International Journal of Advanced and Applied Sciences, 10(5) 2023, Pages: 211-220

Contents lists available at Science-Gate

International Journal of Advanced and Applied Sciences

Journal homepage: http://www.science-gate.com/IJAAS.html

Evaluating the outcomes of a scientific seedbed program for enhancing research capacities in young students

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ARTICLE INFO

Article history:
Received 26 October 2022
Received in revised form
15 March 2023
Accepted 4 April 2023

Keywords:
Research skills
Comprehensive education
Problem-based learning
Research
Science

ABSTRACT

In the current educational landscape, there is a growing emphasis on providing students with a comprehensive education that includes the development of research skills. However, experts argue that it is crucial to cultivate these skills at an early stage, even during primary and secondary education, to enable students to strengthen their research abilities in university. This research project aimed to establish a scientific platform to foster research capacities among young students. The scientific platform comprised three interdisciplinary working groups, consisting of 14 undergraduate students from various Latin American countries pursuing different academic disciplines. The program was overseen by three instructors. Problem-Based Learning (PBL) methodology was employed in the scientific platform program, wherein each group was assigned three challenging cases. As a result, at the conclusion of the program, the students presented their research findings and proposed solutions for the assigned cases. In comparison to previous experiences conducted in specific universities, this platform successfully integrated students from different Latin American countries and diverse professional fields.

1. Introduction

Pedagogical research constitutes the foundational pillar for universities aiming to enhance the quality of education for undergraduate students. Simultaneously, the production and dissemination of scientific knowledge from both scientific and humanistic perspectives address the diverse social issues prevalent in contemporary society (Evans et al., 2021; Herodotou et al., 2019).

Students must develop investigative skills from their academic training to forge professionals with skills that enable them to face scientific challenges adequately. Although it has been identified that these aptitudes do not increase for various reasons. It has been proven that they have knowledge at a low level (Rodríguez-Vargas et al., 2020), mainly because when it is necessary to demonstrate what has been learned, they find significant dilemmas in their development process, and at the first attempt, they abandon the path of research. It has also been identified that they do not have a space that helps them develop their investigative skills or is unaware of investigative tools and their potential usefulness. University education must be directed and willing to motivate the student community to solve social reality problems under the scientific method's rigor. It has been shown that (Numa-Sanjuan and Márquez Delgado, 2019) scientific seedbeds are recognized by the disciplines as spaces where students develop their investigative skills.

The Facultad Nacional de Salud Pública (FNSP) of the Universidad de Antioquia (Antioquia-Colombia) carried out its first research seedbed in 2007, intending to integrate research, public health, and epidemiology. This initiative emerged from interested students looking for a space to do research. The results obtained were academic strengthening, and the acquisition of new knowledge, skills, and attitudes built to perform a specific task. Teamwork and teaching innovation complemented its primary objective, which was

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training research leaders with principles of academic and human excellence that contribute to society (López-Ríos et al., 2016).

On the other hand, at the Universidad Mayor de San Marcos (Lima-Peru), Library Science students obtained significant percentages in developing investigative skills obtained from a seedbed in the classroom. The research began with students from the first semester who received study and research techniques courses. They took courses on scientific research methodology for the fifth semester, and for the ninth semester, they worked on the phases of research projects. This "Seedbeds in the Classroom" program was born as an alternative to actively involve students and improve their investigative skills, achieve language proficiency, and build new research knowledge and interest. This research shows the importance of seedbeds in the university stage as a program that should be included in a curricular design (Alfaro-Mendives and Estrada-Cuzcano, 2019).

In conclusion, research seedbeds allow the development of collaborative skills to reach a common goal (Martinez-Daza et al., 2021). In addition, teamwork allows sharing of participants' ideas and arguments to make the best decisions to solve the identified problem. In this aspect, the mentors or teachers in charge accompany the procedure to achieve a positive impact. In the same way, mentors become participants by living and feeling the learning of the activities they carry out. A scientific seedbed provides individual and collective strength that can emerge in the search for changes in the different areas of knowledge (Numa-Sanjuan and Márquez Delgado, 2019).

