EUROPEAN JOURNAL OF STEM EDUCATION

European Journal of STEM Education,
2025, 10(1), 08
ISSN: 2468-4368

lectito

Academic Self-Efficacy in Peruvian University Students through an Astrobiological Stratospheric Balloon Project

Octavio Alfonso Chon-Torres [1]*, Julio Cesar Ramos Ramirez [1], Rosana Aurora Choy Vessoni [1]

[1] *Universidad de Lima*, PERU

***Corresponding Author:** ochon@ulima.edu.pe

Citation: Chon-Torres, O. A., Ramos Ramirez, J. C. and Choy Vessoni, R. A. (2025). Academic Self-Efficacy in Peruvian University Students through an Astrobiological Stratospheric Balloon Project. *European Journal of STEM Education*, 10(1), 08. https://doi.org/10.20897/ejsteme/16598

Published: July 12, 2025

ABSTRACT

This study investigated the effect of a stratospheric balloon project focused on astrobiology on the academic self-efficacy of university students in Peru. Using the Perceived Academic Self-Efficacy Scale, 154 students were evaluated, divided into experimental and control groups. The project offered practical experience in interdisciplinary research, linking astrobiology with other disciplines. The results showed a significant increase in academic self-efficacy, both in direct participants and non-participants, although it was more notable in the former. This increase in self-efficacy suggests that active participation in practical projects can strengthen students' beliefs about their academic abilities. Additionally, it was observed that the project experience was equally effective in improving self-efficacy in students from both private and public universities, with no significant differences based on gender.

Keywords: academic self-efficacy, stratospheric balloon project, astrobiology, education

INTRODUCTION

Self-efficacy can be defined as the degree of confidence individuals have in their ability to complete specific tasks or achieve certain achievements (Maddux, 2013). In the university context, this concept fosters formative research, aiding in the development of professional researchers endowed with skills in critical thinking and constant, lifelong learning. These researchers seek to identify and solve unresolved problems, thereby contributing to the indispensable technological and scientific progress that nations require (Miyahira Arakaki, 2009).

In our study, we link the concept of academic self-efficacy to stratospheric balloon projects aimed at astrobiology. The participants were engaged through a non-profit organization called the Peruvian Association of Astrobiology (ASPAST), which operates on critical axes for the advancement of science, such as outreach and scientific research. Through an initiative called the "Stratosphere Project," the participation of interdisciplinary groups was solicited, specifically undergraduate students from Metropolitan Lima, who by working together and separately, aimed to send a balloon carrying biological samples into the stratosphere. The goal was to analyze the interactions of these samples with the environment (considered an analog of the planet Mars).

Astrobiology is a transdisciplinary field, meaning that it connects different domains of knowledge towards common purposes (Chon-Torres, 2018). Leveraging this characteristic, the objective of this study was to assess the impact of a stratospheric balloon project with an astrobiological focus on the academic self-efficacy of university students. This paper is structured as follows: first, we will develop the definition of academic self-efficacy based on various authors; second, we will explore the concept of launching stratospheric balloons for astrobiological purposes; third, we will present the methodology, results, and discussion of our research findings; and finally, we will present our conclusions.

Academic Self-Efficacy

The original definition, proposed by Bandura (cited by Hatlevik et al., 2018; Huerta et al., 2017; McBride et al., 2020; Panadero et al., 2017), explains that self-efficacy is the level of confidence a person has in their ability to perform a specific behavior or achieve a given accomplishment. Maddux (2013) emphasizes that self-efficacy does not refer to a person's abilities; rather, it pertains to their judgments about these abilities. This cognitive process is related to planning and anticipating the consequences of one's own behavior. It involves an affective process since emotional reactions can affect action directly or indirectly through coping strategies. It also has a component of Locus of Control; in a self-efficacious person, this tends to be internal. Lastly, it includes antecedents that may encompass expectations, personal and vicarious experiences, and persuasion (Zulkosky, 2009). The significance of this variable lies in the fact that, according to social cognitive theory, the generated expectations and judgments about capability can determine the choice of goals and goal-directed actions, as well as the effort expended and persistence in the face of adversity (Maddux, 2013).

