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RESEARCH ARTICLE

Transdisciplinary contributions in undergraduate university students through a stratospheric balloon project with an astrobiological focus

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Abstract

In a rapidly changing academic-scientific context, it is essential to adapt new learning strategies that foster the acquisition of new knowledge and the development of skills in future professionals, such as interacting synergistically with disciplines outside their own to execute projects successfully and comprehensively. The adaptation is only possible thanks to the inter and transdisciplinarity that Astrobiology has promoted since its inception. We use the term transdisciplinary for education that integrates different disciplines in a way to build new knowledge and increase the student's knowledge and skills. For this reason, this study aimed to demonstrate that an astrobiological stratospheric balloon launch project cultivates transdisciplinary awareness in participants: undergraduate university students in Lima, Peru. The sample consisted of 15 students from the following disciplines: biology, genetics, chemical engineering, physics, industrial engineering, agri-food engineering, forestry engineering, electronics engineering, mechatronics engineering, geology, geological engineering, philosophy, social communication, audiovisual communication and education. Using a semi-structured in-depth interview technique, experts validated the questions from the Universidad Nacional Mayor de San Marcos, Peru, and a matrix of meaning was constructed to classify the responses, ultimately obtaining the categories: contribution, complementarity and quantity. The participants' responses were processed and analyzed with Chat-GPT 3.5, revealing unanimous agreement that each participant's discipline contributed to the success of the balloon launch. To complement the qualitative interpretation of the results, a quantitative measurement was conducted to minimize subjective biases. Additionally, they gained knowledge and insights into other unfamiliar study subjects, collaborated to improve process quality, shared and harmonized their ideas to implement comprehensive solutions, and affirmed that their university education is often isolated or strictly focused on their specialization. In conclusion, experiences where different areas of knowledge converge in praxis, have the potential to awaken new technical, cognitive and communication skills in the individuals involved, utilizing astrobiological resources to invigorate and strengthen collective learning.

Contents

Introduction

Teaching in universities is increasingly focused on specialization according to the career chosen by the student, which is crucial because it allows the future professional to gain in-depth knowledge of the subject of their field of study (Guzmán, 2011). This trend emerged during the Renaissance when the universe began its mathematization and adopted a mechanistic approach (Chon, 2012).

However, the emphasis on specialization can lead to the formation of individuals with particular knowledge of a particular area but with a lack of general knowledge in other areas (Casadevall and Fang, 2014). In other words, it can generate 'micro experts' and 'macro ignorant' individuals (Vilar, 1997). Therefore, it is vital to establish approaches that help us overcome traditional disciplinary barriers and promote a more holistic and interconnected education (Martínez, 2019).

It is necessary to promote a transdisciplinary approach in education that allows students to integrate different disciplines and perspectives to address the complex problems of today's society (Peñuela, 2005; Vizcaino and Otero, 2008). Transdisciplinary education seeks to overcome the limitations of traditional disciplines by fostering collaboration and teamwork among individuals from diverse backgrounds and disciplines (Chon-Torres, 2018). 'Transdisciplinary' encapsulates an educational methodology that unites multiple disciplines to expand and deepen students' competencies and knowledge.

When we talk about the university, we cannot see it as an entity isolated from its surrounding world. On the contrary, the university must be in constant contact with its environment and act through the individuals who comprise it, such as students, professors, researchers and administrative staff. In other words, the university must be an active change agent and its members should become protagonists of this change (Steele and Rickards, 2021). It means that each of them must assume an active responsibility and make decisions that can influence their work environment and society as a whole. In particular, university members who already have an active role in the workforce can make concrete decisions that can positively impact their surroundings. Furthermore, these decisions can inspire others to do the same, thereby generating a positive change in the community members' professional and personal spheres (Chon-Torres and Mares, 2018; Pee and Vululleh, 2020).

Why are multidisciplinary or interdisciplinary approaches not sufficient, what are the differences in front of transdisciplinary? Multidisciplinarity focuses on the coexistence of different disciplines without seeking to establish meaningful relationships between them. Instead of emphasizing knowledge integration, it emphasizes appreciating different disciplinary perspectives without a common objective (Repko, 2007). Additionally, according to Mennes (2020), multidisciplinarity does not question the established boundaries between different disciplines, thus posing no greater risk than a monodisciplinary approach. The assertion suggests that multidisciplinarity is not a threat to the stability and development of disciplines but can be a valuable tool to foster their growth.

