric were the research of the issues related to the problem and the solution proposal (84%) and, also, with 84%, the identification of the benefits of the proposal and the provision of interesting information to the users.

Teamwork scored 72% because some of the teams had difficulty organizing themselves during the process; nonetheless, they were each able to perform their pitch in the end. The presentation of statistics on the problems received a grade of 60%, as well as the communication of ideas during the pitch. The items that had the lowest scores were validating the ideas with potential users and presenting the numbers of users to be impacted (only 48% of the teams presented these with their project proposals). The results are displayed in Figure 3.
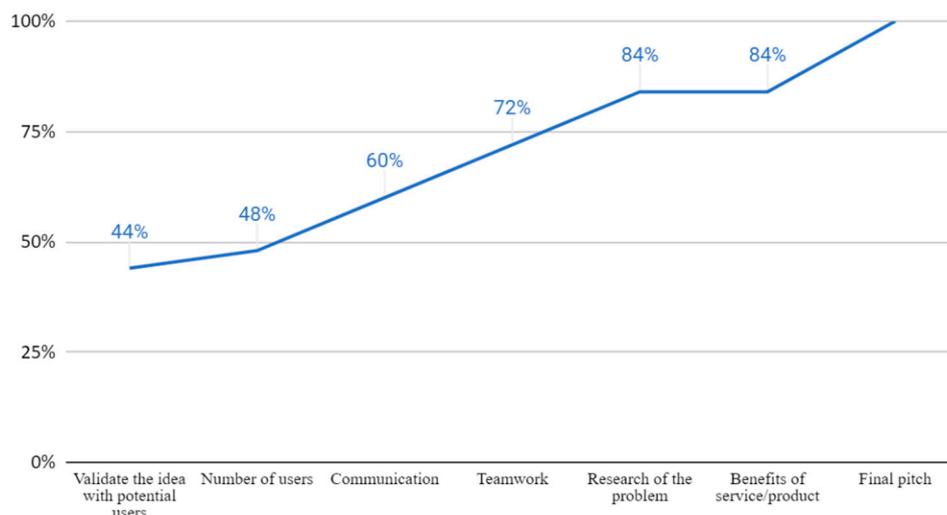
Figure 3. Results of the evaluation rubric.

3.4. Responses to the Questionnaires

In the end, the question "what did you learn during the course" was asked of students. The students answered that their best lessons learned from the course were how to make a profit for society through entrepreneurship and what knowledge could help them create new companies in the future. For the question, "how will these lessons that you learned help you in the future", students mentioned that this knowledge would be not only useful to building a company, but also for other uses in life. They mentioned transversal skills such as knowing how to work on projects, teamwork, and designing and shaping an idea, among others. Regarding the question "how did you handle the problems or complicated situations presented to you", the most frequent inconveniences of the course expressed by the students were a lack of time due to academic workload and an insufficiency of time to do the activities.

4. Discussion

This study sought to determine how CBL can be implemented in an e-learning course to strengthen education oriented toward sustainable development. CBL confronts students with real-life situations, and this project proposed activities that were designed to help them to connect the knowledge they had acquired to the kind of situations that they will find in their professional working lives [29]. This ability is the basis for developing problem-solving proposals that promote sustainable development.

This research aligns with the work reported by Parra [15], where innovative, educational training methods that promote sustainable development include the study of problem causes, the formation of possible hypotheses that come from different points of view, and the understanding that global problems are inter-connected. When students can experience these elements, they can reflect on the practices that lead to greater sustainability [32].

Our implementation of CBL corresponds with other studies where the application of active learning methodologies contributes to the acquisition of values that guide college students towards professional behaviors that promote sustainable development [19]. Also, the training to develop these competencies is integrated into the curricula and combined with technical skills taught in various disciplinary careers [20]. We observed that the participants of this study had a great interest in the social initiatives that help improve the realities of their communities. Therefore, it is appropriate to present transversal content in the courses offered in their disciplines. This way, the students can contribute their technical knowledge to problem-solving and, through a rich reflection, offer insightful solutions that are sustainable and long-lasting [19,20].

In this research, CBL allowed students to take advantage of their desires to find meaning in education [32,33]. The process followed by the participants to resolve the challenges allowed them to define solutions in their fields of study, which benefited the research because the students delved into topics that impacted the community. The students were able to learn more about developing solution proposals in collaborative and multi-disciplinary ways. This finding is consistent with the results of Rådberg et al. [32], where the implementation of CBL with university students favored solving complex, multi-disciplinary problems, and provoked their interest in sustainable development.

In analyzing the elements of CBL that can contribute to solving local problems through an e-learning course, we found that, in this project, the students started from an essential question. The participants of the study considered the importance of the role that entrepreneurship has on economic and social development and employment. In the responses in the discussion forums, the students were very interested in the topic of sustainable development and how to develop initiatives that favor it. However, in some cases, they did not know how to generate proposals to develop initiatives that would address barriers to sustainable development. They also did they know what their skills were and how to leverage them to create new businesses.