This variable is quite broad, and several authors explain that to understand and measure it adequately, self-efficacy must be considered in relation to a specific field or domain of capabilities (Klassen and Klassen, 2018; McBride et al., 2020; Roney et al., 2017). Moreover, since self-efficacy comprises beliefs and judgments about capability in a specific domain, it can also be influenced by variables tied to the domain and not necessarily to the construct itself. For instance, self-efficacy for technology use is also impacted by age, experience with the technology, and socioeconomic level, as it enables access (Roney et al., 2017). Therefore, to properly understand self-efficacy linked to academic activities, analyses must be performed and measures specifically created for this sector should be utilized.

The more specific construct of academic self-efficacy encompasses students' beliefs in their ability to successfully perform tasks required in the educational process; these may vary according to educational level but include judgments on the ability to learn and generate knowledge. According to Honicke and Broadbent (2016), academic self-efficacy has positive correlations with Academic Achievement, whether it is assessed through self-reporting or through official measures; however, this relationship might be mediated by the formulation of prior goals, self-regulation, metacognition, procrastination, discipline, and other cognitive strategies of the students; also, this relationship seems to be moderated by emotional intelligence, neuroticism, and the time spent on a task. Furthermore, academic self-efficacy seems to interact with self-regulated learning and feedback utilization in students. Active use of feedback and confidence in one's abilities increase the level of academic achievement (Brown et al., 2016). Other research shows that academic self-efficacy contributes to academic achievement, although, like the ones mentioned before, it does so indirectly. It is proposed that the effect of academic self-efficacy is mediated by the beliefs related to the expected value of the course that students hold (Doménech-Betoret et al., 2017). While the direct effect of self-efficacy on academic achievement is not always present, the expectations about the outcome seem to be (McBride et al., 2020).

Academic self-efficacy is not only a predictor but can also be affected by various variables. For instance, it appears to be affected by gender: men exhibit higher self-efficacy than women even when academic achievement is the same for both (Marshman et al., 2018). Additionally, situations that allow for proactivity in learning increase the sense of autonomy, motivation, and, ultimately, self-efficacy for engaging with new content (Hatlevik et al., 2018). Furthermore, the use of self-assessment strategies during learning is beneficial for the development of self-efficacy. Monitoring progress allows students to clarify the aspects in which they have become more competent (Panadero et al., 2017). It is also suggested that prior experience in the field of study, achievement of high grades, course structure, and classroom climate are also related to greater self-efficacy (McBride et al., 2020).

According to Baker (2017), during university education, self-efficacy must also encompass judgments for generating knowledge through research. And, just as with academic self-efficacy, students who participate more in research exhibit higher levels of research-related self-efficacy and also Academic Achievement; additionally, there is higher research-related self-efficacy in students who belong to STEM fields, likely because research-related tasks are more frequent in these disciplines.

Likewise, according to Seng et al. (2020), these differences can also be seen based on gender, year of study, and work experience. Similar to academic self-efficacy, men exhibited a higher level of self-efficacy for research than women (Seng et al., 2020); in addition, there are differences in the level of self-efficacy according to the field of study, which could be explained by the lower demand for quantitative or computational skills in fields such as the humanities.

The effect of self-efficacy in academic activity is not limited to higher academic achievement. This variable can also affect the perception of demands, and may enhance coping capabilities when eudaimonic well-being is high (Freire et al., 2019). Furthermore, self-efficacy correlates with more positive attitudes towards research modules during university studies (West and Meier, 2019). It can also reduce anxiety during the writing tasks associated with academic stage research (Huerta et al., 2017). However, in the absence of other personal resources, it can be detrimental as it reduces students' motivation to prepare adequately (Freire et al., 2019), and may even increase the negative effect of procrastination on academic performance (Honicke and Broadbent, 2016).

Strategies to increase self-efficacy are particularly useful when linked to the educational plan (Klassen and Klassen, 2018). Hence, the proposal of research practice as a strategy to increase academic self-efficacy arises. In this regard, Course-Based Undergraduate Research Experiences [CUREs] are proposed as a means to circumvent barriers linked to research during the academic stage and to create opportunities for engaging students in research from introductory levels (Bangera and Brownell, 2014). These learning experiences differ from traditional "workshops" or "laboratories" where the outcome is already known. They involve a mentor teacher, social support from peers, and encourage the development of self-efficacy in students. In these courses, a class of students approaches a research question or problem with unknown solutions or results that are of interest to external individuals (Dolan, 2016). Nonetheless, further research is needed to explore the effect of participation in these specific programs on self-efficacy and academic achievement (Ballen et al., 2018). It is also advisable to promote research in teachers, for their role as moderators of academic research; and in students, to be able to increase self-efficacy in activities related to the creation of knowledge (Seng et al., 2020).