The definition of interdisciplinarity also entails its limitations. For instance, it is an approach that relies on the orientation of one or several disciplines towards the perspective of a leading discipline. In this approach, the leading discipline is the primary beneficiary, and the other disciplines contribute to developing the object of study based on that central discipline (Llano *et al*., 2016). The philosophy of astrobiology is an example of an interdisciplinary approach, where astrobiology is the leading discipline and philosophy contributes to reflecting on its philosophical and ethical implications (Chon-Torres, 2018).

Similarly, astrobiology is conceived as a transdisciplinary field because, according to Santos *et al*. (2016), transdisciplinarity does not seek to eliminate disciplines and their boundaries. Instead, the transdisciplinary space adds a third dimension to the domain where multidisciplinarity and interdisciplinarity operate, including even the scope of both. This space explores the interconnections and interdependencies between disciplines to address complex and global problems. Thus, astrobiology has emerged as a transdisciplinary field based on the sciences of astronomy, chemistry, biology and geology, but also incorporating social sciences and humanities. The success of astrobiology as a new discipline lies in the interactions and collaborations of researchers in these seemingly disparate fields

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(Cornell, 2014). Consequently, astrobiology educators face the challenge of bridging these diverse fields and presenting students with a comprehensive programme that thoroughly encompasses this novel science (Foster and Drew, 2009).

The rapid evolution of the field of astrobiology provides a better opportunity as a vehicle for educational reform than other more established or entrenched scientific disciplines. Moreover, as astrobiology resides on the expansive frontier of interdisciplinary science, it can present a more compelling case for a strategy to educate the upcoming generation of scientists in a distinct manner (Race *et al*., 2012). It is because it is a constantly evolving field where students who receive instruction in astrobiology can develop transdisciplinary skills and learn how to work in teams, communicate their ideas and collaboratively address complex problems. Additionally, since astrobiology deals with the search for life on other planets, it can serve as a source of inspiration to motivate students and ignite their curiosity about the universe and space exploration (Kwok, 2018).

In this context, the project presented seeks to foster collaboration among diverse disciplines by launching stratospheric balloons. Beyond the technical aspect, the influence of astrobiological nuances becomes a critical complement to enrich the relationship between various academic and scientific fields. Furthermore, this didactic approach can provide students with an enriching experience of practical and collaborative learning while developing transdisciplinary skills that will be valuable in their careers and professional lives. Therefore, the objective of this work is to demonstrate that the project of stratospheric launch with astrobiological purposes is a way to promote transdisciplinary work among undergraduate university students.

Although the projects submitted by the student groups are not part of the focus of this study, the table of the works they submitted as part of the stratospheric launch is shown below (Table 1)

Methodology

The study employed a qualitative, cross-sectional and non-empirical approach to examine the subject. At the quantitative level, based on the comments and responses of the interviewees, an exploratory analysis was also conducted. The exploratory research design aims to describe the population's behavior and increase knowledge in a relatively understudied topic. For data collection, a semi-structured interview was utilized, consisting of questions designed based on the theoretical framework of transdisciplinarity. The Universidad Nacional Mayor de San Marcos experts evaluated the questions and rated them according to a rubric that considered sufficiency, clarity, coherence and relevance. Once the instrument was approved, the interview was pilot-evaluated on two stratospheric project members, and the questions' wording was adjusted based on the feedback received. It's crucial to note that the original language for the queries and responses in this research was Spanish. To ensure the authenticity and integrity of the content were retained in this English-language article, the authors themselves undertook the translation. This careful process was pivotal in maintaining the nuanced meaning and essence of the original material.

The study population consisted of university students from different disciplines from the Peruvian Association of Astrobiology in Lima, Peru. The selection of the non-probabilistic sample carried out through 15 students was sufficient, as a point of redundancy was reached in the respondents' answers. An in-depth semi-structured interview technique was used for data collection, which provided the necessary flexibility to delve into the desired aspects. The interview guide was used as the instrument, and the information was recorded on a recorder for subsequent transcription. It was used Google Meet and Zoom for the interviews. A sense matrix was used to classify the responses and determine whether the objective was achieved.