The next step was the presentation of a challenge for students to analyze to create solutions to the problems. They each chose the challenge they wanted to confront collaboratively with classmates from various disciplines. This element of collaborative work has previously been studied by Fidalgo Blanco et al. [35], where CBL encouraged collaboration and communication among team members to generate a common strategy. In addition, the features of online platforms and communication tools allow ubiquitous learning that promotes interactions, flexibility, and the achievement of educational objectives [7,12].

The activities and resources proposed in the course allowed students to reflect on their ideas through brainstorming and researching data for problem-solving to develop a proposal. They followed another step of CBL, where each challenge can have a variety of solutions. Also, the students used previously acquired knowledge that they had developed throughout their curricula. This finding is consistent with other studies indicating that CBL calls on students to put their prior technical skills and knowledge into practice [45].

Finally, the students presented their final products in pitches about their solution projects. They documented their ideas in forums, online documents, and blogs in the course. The teacher of the course evaluated the documentation with an assessment rubric. The analysis determined that the most popular elements of the course were conducting the research on the subject and presenting the expected benefits of the proposed solutions. The items having the lower scores were teamwork, communication, and validation of the solution proposal with potential users. The implementation in a real environment was not possible because it was not in the objective of the course.

The contribution of this study to education for sustainable development is to present CBL as a proposal that provides students the opportunity to reflect on local, national, or global problems. Reflection was possible via the activity of having students discuss their experiences in the course. Most of the students expressed that their experiences in the course allowed them to recognize how to make a profit for society. Such reflections allowed them to delve into their knowledge to generate innovative solutions to these problems. Also, the ubiquitous ability to leverage e-learning for interactions and communication among multidisciplinary groups facilitates the development of transversal competencies in students in university curricula.

5. Conclusions

CBL, as innovative pedagogy, presents university students in multi-disciplinary fields of study with specific, real-world challenges that can be addressed collaboratively in their college courses. Presenting real local, national, or global problems can strengthen their motivations to conduct research and find solutions that address the realities of their environments.

The application of CBL takes advantage of the e-learning mode and communication tools that facilitate collaborative work and interactions among the participants at different times and places. It offers the opportunity to integrate various flexible and inexpensive technological tools into students' studies, and provides the resources and the content that guide students to resolving the challenges they have selected [46].

For future applications, we see a need to plan the activity time better and extend the time to be able to validate the solution proposals with possible users. The students indicated that they do not know how to generate proposals to develop initiatives that would address challenges to sustainable development. They also stated that they do not know what their skills are and how to leverage them to create new businesses. Therefore, it is necessary to provide students with training within their careers so that they can access this knowledge while taking courses.

We propose that other courses be designed so that students can continue developing their solution projects with prototypes that they can validate with potential users. They can establish synergies with other institutions or companies that help them to achieve their goals. Within an entrepreneurship ecosystem, educators can guide students and support the incubation or acceleration of their entrepreneurial businesses. Although a single course can help develop specific competencies, a broader program is more conducive for the integral development of sustainability [47]. Also, we recommend further research be conducted using larger sample sizes in order to gather and analyze data quantitatively.

Limitations of the research included that the results obtained were limited to a small study group that did not represent the general population. However, elements of CBL studied herein could be replicated in e-learning courses as an active methodology that promotes the solutions to local, national, and global problems, as well as in other contexts.

References

1. Khaddage, F.; Christensen, R.; Lai, W.; Knezek, G.; Norris, C.; Soloway, E. A model-driven framework to address challenges in a mobile learning environment. *Educ. Inf. Technol.* **2015**, *20*, 625–640. [CrossRef]
2. Vázquez-Cano, E.; López Meneses, E.; Jaén Martínez, A. The group e-portfolio to improve the teaching-learning process at university. *J. e-Learn. Knowl. Soc.* **2017**, *13*, 65–76. [CrossRef]
3. Ozuorcun, N.C.; Tabak, F. Is M-learning versus E-learning, or are they supporting each other? *Proc. Soc. Behav. Sci.* **2012**, *46*, 299–305. [CrossRef]
4. Barrero Fernández, B. Estudios sobre propuestas y experiencias de innovación educativa. *Revista de Currículum y Formación del Profesorado* **2018**, *22*, 1–10. [CrossRef]
5. Huss, J.A.; Sela, O.; Eastep, S. A case study of online instructors and their quest for greater interactivity in their courses: Overcoming the distance in distance education. *Aust. J. Teach. Educ.* **2015**, *40*, 72–86. [CrossRef]
6. Racovita-Szilagyi, L.; Carbonero Muñoz, D.; Diaconu, M. Challenges and opportunities to eLearning in social work education: Perspectives from Spain and the United States. *Eur. J. Soc. Work* **2018**, *21*, 836–849. [CrossRef]
7. Alemán de la Garza, L.; Gómez Zermeño, M.; Mochizuki, Y.; Bruillard, E.; Anichini, A.; Antal, P.; Beaune, A.; Bruillard, E.; Burke, D.; Henrique Cacique Braga, P.; et al. *Rethinking Pedagogy. Exploring the Potential of Digital Technology in Achieving Quality Education*; UNESCO MGIEP: New Delhi, India, 2019.