The main objective of this research was to provide the participants of the Scientific Seedbed - Level 1 with the knowledge, tools, and instruments that allow them to develop investigative skills through the scientific method. Three instructors directed the seedbed; the first step was to develop an open call until a specific date. The results of this call were published through all social networks. This seedbed was carried out virtually with a duration of 4 sessions of 2 chronological hours each and a total of 24 academic hours of work. Participants were 14 undergraduate students from different universities, specialties, and countries between 19 and 26 years old. For the development of the seedbed, the Problem-Based Learning (PBL) methodology was used, which consists of applying the concepts learned from the sessions to possible scenarios that the students raised as problems (Ortega-Cortez et al., 2021).

The following sections detail the methodology developed, the participants involved, and the instructors who played the role of facilitators and transmitters of information. In addition, the results obtained from the teams identified as Group A, Group B, and Group C are described. Finally, the conclusions are presented.

2. Methodology

The objective of a scientific seedbed is to provide participants with knowledge, skills, and instruments that allow them to develop research activities following the scientific method, write proposals for research projects, carry out systematic searches of scientific literature to establish a good study of state of the art for their research, and learn about the strategies for writing scientific articles and getting them published in indexed journals.

To achieve this objective, the following content has been proposed (Table 1). It was developed in four sessions, with a frequency of once a week and a duration of two chronological hours each.

Table 1: Scientific seedbed content

Session	Thematic content	Activities
1	Introduction The situation of scientific production in Peru Research Basics	Exhibition, dialogue, and participation of teachers and instructors in the development of the class Access to web pages of interest. Access to class material
2	The scientific method Quantitative and qualitative approaches to research Selection of the research topic Research planning	
3	The scientific article A systematic search for information Choose the journal to publish Publication Ethics	
4	Structure of the scientific article Steps to write the scientific article Writing the first draft of the scientific article	

The training was theoretical-practical. Part of the methodology used in the seedbed was the Problem-Based Learning method known as PBL. Unlike the traditional methodology in which the teacher gives knowledge, and the students use that knowledge to solve problems, in PBL, the teacher gives the problem and the students must find the knowledge they need to solve it. The authors of Trullàs et al. (2022) indicated that PBL is a pedagogical approach that gives the student the leading role in the learning process, so PBL is a student-centered methodology with a self-directed approach. According to Tadesse et al. (2022), implementing the PBL methodology is highly recommended due to its different advantages, among which the improvement of problem-solving skills and the development of critical thinking and soft skills can be mentioned.

PBL is a methodology used at different levels and in various specialties, always with good results, such as those shown in Kanyesigye et al. (2022), Liu and Pásztor (2022), de Simone (2009), and Ravn Haslam et al. (2021).

The seedbed sessions were virtual to achieve more open participation from different countries. The Google Meet platform was used to develop the classes.

To identify the participants of the seedbed, an open call was made at the Latin American level, offering full scholarships since the cost of the seedbed would be covered 100%. Of all the applications received, 14 scholarship recipients were selected based on their resumes and motivation letters. These 14 scholars come from countries such as Peru, Paraguay, Ecuador, Mexico, Colombia, and Bolivia. Of the 14 scholarship holders, one has ten women and four men (Table 2).

To identify and select the problems to be worked on, one used the reading and review process based on the post-it challenge. The idea was to identify the most exciting problems that each participant could contribute; each contributed more than one problematic situation that currently affects society. Then all the participants vote based on which of the problems generates the most impact, and thus one identifies the most impactful ones. One then selects what might be of most interest to stakeholders. Finally, one is left with three problems, which would be those that would have the potential to produce a specific project.

For the work of the problems and the application of the PBL methodology, the scholarship holders were divided into three groups trying to form multidisciplinary teams with gender diversity and varied geographical locations. The formation of the groups can be seen in Table 2.

