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NURTURING COMMUNITY: USING COMMUNITY-BASED SERVICE LEARNING IN BIOPHARMACEUTICAL ENGINEERING EDUCATION.

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ABSTRACT

This project evaluates the use of CBSL as a strategy for teaching clinical investigation in the development of biopharmaceutical products based on the nutritional needs of children of a low-income community. To achieve this purpose, our students formulated various functional foods that provided the necessary nutrients for the children in the target community. Afterwards, they drafted the corresponding clinical protocols for each formulation, considering possible ethical implications. The academic evaluation was based on the comparison of courses with and without CBSL. The study found that students showed a slight improvement in academic performance with CBSL. This suggests that CBSL can promote academic excellence while fostering engagement with the local community. Pre- and post-course surveys were used to measure the impact of community work on students and its impact on social commitment. The results showed that students had a greater social commitment to the community after completing the service- based learning activity. This finding suggests that CBSL can play an important role in developing social awareness and responsibility in students. In conclusion, this study supports the use of CBSL as a strategy to promote academic excellence while fostering social engagement and responsibility. CBSL empowers students to make a significant contribution to the local community while also enabling them to learn through practical experience. By incorporating CBSL into the curriculum, students develop a greater sense of social responsibility, which can benefit both their academic and personal lives.

1. INTRODUCTION

Service-learning is a teaching approach that integrates practical experience with academic knowledge by engaging students in community service projects. It has been widely utilized across various disciplines, including medicine, nursing, psychology, and engineering, to enhance learning outcomes and foster civic values, such as ethics and social awareness (Huda et al. 2018).

In the field of biotechnology engineering, experiential learning holds great significance as it allows students to grasp the societal implications of their profession. By addressing biological challenges related to the environment, health, and ethics, students can apply their theoretical knowledge and professional skills in real-world contexts, thereby promoting their intellectual growth (Pierangeli and Lenhart 2018; Vinales 2015; Montgomery 2004).

1.1. Theoretical framework

Community-Based Service Learning (CBSL) is a widely adopted learning strategy in engineering that promotes social values and civic engagement among students. It has

been implemented in various engineering disciplines, including biomedical engineering (Baker 2018; Huda et al. 2018; Brown and Bauer 2021).

In biomedical engineering, CBSL involves clinical experiences with community partners. Students work in teams to design devices based on community needs, and with the approval and supervision of teachers and community partners, they test these devices in the community. CBSL has been shown to improve teamwork skills and task distribution in this context (Jaworski and Cho 2023).

CBSL has also been implemented in biotechnology programs in universities. Activities such as tutoring, group problem-solving exercises, discussions on scientific articles, and engagement in community events have been reported. These activities enhance students' professional skills, community participation, and knowledge of practical applications in biotechnology (Montgomery 2004; Hark 2008; Chrispeels et al. 2014; S. 2013).

Service-based learning in the community is crucial for students to gain knowledge, develop social consciousness, and foster critical thinking and civic values. As educators, it is our responsibility to provide comprehensive training that instills social commitment and contributes to creating a better and more equitable society. The goal of this project was to evaluate the impact of service-based learning in reinforcing theoretical knowledge, promoting interest in community work, and applying theoretical knowledge to solve social problems.

2. METHODOLOGY

2.1 General experimental design

This work is a continuation of a multidisciplinary project that began in 2019 at the School of Medicine with students from the Medical Surgeon and Bachelor of Nutrition programs at Tecnologico de Monterrey. The project aimed to involve students from these two programs in community-based service learning (CBSL) through the microbiological and nutritional analysis of a community of children from low-income backgrounds. The goal was to provide nutritional and infectious disease analysis to children and parents and offer solutions to improve their health outcomes.

As part of this effort, two courses from the Biotechnology Engineering program at Tecnologico de Monterrey were involved. The first course was "Food and Bioproducts Development (FBD)," where students evaluated the nutritional and microbiological status of the children in the low-income community. They educated them about the importance of microbiota and proposed functional foods such as probiotics and symbiotics to improve their health. The students worked in teams to develop a functional food that would enhance the nutritional status of the children, considering their anthropometric and microbiological results.

The second course was "Pharmacology of Biopharmaceuticals Development (PBD)." In this course, students analyzed the feasibility of the functional food proposals developed in the FBD course. They drafted clinical trial protocols to evaluate the effectiveness of these functional foods. The protocols were designed to meet Institutional Review Board (IRB) standards and guidelines. Feedback on the drafts was provided by instructors and peers, and the final versions were submitted to the IRB for review. Although the clinical trial was hypothetical and not executed, the purpose was to provide students with the ethical and regulatory context for research involving human subjects.