The creation of a sense matrix generally starts with the transcription of interviews, followed by a careful reading to identify significant statements or text fragments that are related to the research objective. These fragments are coded and organized in the matrix under relevant themes, which can be done manually -which is our case- or with the help of specialized software for qualitative data analysis such as NVivo or ATLAS.ti. The exact structure of a sense matrix can vary depending on the specific needs

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Table 1. *Project students and why they were chosen*

Student project name	Why it was chosen for the balloon launch	Science question asked	Main result
Germination trial of two varieties of *Chenopodium quinoa* Willd seeds exposed to stratospheric conditions	Astrobiological theme of great interest to the team's students, in addition to the material feasibility for the main project of the stratospheric balloon	What are the germination percentages for two varieties of *Chenopodium quinoa* Willd seeds after exposure to the extreme conditions of the stratosphere?	The germination of the seeds did not significantly vary after exposure to the extreme temperatures and radiation conditions of the stratosphere, and no phenotypic changes were observed post-exposure.
Evaluation of tardigrade resilience in the stratosphere in Peru		How do tardigrades in a state of anhydrobiosis survive after being exposed to the conditions of the stratosphere?	The main result of the study is that 78% of the tardigrades exhibited movement, suggesting survival postexposure to stratospheric conditions. These tardigrades belonged to the class Eutardigrada, family Macrobiotidae, and genus Macrobiotus, marking this as the first study of its kind conducted in Peru.
Cyanomars 1		Can the cyanobacterium Nostoc serve as a viable nutritional source for astronauts under stratospheric conditions?	Notable morphological changes in the Nostoc colonies were observed, indicating potential adaptations to space conditions.

Note. The table displays the names of the student projects, the reasons they were chosen for the balloon launch, the scientific questions posed and the main results obtained in each project.

of the study, but it is often organized in rows and columns with thematic categories and data excerpts that illustrate those themes.

For the elaboration of this article, the most representative and repetitive responses from the Interviewees were selected. A Large Language Model (LLM) called Chat-GPT 3.5 was employed. This model is based on artificial intelligence (AI), using machine learning algorithms to process, analyze and generate text with natural language processing (NLP) capabilities (Open AI, 2023). However, the process and output of this LLM were under human supervision and correction. In this sense, expert judgment has never been replaced, adhering to the recommendations for using AI as a research tool to assist humans in their work, but it should never be substituted for them (Salvagno *et al.*, 2023).

The specialties of the participants, who were assigned a number as 'Interviewee 1,' 'Interviewee 2,' …, or 'Interviewee 15,' were in the fields of biology, genetics, chemical engineering, physics, industrial engineering, agri-food engineering, forestry engineering, electronics engineering, mechatronics

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engineering, geology, geological engineering, philosophy, social communication, audiovisual communication and education.

Based on the responses from the interviews, and to avoid falling into overly subjective positions, the responses were quantified and organized into tables. This could be achieved by assigning numerical values to the responses and displaying them in tabular form, which would offer a measure of objectivity to complement the qualitative data. This is a method that seeks to complement the qualitative nature of this study. Since the sample was non-probabilistic, it allowed us to conduct a quantitative exploratory analysis which revealed a trend that corresponds with the conclusions drawn from the qualitative analysis. The quantitative exploratory analysis consisted of determining the descriptive prevalences of the indicators used in the measurement instrument of the in-depth interviews. These are presented in tables below the interpretation made of the respondents' answers.

Finally, it is essential to highlight that the participants knew the meaning of transdisciplinarity, as they had access to the San Marcos Educational Model, where its meaning is explained (Vicerectorado académico – UNMSM, 2015).

Results and discussion

The initial categories were contribution, complementarity and quantity – the first indicator aimed to define the degree of two-way contribution concerning the interviewee's discipline, and the second sought to directly assess the experience of complementarity regarding the disciplinary aspects involved. The third aimed to account for the diversity of disciplines, as transdisciplinarity could not be conceived without it.

In that sense, subcategories were perceived as a result of the participant's responses. Thus, for the first category, we have.:

Contribution
- Contribution of the discipline to the project.
- Contribution of the project's knowledge to the discipline.
- Collaboration between disciplines during the project.
- Contribution of the discipline to the project's knowledge.
- Methodological involvement of disciplines in the object of study.
- Gains in transdisciplinary research.