Table 2: Scientific seedbed groups

	Name	Last Name	University	Speciality	Country
Group 1	Rosarela Sara	Mamani Ticona	Universidad Nacional del Altiplano	Management	Perú
	Isabel Andrea	León Luna	PUCP-UPCH	Biomedical Engineering	Perú
	Alejandra	Guzmán Jaldin	Universidad Mayor de San Simón	Biology	Bolivia
	Erick Antonio	Martínez Rodríguez	Universidad Veracruzana	Nutrition	México
	Matías Eduardo	González Ozuna	Universidad Nacional de Asunción	Materials Science Engineering	Paraguay
Group 2	Max Peter	Panca Jevera	Universidad nacional del altiplano Puno	Biology ecology	Peru
	Ana Milagros	Saavedra Quintana	Universidad de Ingenieria y Tecnologia	Environmental engineering	Perú
	Javier Andrés	Santos Soto	Universidad Autónoma de Bucaramanga - UNAB	Biomedical Engineering	Colombia
	Kiara	Lopez Ramos	Universidad autónoma Gabriel René moreno	Psychology	Bolivia
Group 3	María del Carmen	Zubiate Castillo	Universidad Peruana Cayetano Heredia-Pontificia Universidad Católica del Perú	Biomedical Engineering	Perú
	Luz Lucero	Mora Ccarhuarupay	Universidad Nacional de San Antonio Abad del Cusco	Computer and Systems Engineering	Perú
	Mara Selena	Mesias Bastidas	Universidad de Nariño	Biology	Colombia
	Andrea Araceli	Ariñez Alvarez	Universidad Católica Boliviana San Pablo	Biomedical Engineering	Bolivia
	Isabel Rossnery	Echeverria Zuñiga	Universidad Politécnica Salesiana	Mechatronic Engineering	Ecuador

Subsequently, the teams mentioned above were formed, and the students had to work in stages based on the PBL methodology. Finally, they provided proposals with innovative solutions.

For the development of this seedbed, three instructors with considerable experience in science, technology, and research issues were able to share experience and knowledge with all the scholarship recipients using the tools mentioned above and methodology. In Table 3, one can see the details of each instructor.

Table 3: Scientific seedbed instructors

Full name	Academic background	Experience
Rut Patricia CONDORI OBREGON	Systems engineer	Expert in designs based on user experience. Six articles were published and indexed in SCOPUS.
Natalia Indira VARGAS CUENTAS	Master in remote sensing Electronics engineer	More than five years of teaching courses related to research Participation in research projects with external funding. More than 60 articles published and indexed in SCOPUS
Avid ROMAN GONZALEZ	Ph.D. in signal and image processing Master in industrial and human automatic Electronics engineer Systems engineer	More than ten years of teaching courses related to research Participation in research projects with external funding. More than 140 articles published and indexed in SCOPUS

3. Results

This section describes the results of the three groups formed in the scientific seedbed program.

3.1. Outcomes group A

The first group worked on the following problematic situation: "Shortage of supplies and medicines in rural areas." It was presented as an initial axis that access to timely and good-quality health services is essential to maintain adequate health conditions (WHO, 2008). Likewise, the lack of qualified personnel significantly impacts these services, making it extremely difficult to access medication and quality health care. These deficiencies are noticed to a greater extent in rural and remote areas (Gupta et al., 2003; WHO, 2021).

Although it has been seen and discussed that various factors are involved in the problem, the primary aspect that must be addressed in the first instance concerns access to roads. The difficulties in transportation and communications, given the lack of access routes and highways, aggravate the situation of these populations and, in many cases, lead to total isolation. Health monitoring for families living in rural areas is always challenging due to this lack of infrastructure and the great distances. Moreover, reaching those who need supplies and medical care in low-income locations is difficult. For this reason, it is essential to make access roads available for each region and ensure that transportation seeks the slightest loss in essential health resources. For this reason, this group considered at least three solutions that, through the filters used, resulted in greater viability or greater use by the authorities in Latin America. The proposed solutions are: Designing a wireless network for telehealth services, using drones to transport medical supplies, and constructing paved roads.

According to data from the World Bank, about 40% of the world's population lives in rural areas (WBG, 2021), making it especially important to ensure that those populations have easy access to basic services such as health care.