To evaluate the educational impact of both courses and the CBSL activity, comparisons were made between the final grades, project outcomes, and overall project grades of the group without CBSL activity (year 2019) and the group with CBSL activity (years 2020 and 2021); for the methodology impact in learning process, the students were surveyed with an overall satisfaction survey at the end of each course where not useful (1) to extremely useful (10) scale was used. The students were also surveyed about their commitment to the community to assess the social impact of the project (1 to 10 scale).

2.2 Data analysis

Proportional analysis was used to analyze the ethical and civic components of the project surveys. Numerical data were analyzed using nonparametric Mann-Whitney U tests, as well as parametric Student's T tests, to compare student performance in the two courses with and without the CBSL activity. The data were analyzed using GraphPad Prism (V9, GraphPad Software, USA) and were considered statistically significant with a p-value of less than 0.05.

2.3 Ethical considerations

The study protocol for children’s clinical data and sample collection, along with student interaction for evaluation by nutrition and medicine students, and health lessons by biotechnology students was approved by the Institutional Review Board of Hospital La Mision. Preschool director also approved the interaction of our students with kindergarten alumni.

3. RESULTS

3.1. Participants

The intervention involved 54 students, with 19 (35%) enrolled in the FBD course and 35 (65%) in the PBD course. In the FBD course, 63.4% were female and 36.6% were male, with an average age of 22 years. In the PBD course, 56.3% were male and 43.8% were female, with an average age of 23 years.

3.2. Educational impact analysis

3.2.1 Food and Bioproducts Development (FBD)

To assess student performance in the FBD subject, we compared two groups: one without a CBSL intervention in 2019 and one with an educational intervention in 2020 (Figure 1). Despite COVID-19 limitations, both groups showed similar progress in their projects. The group with educational innovation had slightly better final grades, which were statistically significant ($p<0.05$). The overall satisfaction survey indicated that students found the activity relevant to their learning process and its real-life application.

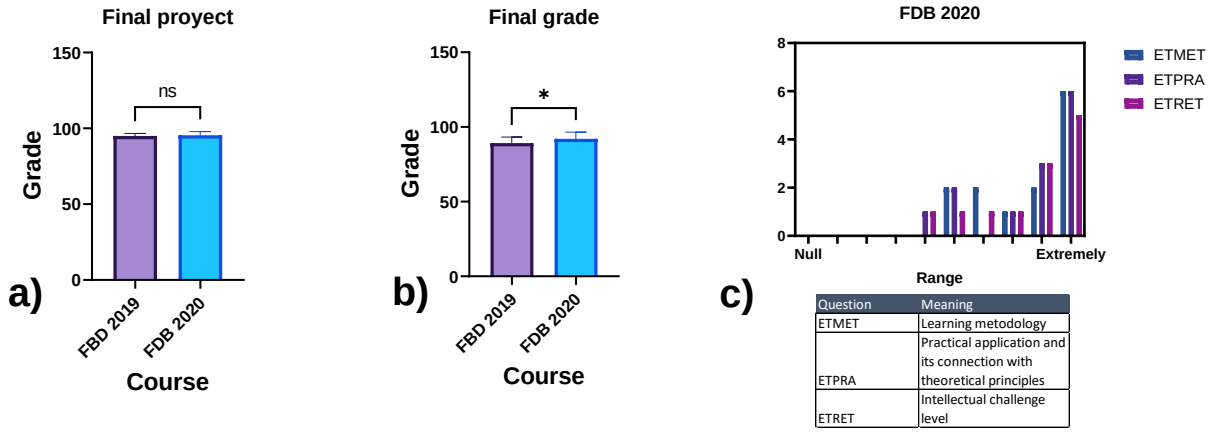
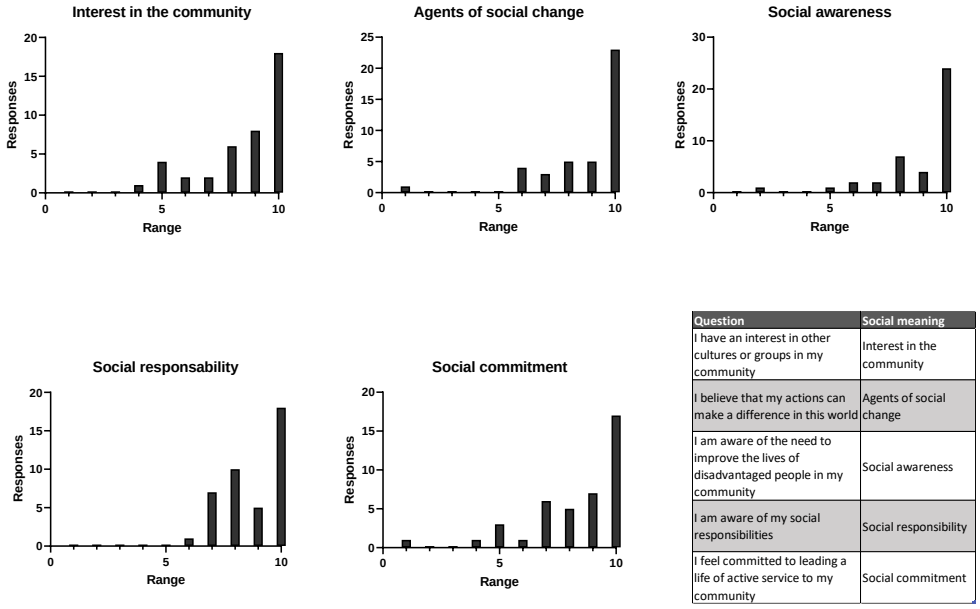