Complementarity
- Complementarity among disciplines.
- Perception of the influence of transdisciplinarity on the project's results.
- Impact of the project on the improvement of capabilities to relate to other disciplines.
- Transdisciplinarity of the project.
- Relationship between the project's transdisciplinarity and the San Marcos model.

Quantity
- Involved disciplines.

Subsequently, some responses will be presented that correspond to the different criteria mentioned, except for the last one, which is Quantity, where reference is made to the disciplines that each student pursues and that was previously mentioned. Finally, regarding the rest, the responses will be summarized for each subcategory. It will help us determine whether this astrobiological-contexted stratospheric launch project effectively promotes transdisciplinarity.

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Contribution

Regarding the 'Contribution' category, according to the informants, each of their academic specializations has played an important and suitable role in the project. It is because the project is broad and diverse, and each discipline finds a task related to its field of study. In other words, the work has allowed each discipline to contribute its specialized knowledge and specific skills to address different aspects of the project effectively and relevantly. Thanks to the collaboration and joint work of these different sciences, the project has been able to be developed comprehensively and successfully.

In this regard and concerning the question within the ' Contribution of the discipline to the project' subcategory, interviewee 4, from biology, emphasized: 'It was relevant […] My career was important for evaluating the samples after the launch of the stratospheric balloon'. While interviewee 7, from communications, expressed: 'I have been in charge of audiovisual recording, of being able to present this information, this work. So, from that perspective, I can say that it is relevant'. In this sense, the participation of the involved disciplines is highlighted through their participants.

Likewise, in the subcategory 'Contribution of the project's knowledge to the discipline', the interviewees expressed that the project has been a unique opportunity to conduct a practice or experiment that has enriched the knowledge in their respective disciplines. The participation of each discipline in the project has been different, allowing each one to benefit in its way. Additionally, several participants have developed communication and leadership skills that have been very useful to them. At the same time, the project has provided an opportunity to delve into more specific topics relevant to each area of knowledge, such as the study of the atmosphere, electronic systems, climate change, cyanobacteria and other related subjects. The project has been a highly enriching experience for the Interviewees, allowing them to enhance their knowledge and skills in their respective disciplines (Table 2).

In the subcategory 'Contribution between disciplines during the project,' the interviewees agree that the interaction among the diverse disciplines that are part of the project team has been highly fruitful in achieving the proposed objectives and academic development. Collaboration between disciplines has allowed for exposure to multiple viewpoints and approaches, significantly enriching team members' personal and disciplinary perspectives. The constructive interaction created by diverse perspectives has resulted in a rewarding and beneficial learning experience for all project participants. Interviewee 12, from Environmental Engineering, stated, 'There is a complementarity between disciplines […] each discipline contributed to my knowledge and vice versa […] interacting with other disciplines enriches research'. Meanwhile, interviewee 9, from agro-industrial engineering, mentioned, 'Beneficial […] it helps you see it from different perspectives and makes your work more meticulous'. Both interviewees agree on the importance of interaction and collaboration between disciplines to enrich their knowledge and improve the quality of their work. They emphasize the complementarity of different disciplines and how their interaction can be highly beneficial in achieving the project's objectives. Furthermore, they both mention how exposure to different perspectives has allowed them to broaden their vision and conduct their in work more detail. The Interviewees highlight the

Table 2. *Contribution of the project's knowledge to the discipline*

	Pertinent		Relevant		DK/NO	
Indicator	Cases	%	Cases	%	Cases	%
To what extent did the discipline in which you are involved contribute to the launch of the stratospheric balloon for astrobiological purposes?	4	26.7%	10	66.7%	1	6.7%

Note. Of all the respondents, 66.7% believe that the discipline they are in made a relevant contribution to the launch of the stratospheric balloon for astrobiological purposes. Likewise, 26.7% consider it pertinent.

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Table 3. *Perceptions on disciplines involvement in the project*

	No		Yes	
Indicator	Cases	%	Cases	%
Perception that science is involved in the project	0	0.0	15	100.0
Perception that engineering is involved in the project	2	13.3	13	86.7
Perception that the humanities are involved in the project	4	26.7	11	73.3

Note. Of all the respondents, 100% state that science (biology, genetics, chemistry, and physics) is directly involved in the project. Likewise, 86.7% of the respondents indicate that engineering is directly involved in the project, and 73.3% of the respondents state that the humanities (education, communication, and philosophy) are also involved in the project.

significance of transdisciplinary collaboration in enhancing the quality of their work and their overall knowledge (Table 3).