The following data (Fig. 1) was found for Latin American countries:

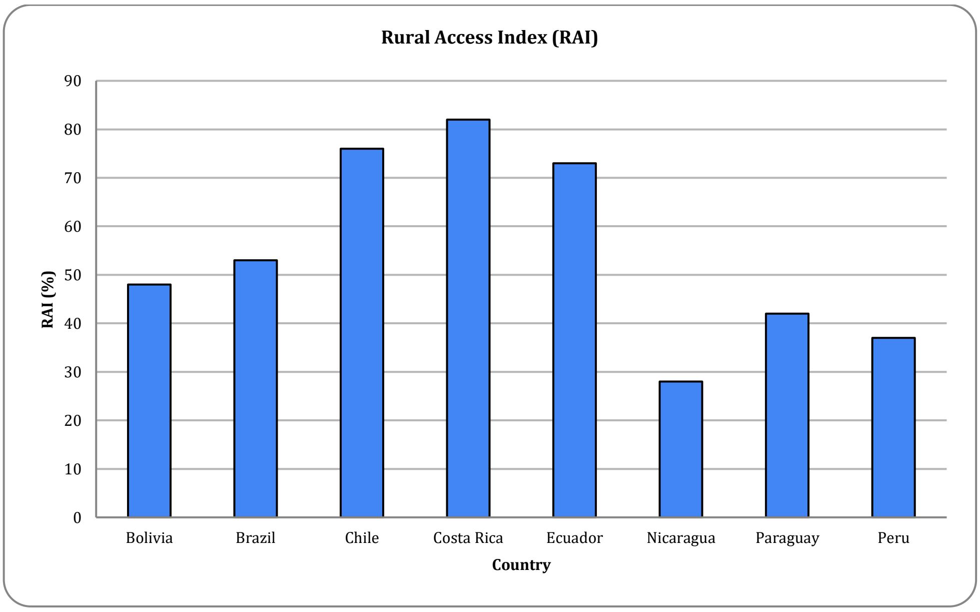

Fig. 1: Rural access index for selected Latin American countries

The Rural Access Index (RAI) is an indicator that measures the proportion of people who live no more than 2 kilometers from a passable road at all times of the year. It is noteworthy that the data obtained for the nations of Paraguay in 2019 and Peru in 2016 exhibit resilience adoption index (RAI) values of 42% and 37% correspondingly (Upton et al., 2022). However, when analyzing by region, it can be found that in territories such as Alto Paraguay, its accessibility is only 1.6%. While those areas close to the Peruvian Amazon, such as Loreto and Ucayali, do not even reach 5% (Banick et al., 2021).

As a central solution, it has been concluded that the priority states should have is the construction of rural and paved roads to improve accessibility to these remote areas. Their importance is such that they are usually named the veins of the countries. They are essential for the functioning of all national economies, generating a positive economic and social impact (Banick et al., 2021; Obregón-Biosca, 2010) as long as the construction of these follows specific social, productive, and resilience parameters for the communities.

The construction of highways was considered the central base in the search for universal health coverage. However, there are areas where the construction of roads presents enormous difficulties due to the conditions of the terrain. For example, Loreto in Peru is a jungle plain surrounded by numerous rivers. Or the communities located between the sinuous mountains of the province of San Juan de la Maguana in the Dominican Republic. Given this, drones for medical supplies have been proposed as a complementary solution. A drone-based solution is an alternative for those communities that, due to their location and the lack of an adequate access route, could see access to medicines by land hampered (Euchi, 2021).

In Peru, tests of antivenom serum and blood samples have been carried out using a refrigerated and airtight transport container; this was carried out in the Ucayali region. A flight from Contamana to Pampa Hermosa, located about 40 kilometers away. Using traditional transportation between these locations, which would be through the river, depending on the type of boat used, the trip could take between 2 to 6 hours. In one of the tests, the drone took 35 minutes to get from one location to another, thus demonstrating its great potential to deliver medical supplies quickly (Flemons et al., 2022).