Figure 1. Comparison of ratings of the Food and Bioproducts Development (FBD) groups. The didactic strategy was implemented in the 2020 group of the year, while the 2019 group did not have educational innovation. (a) Grades of the final project. (b) Course final grade. For a), the Mann Whitney U test was used, being not significant. Statistically significant differences (T for Students) for b) are indicated by (*). (c) Post- course students' satisfaction survey show that the students find useful the CBSL methodology in their learning process.

We conducted a survey to assess students' perceptions of service learning, including their commitment to society and sense of responsibility. The questions were rated on a scale of 1 to 10. Here are the results of the survey on their social perception.



Question	Social meaning
I have an interest in other cultures or groups in my community	Interest in the community
I believe that my actions can make a difference in this world	Agents of social change
I am aware of the need to improve the lives of disadvantaged people in my community	Social awareness
I am aware of my social responsibilities	Social responsibility
I feel committed to leading a life of active service to my community	Social commitment

Figure 1. Food and Bioproducts Development (FBD) group social perception. This figure shows how almost half of the students show higher social commitment, social responsibility and consider themselves agents of social change in their community.

Figure 1 shows that most of the students have a strong sense of commitment towards their community and believe that their involvement in activities aimed at community improvement is crucial for promoting social development.

3.2.2. Pharmacology of Biopharmaceutical Developments (PBD)

The subject discussed is an elective course in the Biotechnology Engineering program, offered upon request. It was not available in the August-December 2020 semester due to low enrollment but was offered in 2021. However, due to COVID-19 restrictions, the course had to be adapted, focusing on ethics instead.

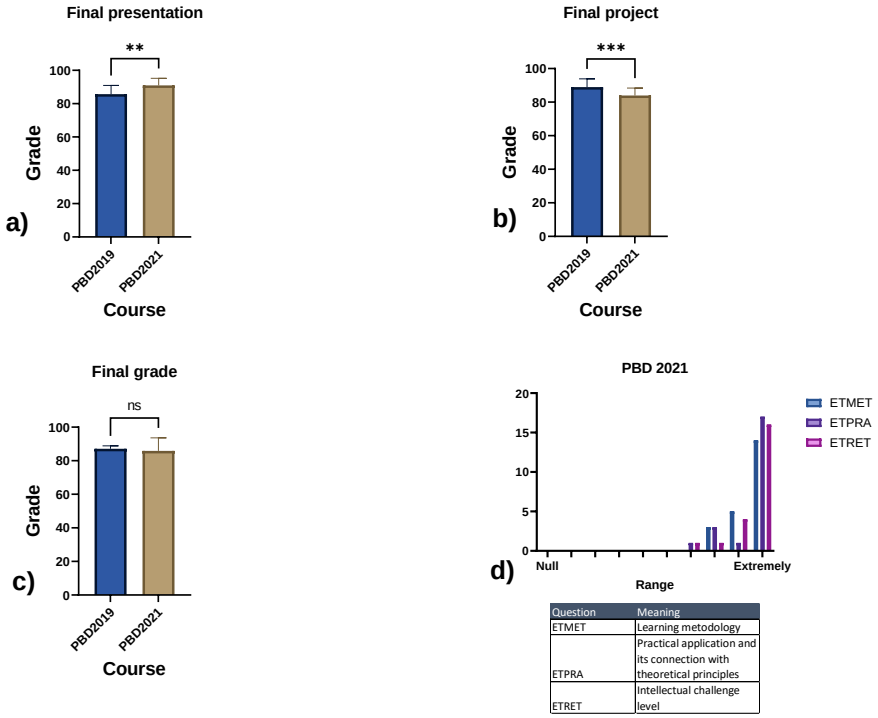
During the course, students developed clinical protocols for the community, which underwent ethical review, providing practical training in bioethics within a social context.