Astrobiology-Oriented Stratospheric Balloon Launches

Experimental astrobiology studies at high altitudes can examine topics such as the limits of the biosphere, habitable atmospheres, extremophilic organisms, rapid evolution, intra- and interplanetary dispersal, contamination control, and planetary protection (Smith, 2013). Additionally, potential medical and public health implications point to the need for more detailed studies on microbial transport through the atmosphere and research into mechanisms related to their survival (DasSarma and DasSarma, 2018).

For these reasons, the necessity of developing tools for experimentation in the high atmosphere through a variety of sampling platforms is emphasized. One tool that allows access to this environment is stratospheric balloons. In comparison to airplanes, which can inspect small areas of land in great detail, and satellites, which cover the entire globe but provide images at much lower resolutions, stratospheric balloons are in a middle ground, offering quality imagery over larger areas than those shown by airplanes (Witze, 2018). The mission design for balloon launches is divided into three main areas (Gai et al., 2014):

1. Design and planning of the mission, including the development of a trajectory simulator.
2. Development and integration of the payload.
3. Flight segment (the balloon-parachute system and its interfaces with other systems).

The payloads of stratospheric balloons can carry instruments to measure atmospheric variables (temperature, relative humidity, and wind direction) or a video camera to capture images during the journey. After the balloon bursts, the payload falls to the ground slowly due to the activation of a parachute (Gai et al., 2014).

According to Walker et al. (2010), the design, development, and construction of hardware and software systems related to studies in the upper atmosphere and space have proven to be a very powerful educational tool. This is why various programs are conducted that are oriented toward the use of stratospheric experimentation tools.

One such program is HARP, which provides an engaging laboratory, offers challenging field experiences in science, technology, engineering, and mathematics (STEM), reaches students from diverse backgrounds, encourages collaboration among science teachers, and provides a quantitative assessment of learning outcomes (Voss et al., 2011).

The Balloon High-Altitude Research Platform (HARP) allows students to learn the scientific method, practical skills, engineering principles, atmospheric variables and structure, as well as to provide physical knowledge, apply data analysis skills, and documentation (Voss et al., 2011).

As an alternative to costly orbital launches, HASP (The High Altitude Student Platform) emerged. This program operates as a partnership and has received collaboration from the Louisiana Space Consortium, NASA, Balloon Program Office (BPO), Columbia Scientific Balloon Facility (CSBF), and with the support of the Louisiana Board of Regents (Guzik, 2015).

The HASP program proposes the creation of a multi-platform to engage students in science, mathematics, engineering, and technology, as there was a decrease in the number of students in the U.S. around mid-2005.

The HASP system currently has a routine for launching that begins, during the first two days, with a review of the student balloon's equipment. Then, on the third day, students install their payloads into a thermal/vacuum chamber, which simulates some atmospheric conditions to detect potential failures. Students have four days to review and fix their payloads. After that, a general review of the HAPS systems and the balloon is conducted, and the students' payloads are assembled. On the day of the launch, all systems are checked again, followed by the inflation of the balloon with 11 million cubic feet of helium, which takes about 35 to 40 minutes. The HASP flight reaches an altitude of 36km and takes about 12 hours for its entire journey (Guzik, 2015).

The ESA Education Office was established in 1998 with the purpose of motivating young people to study Science, Engineering, and Technology subjects and to ensure a skilled workforce for ESA and the European space sector in the future. They have conducted experiments such as “Sounding rockets & balloon experiments,” giving students opportunities for experiments with rocket and stratospheric balloon launches (Walker et al., 2010).

The Educational Projects Division and the University of Porto (Portugal) develop the STRAtospheric PLatform EXperiment (STRAPLEX) program, which provides European students with the opportunity to conduct experiments using stratospheric balloons. These can be customized according to the needs of the experiment to be performed and are always accompanied by a digital camera that films the ascent, along with telemetry equipment to measure environmental conditions as it ascends (Pont, 2006).