3.1.1. Dissemination of the proposed solution

A way to verify and validate that what was proposed has considered the needs, a consultation with the general population was developed through social networks since, as mentioned (López et al., 2017) in their work on "Interventions that include websites and social networks: Tools and indicators for evaluation," qualifies these as representative platforms, which empower the user and allow interaction, with a critical factor being virality.

The Instagram platform was chosen because it meets the appropriate characteristics for dissemination and interaction with users to validate the proposals (Santarossa and Woodruff, 2018). The publication was made in a personal account from September 1 to October 14, 2022, and as seen in Fig. 2 and Fig. 3, the nature of the research carried out, the importance, the possible solutions and a call to action were specified.

Fig. 2: Dissemination poster on the problem and proposed solutions

Fig. 3: Poster for the call to action/interaction and user's own comments

The number of posters published in total was three, one of them fulfilled the diffusion function Fig. 2, and the other two had a call to action function. Through the interactions of (likes and comments), the user could vote for one proposed solution Fig. 3.

The dissemination on Instagram resulted in 156 accounts reaching (Fig. 4). At the same time, ten actions of visiting the tagged profiles were registered.

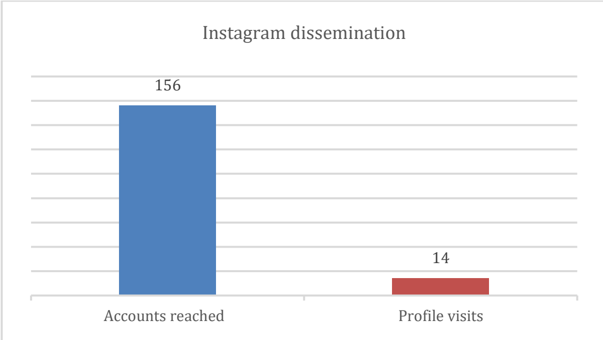

Fig. 4: Instagram metrics measured by accounts reached and profile visits

As shown in Fig. 5, regarding the interaction for voting for a solution, 49 likes (drone-based solution) and eight comments (paved road solution) were received, and the post was shared six times.

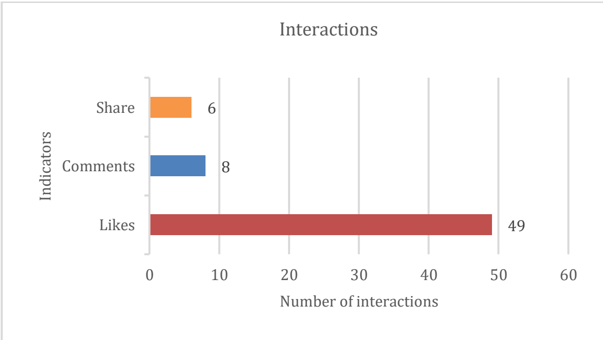

Fig. 5: Post interactions, measured by the number of likes, comments, and shares

Additionally, some users provided additional comments to explain their choice, such as the following comment from a user of Instagram:

"I believe that the construction of roads would solve other problems of the population and not only the distribution of medical supplies. The truth is that, although drones have the autonomy to make trips of more than 2 hours, they have a cost of approximately 500 thousand pesos (Mexican) and would be the most economical solution; I believe that if it is feasible, the ideal would be to expand the road network."

One comment also emphasized the deficiencies in both points:

"I think they are good options, but there are also some issues to consider. For example, road construction is not only about planning and building since government support is necessary. Drones are a good option; however, it is crucial to have access to them, train, and consider the impact of weather conditions on this solution."

3.2. Outcomes group B

The second group was assigned the theme "Loss of biodiversity and degradation of ecosystems." Since this topic was extensive, it was limited by the decision of the members of the group to only the second sub-topic (degradation of ecosystems). The panorama of the problem was identified through the execution of the methodology called "Tree of problems," relating the causes and consequences in different areas such as health, industry, the environment and the economy; categorizing the causes related to the human being (anthropic causes) and the causes related to the environment (natural causes). For the build of this problem tree, Group B collected information from Ehrlich et al. (2013), Eguiguren et al. (2019), and Reid and Mooney (2005); the result of this identification is shown below in Fig. 6.