8. Robinson, S.; Neergaard, H.; Tanggaard, L.; Krueger, N. New horizons in entrepreneurship education: From teacher-led to student-centered learning. *Educ. Train.* **2016**, *58*, 661–683. [CrossRef]

9. Rivera Vargas, P.; Alonso Cano, C.; Sancho Gil, J. Desde la educación a distancia al e-learning: Emergencia, evolución y consolidación. *Revista Educ. y Tec.* **2017**, *10*, 1–13.

10. UNESCO. Available online: https://www.un.org/sustainabledevelopment/es/education/ (accessed on 1 April 2020).

11. Lozano, R.; Lukman, R.; Lozano, F.; Huisingh, D.; Lambrechts, W. Declarations for sustainability in higher education: Becoming better leaders, through addressing the university system. *J. Clean. Prod.* **2013**, *48*, 10–19. [CrossRef]

12. Azeiteiro, U.; Bacelar Nicolau, P.; Caetano, F.; Caeiro, S. Education for sustainable development through e-learning in higher education: Experiences from Portugal. *J. Clean. Prod.* **2015**, *106*, 308–319. [CrossRef]

13. UNESCO. Available online: https://gem-report-2016.unesco.org/es/chapter/la-prosperidad-economias-sostenibles-e-inclusivas/ (accessed on 1 April 2020).

14. UNESCO. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000252423/PDF/252423spa.pdf.multi (accessed on 1 April 2020).

15. Parra, S. Exploring the incorporation of values for sustainable entrepreneurship teaching/learning. *J. Technol. Manag. Innov.* **2013**, *8*, 11–20. [CrossRef]

16. Hák, T.; Janoušková, S.; Moldan, B. Sustainable Development Goals: A need for relevant indicators. *Ecol. Indic.* **2016**, *60*, 565–573. [CrossRef]

17. Gordon, J.; Halsz, G.; Krawczyk, M.; Leney, T.; Micehl, A.; Pepper, D.; Putkiewicz, E.; Wisniewski, W. *Key Competences in Europe: Opening Doors for Lifelong Learners across the School Curriculum and Teacher's Education*; Centre for Social and Economic Research on behalf of CASE Network: Warsaw, Poland, 2009.

18. Camacho Yáñez, I.; Gómez Zermeño, M.; Pintor Chávez, M. Competencias digitales en el estudiante adulto trabajador. *Revista Interamericana de Educación de Adultos* **2015**, *37*, 10–24.

19. Alcalá del Olmo, M.; Gutiérrez Sánchez, J. El desarrollo sostenible como reto pedagógico de la universidad del siglo XXI. *Anduli* **2019**, *19*, 59–80. [CrossRef]

20. Takala, A.; Korhonen-Yrjänheikki, K. A decade of Finnish engineering education for sustainable development. *Int. J. Sustain. High. Educ.* **2019**, *20*, 170–186. [CrossRef]

21. El-Zein, A.H.; Hedemann, C. Beyond problem solving: Engineering and the public good in the 21st century. *J. Clean. Prod.* **2016**, *137*, 692–700. [CrossRef]

22. Antonaci, A.; Dagnino, F.; Ott, M.; Bellotti, F.; Berta, R.; De Gloria, A.; Lavagnino, E.; Romero, M.; Usart, M.; Mayer, M. Gamified collaborative course in entrepreneurship: Focus on objectives and tools. *Comput. Hum. Behav.* **2016**, *51*, 1276–1283. [CrossRef]

23. Zuzeviciute, V.; Praneviciene, B.; Simanaviciene, Z.; Vasiliauskiene, V. Competence for sustainability: Prevention of dis-balance in higher education: The case of cooperation while educating future law enforcement officers. *Montenegrin J. Econ.* **2017**, *13*, 121–130. [CrossRef]

24. Frey, C.; Osborne, M. The future of employment: How susceptible are jobs to computerization? *Technol. Forecast. Soc. Chang.* **2017**, *114*, 254–280. [CrossRef]

25. Wright, N.; Wrigley, C. Broadening design-led education horizons: Conceptual insights and future research directions. *Int. J. Technol. Des. Ed.* **2019**, *29*, 1–23. [CrossRef]