The University of North Dakota has developed solar balloons, which could reduce the use of helium to zero, given that helium tends to be quite expensive. These balloons harness the sun’s energy to heat the gases inside, creating lift due to the difference in densities. This temperature difference is achieved because the balloon’s surface is dark-colored, promoting greater heat absorption; the material used is a polyethylene plastic sheet, and they can be constructed in various ways, even with geometric designs. The disadvantages include the need for clear skies so that a greater amount of solar rays can contact the surface, heating the balloon walls and allowing the gas inside to expand (Nordlie et al., 2014).

In Peru, the Peruvian Association of Astrobiology (ASPAST) conducts astrobiological-focused stratospheric balloon launches through the “Stratosphere Project.” This research aims not only to evaluate the effects the stratosphere has on different life forms, particularly extremophiles, but also to assess the positive effects that a transdisciplinary research project has on the members of this institution, as demonstrated in Chon-Torres et al. (2024). The members of ASPAST are primarily university students from various universities in the country, representing different specialties. The existing interest among university youth in scientific research on life in the universe (Chon-Torres et al., 2020) is leveraged to promote scientific leadership and academic self-efficacy.

Despite the growing recognition of the benefits of hands-on scientific research in higher education, there is still limited empirical evidence on the specific impact of transdisciplinary research projects on students’ academic self-efficacy. This study aims to bridge this gap by analyzing the effects of participation in an astrobiological research initiative on students’ confidence in their academic abilities. The problem addressed in this study revolves around the need to identify effective educational strategies that enhance self-efficacy among university students, particularly in STEM fields, where research participation plays a crucial role in professional development. The sub-problems examined include understanding the extent to which participation in a high-impact, collaborative research project influences students’ academic self-efficacy, and whether this effect varies based on factors such as gender and type of university (public vs. private).

Astrobiology is a transdisciplinary science, integrating knowledge from natural sciences, engineering, and social sciences, providing an ideal platform for fostering collaborative and interdisciplinary learning. The opportunity for ASPAST members to engage with diverse domains of knowledge enhances not only their scientific competencies but also their ability to navigate complex academic and research challenges. By evaluating the impact of this initiative, the study contributes to the broader literature on academic self-efficacy and experiential learning, offering insights into how similar research-based educational models can be implemented in other scientific fields and institutional contexts.

MATERIALS AND METHODS

Research Design

The study was quantitative and cross-sectional, following a quasi-experimental design with a non-equivalent control group, including pretest and posttest measurements.

The research design is summarized in **Table 1**.

Table 1. The research design

Groups	Pretest	Treatment	Posttest
Experimental group (They participated in the launch on-site)	Level of self-efficacy in formative research.	Full participation in the educational astrobiology project involving the launch of stratospheric balloons.	Level of self-efficacy in formative research.
Control group (They participated in the sessions but did not attend the launch)	Level of self-efficacy in formative research.	Participation only in the training phase of the educational astrobiology project involving the launch of stratospheric balloons.	Level of self-efficacy in formative research.

Table 2. Distribution of students by participation and type of university

Type of university	Did you attend the launch in person?					
	No		Yes		Total	
	Frequency	%	Frequency	%	Frequency	%
Private	8	26.7	22	73.3	30	100
Public	44	35.5	80	64.5	124	100
Total	**52**	**33.8**	**102**	**66.2**	**154**	**100**

Table 3. Distribution of students by participation and area of undergraduate studies specialization

Area of undergraduate studies specialization	Did you attend the launch in person?					
	No		Yes		Total	
	Frequency	%	Frequency	%	Frequency	%
Agricultural Sciences	2	18.2	9	81.8	11	100
Basic Sciences	24	40.0	36	60.0	60	100
Health Sciences	0	0.0	5	100	5	100
Economic and Financial Sciences	0	0.0	2	100.0	2	100
Humanities	1	50.0	1	50.0	2	100
Engineering	25	33.8	49	66.2	74	100
Total	**52**	**33.8**	**102**	**66.2**	**154**	**100**

Study Subjects

The study involved 154 university students, with the sample size determined at a 95% confidence level and a 7.5% margin of error, distributed between the experimental and control groups. Both groups consisted of undergraduate students from Metropolitan Lima.