Once the problem was identified and delimited, brainstorming was carried out, where each member proposed different solutions to solve the problem. Afterward, 12 proposals were obtained in different fields, such as engineering, computer science, education, social sciences, and law. For the selection of the solution, there were two filters. The first consisted of a qualitative evaluation of the options as shown in Table 4; for this, it was determined that the options should accomplish the parameters of execution in virtuality, temporality in the present, and determination of low resources. The options that did not meet the parameters were discarded since it was necessary to ensure faster action and greater coverage. The second filter consisted of a quantitative evaluation regarding the criteria observed in Table 4. For each proposal (A1=Informative mobile application on economic valuation of the environment; A2=Informative web page on environmental degradation; A3=Declaration of vulnerable ecosystems as entities of right to create a protection law; A4=Use of social networks for environmental awareness).

Table 4: Selection criteria of the proposed solutions in group B

#	Criterion	Weight
C1	Easy access and understanding for different population groups	22%
C2	Awareness about the current panorama of the environment	30%
C3	Positive response in the short-medium term	16%
C4	Low acquisition - investment costs	17%
C5	Learning curve on the importance of avoiding environmental degradation	15%

As observed in Table 5, alternative 1 (Informative App on economic valuation of the environment) is chosen since it obtained the highest score (6.34) in the second filter. This alternative aims to outspread ecosystems' environmental, economic, social, and cultural importance.

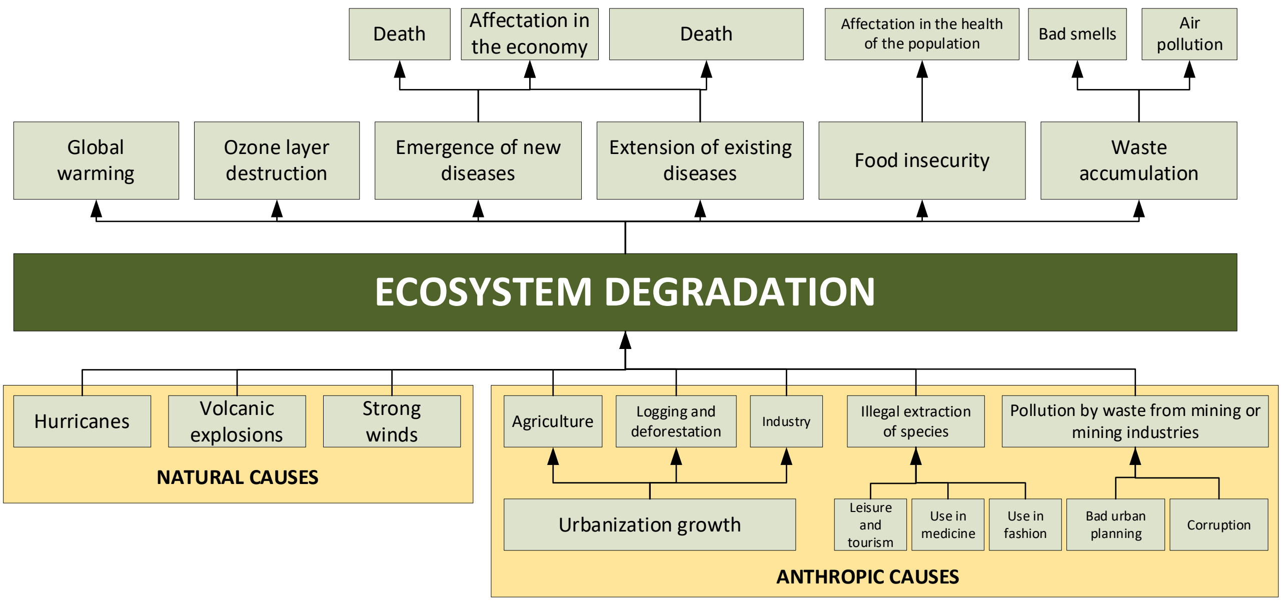

Fig. 6: Identification of the causes and consequences of ecosystem degradation

The general public needs to understand that ecosystems provide essential services such as supply (food, wood, medicines, energy, fibers), regulation (water purification, waste decomposition, pollination, climate regulation, disease control), and cultural (aesthetic, spiritual relaxation, enrichment, leisure and amusement) (Mengist et al., 2020). The proposed App will be oriented to the general public, students, and teachers, among others, to learn about the economic value of these ecosystems.