To assess learning outcomes, a comparison was made between a control group (PBD2019) without the educational innovation and an innovation group (PBD2021). The parameters evaluated included the final presentation, project, and grades.

The innovation group achieved significantly higher grades in the final presentation (Fig. 3a). In terms of final project grades, there was a decline in the innovation group compared

to the control group (Fig. 3b). However, no significant difference was observed in the final grades (Fig. 3c), indicating similar overall performance between the two groups.

Furthermore, a post-course survey was conducted to evaluate the perceived relevance of the activity and its applicability to real-life situations. The survey responses, rated on a scale of 1 to 10, are depicted in Figure 3(d).

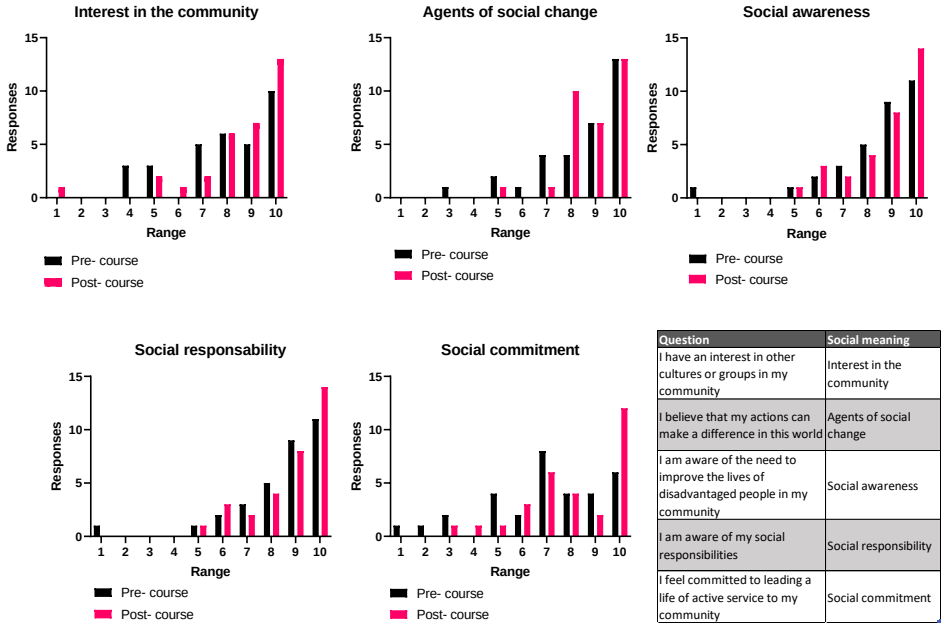


Question	Meaning
ETMET	Learning metodology
ETPRA	Practical application and its connection with theoretical principles
ETRET	Intellectual challenge level

Fig. 2 Comparison of performance of the Pharmacology of Biopharmaceutical Developments (PBD) groups. The CBSL didactic strategy was implemented in the 2021 group, while the 2019 group did not have educational innovation. (a) Qualification of the final presentation. b) Qualification of the final project. c) Final grade. The statistically significant differences (Mann Whitney U) for a) and b) are indicated by (*). For c), the T test of Students was used, being not significant. (d) Post-course students' satisfaction survey show that the students find useful the CBSL methodology in their learning process.

In the PBD group, we compared the results of pre- and post-course surveys that assessed students' perception of service-based learning, including their level of engagement and sense of responsibility towards society. The results of this comparison are presented in Figure 4. We observed an increase in responses close to 10, indicating greater social awareness, after the educational innovation. Specifically, there was an increase in the categories of agents of social change (pre-course 87.5%; post-course 96.90%) and social commitment (pre-course 68.8%; post-course 75.1%). Although there wasn't a significant increase in the other questions, we observed a general trend towards improved social perception among students following the educational innovation. The survey used a scale

of 1 to 10 for assessing students' social perception. The results of their social perception are provided below.



Question	Social meaning
I have an interest in other cultures or groups in my community	Interest in the community
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I am aware of my social responsibilities	Social responsibility
I feel committed to leading a life of active service to my community	Social commitment

Fig. 3. Pharmacology of Biopharmaceutical Developments (PBD) social perception. This figure shows the impact of service learning on changing students' social perception. In each question we can observe that at the end of the course the students felt greater commitment, responsibility, and interest in community service.

4. CONCLUSIONS

Despite the COVID-19 challenges, the educational innovation had a positive impact on student learning and their community engagement. However, individual differences and the unique characteristics of each group should be considered when interpreting the results. Further experiences with Community-Based Service Learning are needed to better understand the effects of this innovation. Students found the innovation beneficial for their learning and appreciated its real-life relevance. Service learning is seen as a valuable strategy for students to contribute to the community and fulfill their social responsibilities.

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