An open call was issued for university students from Metropolitan Lima. The selection process filtered candidates based on specific criteria, including being of legal age, being enrolled as undergraduate students in universities within Metropolitan Lima, and having the availability to attend the project sessions. A total of 154 students were selected and divided into four groups. Each group participated in four training sessions focused on the launch of stratospheric balloons, covering probe design, basic telemetry knowledge, and active involvement in subgroups responsible for different aspects of the project.

Each subgroup was tasked with selecting and preparing a biological or material sample for launch. In general, participants chose to send tardigrades, onion roots, minerals, and seeds. The project concluded with a field expedition for the actual balloon launch. All activities took place between 2023 and 2024, with the training sessions conducted at the University of Lima and the balloon launches carried out in Ica, a region located south of Lima.

Students in both groups completed the Self-Efficacy Scale for Formative Research, administered before and after the launch. The selected students actively participated in the astrobiology educational project, which involved launching stratospheric balloons in the Ica Desert, Peru, approximately 310 km south of Lima.

Table 2 shows the distribution of students based on whether they attended a launch event in person, with data differentiated between private and public universities. **Table 2** presents the frequency and percentage of participation in each case. In private universities, out of a total of 30 students, 8 (26.7%) did not attend in person, while 22 (73.3%) did. In public universities, out of 124 students, 44 (35.5%) did not participate, whereas 80 (64.5%) attended in person. Overall, out of 154 students, 52 (33.8%) did not participate in person in the launch event, while 102 (66.2%) did. All percentages are rounded to the nearest tenth.

Table 3 illustrates the in-person participation of students in a launch event, segmented by their area of specialization. A high attendance rate was observed in the Health Sciences and Economic and Financial Sciences fields (100%), while Humanities showed a lower attendance rate (50%). Overall, 66.2% of the students participated in person.

Table 4 presents the distribution of students who attended the event in person, categorized by gender. 59.6% of women and 69.6% of men attended the launch. Overall, 66.2% of the students participated in person.

Table 5 shows the in-person attendance of students at a launch event, categorized by undergraduate study cycle. The cycles with the highest attendance are VII and VIII, with over 80% participation. The average in-person participation across all cycles is 66.2%.

Table 4. Distribution of students by participation and gender

Gender	Did you attend the launch in person?					
	No		Yes		Total	
	Frequency	%	Frequency	%	Frequency	%
Female	21	40.4	31	59.6	52	100
Male	31	30.4	71	69.6	102	100
Total	**52**	**33.8**	**102**	**66.2**	**154**	**100**

Table 5. Distribution of students by participation and undergraduate study cycle

Undergraduate study cycle	Did you attend the launch in person?					
	No		Yes		Total	
	Frequency	%	Frequency	%	Frequency	%
I	2	66.7	1	33.3	3	100
II	4	50.0	4	50.0	8	100
III	9	34.6	17	65.4	26	100
IV	10	45.5	12	54.5	22	100
IX	8	32.0	17	68.0	25	100
V	4	21.1	15	78.9	19	100
VI	6	46.2	7	53.8	13	100
VII	2	18.2	9	81.8	11	100
VIII	2	16.7	10	83.3	12	100
X	5	33.3	10	66.7	15	100
Total	**52**	**33.8**	**102**	**66.2**	**154**	**100**

Table 6. The nine items that make up the self-efficacy scale

No	Items	Never	Sometimes	Quite Often	Always
1	I consider myself sufficiently capable of successfully facing any academic task.	0	1	2	3
2	I think I have the ability to understand a subject well and quickly.	0	1	2	3
3	I feel confident in tackling situations that test my academic ability.	0	1	2	3
4	I am convinced that I can achieve good results in exams.	0	1	2	3
5	I don't mind if professors are demanding and strict because I trust my own academic ability.	0	1	2	3
6	I believe I am a skilled and competent person in my academic life.	0	1	2	3
7	If I set my mind to it, I believe I have enough ability to achieve a good academic record.	0	1	2	3
8	I think I can pass courses quite easily and even get good grades.	0	1	2	3
9	I believe I am prepared and capable of achieving many academic successes.	0	1	2	3

Data Collection Technique and Instrument

The data collection technique used was a random sampling survey. The data collection instrument employed was the Perceived Self-Efficacy Scale for Specific Academic Situations (EAPESA) (Dominguez Lara, 2014; Dominguez-Lara and Fernández-Arata, 2019), which has been previously tested in a university population in Metropolitan Lima.