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Regarding the subcategory 'contribution of the discipline to the knowledge of the project,' the project has benefited from the individual contribution of each discipline involved. Participants have focused their knowledge and skills on specific project areas, such as sample evaluation, probe structuring, educational impact, or dissemination. In this sense, transdisciplinary collaboration has been achieved, allowing the integration of different contributions into a single solution and enriching the quality of the work and the obtained results (Table 4).

Table 4. *How does the project contribute knowledge to your discipline?*

	Application of knowledge		Contribution to scientific research		Skill development		Scientific dissemination	
Indicador	Cases	%	Cases	%	Cases	%	Cases	%
How does the project contribute knowledge to your discipline?	4	26.7	5	33.3	3	20.0	3	20.0

Note. From the total number of interviewees, 33.3% affirm that the project contributes to scientific research, 26.7% believe it contributes to the application of knowledge, 20% to the dissemination of Scientific knowledge and 20% to the development of Skills.

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Table 5. *How has your discipline managed to contribute to the knowledge about astrobiological stratospheric balloon projects?*

	Probe structuring		Sample evaluation		Educational impact	
Indicator	Cases	%	Cases	%	Cases	%
How has your discipline managed to contribute to the knowledge about astrobiological stratospheric balloon projects?	5	33.3	8	53.3	2	13.3

Note. Of all the respondents, 53.3% believe that their discipline contributed to the sample evaluation of the astrobiological stratospheric balloon project, 33.3% believe that it contributed to the structuring of the probe and 13.3% believe that it contributed to the educational impact.

In this way, the disciplines have contributed in different ways and at different levels, generating constructive interaction that has allowed for the overall complementation and growth of the project. Each discipline has focused its knowledge and skills in a specific area, which has enabled greater efficiency and effectiveness in each task and, therefore, in the entire project. The contribution of each discipline has been essential for the project's success, enabling an integrated and enriching vision for solving a complex problem. Collaboration and knowledge exchange between disciplines have been vital in achieving the desired outcomes (Table 5).

Interviewee 3 from chemistry indicated: 'Everyone had a very important role, regardless of the discipline they are in. […] I consider this work to have been systematic. […] I realized that it is also very important for me to be able to converse with people from other fields, so that I can have a better complement not only for myself but also for those I collaborate with'. In the same vein, interviewee 3 from environmental engineering stated: 'The students from the biology programme contributed significantly when evaluating whether to send samples in Petri dishes or in Eppendorf tubes to save space on the stratospheric balloon platform. They also played a role in analyzing the samples during the cultivation phase'.

Both interviewees highlight the importance of collaboration and teamwork and the valuable contribution of each discipline to the project. Interviewee 3 from chemistry emphasizes that all disciplines had an important role, and regardless of the discipline, each individual contributed something valuable to the project. He also mentions the importance of conversing with people from other fields to achieve a better complement. On the other hand, interviewee 3 from environmental engineering explicitly highlights biology students' valuable contribution to sample evaluation and the cultivation phase. In this way, he emphasizes how collaboration and interaction between disciplines can positively impact the project and enrich the knowledge of all those involved. Both interviewees agree on the importance of transdisciplinary collaboration and teamwork for the project's success. Additionally, they both emphasize the valuable contribution of each discipline and how the interaction between disciplines can generate a positive and enriching impact on the project and the individual knowledge of each participant.

In the subcategory 'methodological involvement of disciplines in the object of study', participants acknowledged that each area of knowledge has contributed at different stages of the project's progress. For example, during the planning and deployment phase of the probe, all disciplines were integrated; however, there were specific situations where certain branches had a more prominent role. For example, biology played a fundamental role in collecting and studying samples.

In the subcategory 'gains in transdisciplinary research', collaboration among different areas of knowledge has been crucial for the project's success, as it has allowed for the integration of different perspectives and enriched the outcome with the knowledge from each discipline. Likewise, the participants have benefited from the opportunity to gain experience from diverse academic perspectives,

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enabling them to understand the project's complexity and how each discipline complements one another in practice.