Table 5: Evaluation of criteria of group B

	C1	C2	C3	C4	C5	Score
A1	7	7	5	5	7	6.34
A2	3	5	1	3	5	3.58
A3	1	1	3	1	1	1.32
A4	5	3	7	7	3	4.76

The selected proposal consists of creating a digital platform (mobile application) that displays data on each country's different types of ecosystem services. For this, standardized models in the international market would be used on the cost of fixing or controlling each element of interest (carbon, water, heavy metals, among others). In addition, various scientific studies developed in ecosystems on the quantification of carbon stored in biomass, water purification of water, air or soil, storage of atmospheric carbon in the soil, ecosystem services, landscape assets, quality of life and sustainability will be cataloged. The objective of the mobile application is to decentralize information in the various studies to make them accessible and interpretable for the general public that, in many cases, is unaware of this crucial data due to the inherent technicality of the area.

3.2.1. Dissemination of the proposed solution

In order to know the impact that this project could have if implemented, a series of infographics were published on the social network Facebook, where the problem, the proposed solution, and some key definitions were briefly described.

The general public received this publication well, achieving 51 reactions from people from different cities in Latin America, obtaining three comments, and being shared ten times. It should be mentioned that most of the reactions received came from people between 17 and 28 years, the youth sector, something predictable due to their affinity with social networks.

3.3. Outcomes group C

The third group worked on the problem of "Anthropogenic Environmental Pollution." This subject was chosen since air pollution is one of the most severe environmental problems caused by anthropogenic causes. A quarter of the air pollutant is caused by the gasses emitted by transport (Navalpotro et al., 2011).

According to UNICEF, 92% of the population lives in places with high levels of air pollution; this is a factor that causes the deaths of 600,000 children under five years each year. On the other hand, in Latin America, around 130 thousand children live in cities with high air pollution (Cifuentes Martínez et al., 2020).

In order to obtain the necessary technical information and achieve the stated objectives, the following research methodology was implemented: Analysis of the problem scenario, collection of information, proposal of possible solutions, and selection of an optimal solution.

The group developed a brainstorming of potential solutions to reduce the impact of air pollution caused by transportation. The following ideas can be mentioned: Reduction of imported vehicles, use of electric vehicles, use of alternative forms of mobility, such as walking or cycling, and finally, use of innovative products such as photocatalytic paint that traps CO_2. Table 6 shows the proposed solutions and their advantages and disadvantages.

Table 6: Comparison of proposed solutions in group C

Solutions	Reduction of vehicle imports	Use of electric vehicles	Other forms of mobility (biking, walking)	Use of innovative products (photocatalytic paint)
Advantages	Fewer polluting vehicles	Less polluting vehicles, the possibility of using rechargeable batteries	Good for health, use it as a means of transportation and not just for sports purposes	Purifies the environment, destroys bacteria and germs, and reduces bad odors
Disadvantages	Lack of rules and regulations to control the importation of used vehicles	Little autonomy, high prices, short-lived batteries	Lack of infrastructure and safety standards, little encouragement in its use	Price is a little high but affordable

In order to determine the most viable alternative solution, a thorough analysis was conducted to identify the advantages and disadvantages of each proposed solution. Ultimately, the solution that demonstrated the highest feasibility was the utilization of innovative products, specifically photocatalytic paint. This selected solution exhibits more advantages and fewer disadvantages when compared to the other alternatives.

An essential aspect to consider is the estimated impact that implementing photocatalytic paint on buses and automotive transport could have. It is noteworthy that 12 liters of photocatalytic paint can absorb up to 250 kg of carbon dioxide, equivalent to the annual CO_2 absorption capacity of an adult tree.