26. Hasan, M.; Khan, E.; Nabi, M. Entrepreneurial education at the university level and entrepreneurship development. *Educ. Train.* **2018**, *59*, 888–906. [CrossRef]

27. Roffeei, S.; Yusop, F.; Kamarulzaman, Y. Determinants of innovation culture amongst higher education students. *Turkish Online J. Educ. Technol.* **2018**, *17*, 37–50. [CrossRef]

28. Lee, C.; de Vries, W.T. Sustaining a culture of excellence: Massive Open Online Course (MOOC) on land management. *Sustainability* **2019**, *11*, 3280. [CrossRef]

29. Lozano, A.; García, F.; Zubieta Ramírez, C.; López Cruz, C. Competencies associated with Semestre i and its relationship to academic performance. *High. Educ. Skills Work-Based Learn* **2019**, *10*, 387–399. [CrossRef]

30. Edutrends. *Aprendizaje Basado en Retos*; Observatorio de Innovación Educativa del Tecnológico de Monterrey: Monterrey, Mexico, 2018.

31. Yang, Z.; Zhoua, Y.; Chung, J.; Tang, Q.; Jiang, L.; Wong, K. Challenge Based Learning nurtures creative thinking: An evaluative study. *Nurse Educ. Today* **2018**, *71*, 40–47. [CrossRef]

32. Rådberg, K.; Lundqvist, U.; Malmqvist, J.; Svensson, O. From CDIO to challenge-based learning experiences –expanding student learning as well as societal impact? *Eur. J. Eng. Educ.* **2020**, *45*, 22–37. [CrossRef]

33. Malmqvist, J.; Rådberg, K.; Lundqvist, U. Comparative analysis of challenge-based learning experiences. In Proceedings of the 11th International CDIO Conference, Chengdu, Sichuan, China, 8–11 June 2015.

34. Rowe, C.; Klein-Gardner, S. A study of challenge-based learning techniques in an introduction to engineering course. In Proceedings of the 2007 Annual Conference & Exposition, Honolulu, Hawaii, 24 June 2007.

35. Fidalgo Blanco, A.; Sein-Echaluce, M.; García Peñalvo, F. Aprendizaje Basado en Retos en una asignatura académica universitaria. *Revista Iberoamericana de Informática Educativa* **2017**, *25*, 1–8. [CrossRef]

36. Buil, M.; Aznar, J.; Galiana, J.; Rocafort-Marco, A. An explanatory study of MBA students with regards to sustainability and ethics commitment. *Sustainability* **2016**, *8*, 280. [CrossRef]

37. Penttilä, T. Desarrollo de organizaciones educativas con pedagogía de innovación. *J. Adv. Educ.* **2016**, *2*, 259–267.

38. Portuguez Castro, M.; Ross Scheede, C.; Gómez Zermeño, M. The impact of higher education in entrepreneurship and the innovation ecosystem: A case study in Mexico. *Sustainability* **2019**, *20*, 5597. [CrossRef]

39. García-Peñalvo, F.; Seoane Pardo, A. Una revisión actualizada del concepto de eLearning. Décimo Aniversario. *Educ. Knowl. Soc.* **2015**, *16*, 119–144. [CrossRef]

40. Creswell, J.W.; Poth, C.N. *Qualitative Inquiry and Research Design. Choosing Among Five Approaches*; Sage Publications: Thousand Oaks, CA, USA, 2018.

41. Yin, R. *Case Study Research*; Sage: Thousand Oaks, CA, USA, 2009.

42. Otzen, T.; Manterola, C. Técnicas de Muestreo sobre una Población a Estudio. *Intern. J. Morphol.* **2017**, *35*, 227–232. [CrossRef]

43. Consejo Nuevo León para la Planeación Estratégica. *Plan Estratégico para el Estado de Nuevo León 2015–2030*; Consejo de Nuevo León: Monterrey, Mexico, 2016.

44. International Institute for Qualitative Methodology. Available online: https://sites.ualberta.ca/~{}iiqm/pdfs/introduccion.pdf (accessed on 1 April 2020).

45. Hernández-de-Menéndez, M.; Vallejo Guevara, A.; Tudón Martínez, J.C. Active learning in engineering education. A review of fundamentals, best practices, and experiences. *Int. J. Interact. Des. Manuf.* **2019**, *13*, 909–922. [CrossRef]

46. Rajabion, L.; Wakil, K.; Badfar, A.; Nazif, M.; Ehsani, A. A new model for evaluating the effect of cloud computing on the e-learning development. *J. Workplace Learn.* **2019**, *31*, 324–344. [CrossRef]

47. Mindt, L.; Rieckmann, M. Developing competencies for sustainability-driven entrepreneurship in higher education: A literature review of teaching and learning methods. *Teoría de la Educación* **2017**, *29*, 129–159.