For example, interviewee 7, from the communications field, stated: 'Yes, I perceive that I have gained experience in transdisciplinary work. I believe that specifically this combination of scientific areas is not conventionally seen in other types of projects […] the approach is so broad that it allows you to choose what aspects to focus on more, which is what you could take away from such distinct worldviews'. This participant recognizes that they have acquired experience in projects involving collaboration between different disciplines. However, they consider this project unique because combining integrated scientific areas is rare in other conventional projects. The breadth of the project's approach has provided them with a broader range of perspectives, allowing them to make the most of each. On the other hand, interviewee 9, from the field of Agricultural Engineering, mentions: 'yes, before I was more technical, and I followed the notion that you follow a guideline and that's it. But the contributions from fields like biology, chemical sciences or social sciences have helped me to have a greater impact on what things should be taken into account, which aspects should be a topic for research in order to properly track the objectives'. The participant acknowledges that they previously had a more technical perspective and followed established rules without questioning them too much. However, the contributions from disciplines such as biology, chemical sciences and social sciences have allowed them to broaden their focus and consider other essential aspects of research and fulfilling the project's objectives. As a result, they now understand the need to consider various factors and not simply follow predetermined guidelines (Table 6).

Complementarity

In the Complementarity category, we find the subcategory 'complementarity among disciplines'. In this subcategory, project members have expressed that, overall, they have interacted smoothly with the involved disciplines without significant difficulties. However, some have pointed out that one of the main challenges they have faced is communication with engineering disciplines, as they often use terminology and technical language that is only sometimes easy to understand for those without experience in that field. It has sometimes led to delays or confusion in implementing specific technical solutions, requiring additional effort to ensure effective communication between the disciplines. Ultimately, the interaction among disciplines is crucial for achieving collaborative and successful work, but it requires additional effort to overcome linguistic and technical barriers that may arise.

Participant 2 from microbiology expressed, 'through many conversations, we managed to form a great team. We all learned something together and achieved a successful project'. Meanwhile,

Table 6. *Contribution*

	Good		Regular		Poor	
Indicator	Cases	%	Cases	%	Cases	%
How do you perceive the contribution among the participating disciplines as a result of the stratospheric balloon project?	15	100.0	0	0.0	0	0.0
¿In what way have the participating disciplines methodologically involved themselves in the study subject?	15	100.0	0	0.0	0	0.0
What gain is observed in the research regarding the implementation of the achieved transdisciplinary approach?	15	100.0	0	0.0	0	0.0%
What is your opinion on the results obtained from the project considering the interaction among the involved disciplines?	15	100.0	0	0.0	0	0.0

Note. This table presents participant perceptions on the impact of a transdisciplinary approach within a stratospheric balloon research project. Respondents unanimously reported positive outcomes regarding inter-disciplinary contribution, methodological involvement, observed benefits in research and the perceived improvement in results due to transdisciplinary collaboration.

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participant 13 stated, 'In a way, it was like speaking the same language with all the disciplines. The only difference is in the knowledge. Each one has more depth in a specific area, so each professional has contributed based on their experience'. Both participants highlight the importance of teamwork and the richness that can be obtained from collaboration among disciplines. However, while participant 2 emphasizes the significance of communication and mutual learning, participant 13 highlights the complementarity of different areas of knowledge. Participant 2 emphasizes that thanks to conversations and teamwork, a successful project was achieved in which all members could learn from the disciplines involved. For them, collaboration among disciplines is an opportunity to broaden their horizons and acquire new knowledge. On the other hand, participant 13 points out that although each discipline has a specific focus and knowledge, ultimately, everyone is working towards a common goal. For them, transdisciplinarity is an opportunity to gain experience from other areas of knowledge and find more comprehensive and practical solutions, as each professional can contribute from their own experience and specific knowledge.

In summary, both participants acknowledge the importance of collaboration among disciplines but emphasize different aspects of it. While participant 2 highlights the significance of mutual learning and communication, participant 13 emphasizes the complementarity of different areas of knowledge and the possibility of finding more comprehensive solutions through the contribution of each discipline.