Taking into account that there are approximately 273,600 trucks operating between Peru and Ecuador, the potential absorption of CO_2 could reach up to 68 million kg (MTC, 2022). Such a solution holds the potential to mitigate air pollution significantly, thereby substantially enhancing the quality of life for local inhabitants. The nature of the problem and the proposed solution were effectively communicated to the general public.

An infographic illustrating the proposed solution was shared on the Facebook social network, generating 83 reactions, receiving nine comments, and being shared 13 times. Furthermore, the post was shared an additional six times by other profiles, further expanding its reach and dissemination.

4. Discussion and conclusions

A total of 14 undergraduate students took part in the scientific seedbed program, with ten being women and four being men. The participants were distributed across various countries, with six from Peru, three from Bolivia, two from Colombia, and one representative each from Mexico, Ecuador, and Paraguay. Additionally, three instructors provided guidance and support throughout the program.

The scientific seedbed program served as a platform for sharing scientific knowledge with young undergraduate students, equipping them with knowledge, skills, and tools necessary for their future research endeavors.

Moreover, the scientific seedbed experience facilitated the development of critical thinking and soft skills among the participants. The instructors deliberately formed multidisciplinary groups, comprising individuals from diverse genders and geographical locations, with the aim of fostering networking opportunities among the students. This approach enabled participants to witness how distinct approaches and academic disciplines can be employed to solve the same problem.

Furthermore, through the implementation of Problem-Based Learning (PBL) methodology, the participants were able to enhance their problem-solving skills and learn to utilize scientific research to acquire the necessary knowledge for understanding and proposing solutions to complex problems.

The three groups engaged in investigative work to explore a specific problem and devise potential solutions. They shared their findings during the scientific seedbed sessions and also disseminated them to the general public through various social media platforms.

Firstly, Group A addressed the issue of healthcare in rural areas. They suggested that constructing paved roads and utilizing drones for transportation could mitigate the scarcity of supplies and medicines. Their research indicated that implementing cost-effective solutions such as building paved roads could address multiple challenges related to sustainable development objectives. Furthermore, they conducted a social media poll on Instagram, where 49 votes favored the use of drones for medical supply transportation. Community comments on social media provided valuable perspectives that not only contributed to identifying solutions but also paved the way for future research directions to enhance the distribution of medicines and medical supplies.

Group B focused on the problem of ecosystem degradation and employed the problem tree methodology. They identified five anthropic causes and three natural causes of the problem and proposed 12 potential solutions from various disciplinary perspectives. After conducting qualitative and quantitative analyses, they selected the creation of an informative digital platform (a mobile application) for economic valuation of the environment as the optimal solution, given its higher score of 6.34. To disseminate their proposed solution, Group B utilized the social network Facebook and received 51 reactions from users aged 17 to 28 in different cities across Latin America. They also received three comments, and the post was shared ten times.

Group C tackled the issue of anthropogenic environmental pollution and proposed five potential solutions, evaluating their advantages and disadvantages. Ultimately, they chose the solution of using photocatalytic paint to capture CO_2 emissions from automotive transportation. Their estimation suggested that 12 liters of this paint could absorb up to 250 kg of carbon dioxide, significantly impacting the problem. For dissemination purposes, Group C selected Facebook as their social media platform and garnered 83 reactions, along with nine comments. The post was shared 13 times.

The study highlighted the power of social networks as effective tools for scientific dissemination and interaction with the general public. Such platforms offer a broader reach and enable the sharing of scientific knowledge and technological advancements. It is crucial for more individuals to recognize that science and technology play pivotal roles in addressing the challenges faced by Latin American countries. Future endeavors should consider utilizing a variety of social media platforms to disseminate the proposed solutions from each group, thereby ensuring wider coverage and soliciting better feedback from the general public.

Finally, the participants expressed their satisfaction with the research experience and acknowledged that the scientific seedbed program provided a sense of community and a safe space for sharing ideas and learning from peers and instructors. As part of future work, there are plans to continue conducting calls for participation in the scientific seedbed program.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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