According to the participants in the subcategory 'perception of the influence of transdisciplinarity on project outcomes,' the transdisciplinary collaboration among students from different fields of study has been beneficial for the project's development, given its complexity. Informant number six mentions that interaction between disciplines is necessary to cover potential gaps and achieve more effective results. In this way, the obtained results have been enriched and deepened thanks to the presence of multiple academic perspectives. Additionally, the participants consider this collaboration a challenge as it requires listening to and considering the ideas and approaches from other fields of study, contributing to their growth and formation. Interviewee 14 expressed, 'It is much better with a transdisciplinary approach; the interaction and contribution of diverse sciences are important to enrich my career. The project was a success'. The participants believe the transdisciplinary approach has allowed them to broaden their academic education, enriching it with knowledge from other disciplines and applying those learnings in their field of study. Thus, teamwork and transdisciplinary collaboration are presented as fundamental values in the formation and development of projects.

In the subcategory 'Impact of the project on improving abilities to relate to other disciplines', the importance of the transdisciplinary approach has been highlighted, as it has facilitated interaction and collaboration among the different academic disciplines involved in the project. Additionally, the participants expressed that transdisciplinarity has allowed for mutual enrichment among the various sciences, enhancing their professional development.

Regarding the project's success, it has been mentioned that the interaction and contributions of each discipline have been crucial in achieving it. In this regard, it has been recognized that the project would have been more limited and less comprehensive if it had relied solely on one academic discipline. Therefore, the participants have valued the importance of transdisciplinary collaboration in achieving complex and challenging objectives such as the project at hand.

In the subcategory 'Transdisciplinarity of the project,' the interviewed participants agree that the project is characterized by transdisciplinarity, which represents an innovative concept for many of them since they had never had the opportunity in their respective institutions to collaborate in teams composed of individuals from diverse disciplines. For example, Interviewee 11, a biology student, expressed, 'The stratosphere project helps you interact with other disciplines. This project involves a broader range of researchers. Undergraduate projects are more limited'. Likewise, interviewee 15, also from biology, stated, 'I consider it to be transdisciplinary and it aligns with the San Marcos Educational Model'. On the other hand, Interviewee 13, from education, said, 'In the stratosphere project, I have seen that various disciplines contribute to a common goal. However, at university, each subject works independently'. First, all three interviewees acknowledge the presence of multiple disciplines involved in the stratosphere project. Second, the interviewees agree that this type of project

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Table 7. *Complementarity of disciplines*

	Yes		No	
Indicator	Cases	%	Cases	%
Do you believe that this type of project helps you to better relate to other disciplines in a transdisciplinary way?	15	100.0	0	0.0
Do you think that this type of projects does comply with being viceredisciplinary compared to your undergraduate projects at the university?	15	100.0	0	0.0
¿Do you consider that the definition of transdisciplinarity of the San Marcos educational model is complemented in this astrobiological stratospheric project?	15	100.0	0	0.0

Note. Table 6 reflects the unanimous agreement among participants ($n = 15$) regarding the transdisciplinary nature of astrobiological stratospheric projects. All respondents confirmed that these projects enhance transdisciplinary collaboration, exceed the transdisciplinary aspects of their undergraduate studies, and align with the transdisciplinary definition of the San Marcos Educational Model.

represents a unique opportunity to interact with people from different academic fields. Finally, the interviewees highlight that work is conducted within individual subjects in their universities, and the interaction between disciplines is limited.

In the subcategory 'relationship of the project's transdisciplinarity with the San Marcos Educational Model', the participants acknowledge that the definition of transdisciplinarity is fulfilled. In this sense, this type of project is suitable if the aim is to promote activities that facilitate transdisciplinary interaction (Table 7).

Conclusion

Based on the results obtained through the interviewees' responses, the project in question effectively promotes and fosters transdisciplinary work. This conclusion is important, as a multidisciplinary approach in university education is essential to address today's society's complex and global challenges. It is important to highlight that a monodisciplinary approach can limit students' ability to address problems from multiple perspectives. Therefore, a project that promotes transdisciplinary collaboration is fundamental to overcoming these limitations and providing students with a more comprehensive education. Another advantage of transdisciplinary projects is that they prepare students to work in teams with peers from different disciplines. In an increasingly diverse work environment, it is essential to have teamwork skills and the ability to collaborate with individuals who have different perspectives and skills.

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