This is a self-report instrument based on the self-efficacy scale for formative research. The scale consists of nine items and is generally unidimensional. Each item represents a thought (perception or belief) about the individual's ability to conduct research based on their participatory experience in the Stratosphere Project. Participants indicate their level of certainty regarding each statement.

The response options for each item are:

- "Never" (0)
- "Sometimes" (1)
- "Quite often" (2)
- "Always" (3)

The nine items that make up the self-efficacy scale are presented in **Table 6**.

Table 7. Results of the KMO index and Bartlett's test

KMO measure of sampling adequacy		**0.911**
Bartlett's test of sphericity	Approximate Chi-square	665.57
	Degrees of freedom	36
	p-value	0.000

Table 8. Results of factor loadings for self-efficacy items

	Factor 1
I consider myself sufficiently capable of successfully facing any academic task.	0.786
I think I have the ability to understand a subject well and quickly.	0.641
I feel confident in tackling situations that test my academic ability.	0.788
I am convinced that I can achieve good results in exams.	0.746
I don't mind if professors are demanding and strict because I trust my own academic ability.	0.697
I believe I am a capable and competent person in my academic life.	0.784
If I set my mind to it, I believe I have the ability to achieve a good academic record.	0.728
I think I can pass courses quite easily and even get good grades.	0.721
I believe I am prepared and capable of achieving many academic successes.	0.822

Table 9. Results of reliability level if the self-efficacy instrument item is removed

Item	**Corrected Item - Total Correlation**	**Cronbach's alpha if item is deleted**
I consider myself sufficiently capable of successfully facing any academic task.	0.708	0.884
I think I have the ability to understand a subject well and quickly.	0.560	0.895
I feel confident in tackling situations that test my academic ability.	0.712	0.884
I am convinced that I can achieve good results in exams.	0.668	0.888
I don't mind if professors are demanding and strict because I trust my own academic ability.	0.618	0.893
I believe I am a capable and competent person in my academic life.	0.708	0.884
If I set my mind to it, I believe I have the ability to achieve a good academic record.	0.646	0.889
I think I can pass courses quite easily and even get good grades.	0.637	0.890
I believe I am prepared and capable of achieving many academic successes.	0.755	0.881

Validity and Reliability of the Instrument

To determine the construct validity of the self-efficacy scale, factor analysis was conducted to reduce the number of items in the instrument and extract the appropriate factors. Since the self-efficacy scale is unidimensional, it was expected to extract a single factor from the factor analysis.

According to Hair et al. (1999), prior to factor extraction, the sample adequacy was assessed using the Kaiser-Meyer-Olkin (KMO) index, and multicollinearity among items was evaluated through Bartlett's test of sphericity.

In **Table 7**, it was observed that the KMO index reached a value of 0.911, which is very close to the maximum value of 1, indicating that the sample is suitable for factor analysis. Meanwhile, Bartlett's test showed a significant result ($p < 0.05$), demonstrating multicollinearity among the items that make up the self-efficacy scale.

According to the results in **Table 8**, the self-efficacy scale items were grouped into a single factor, which explained 55.92% of the total variance, confirming the unidimensionality of the scale. Subsequently, the factor loadings of the extracted factor with the items were determined. The factor loadings results in **Table 8** showed that all nine items of the self-efficacy scale achieved a correlation above 0.5. These findings demonstrated that the self-efficacy measurement instrument has construct validity.

A reliability analysis of the self-efficacy scale was conducted using Cronbach's alpha to assess internal consistency among items. The reliability level achieved was 89.9%, leading to the conclusion that the self-efficacy scale has adequate reliability, according to Hernandez Sampieri et al. (2014).

The reliability analysis was complemented with an item-by-item analysis, which showed that removing any item from the instrument does not result in a significant change in the estimated reliability level. **Table 9** summarizes the correlations of each item with the total score and the reliability level achieved when an item is removed.

Most of the corrected total correlation values are high (above 0.5), suggesting that the items are well-aligned with the overall construct of academic self-efficacy and, therefore, no item needed to be removed. Furthermore, if any item were removed from the scale, the reliability level would never exceed 89.9%.

Additionally, since the second item showed the lowest correlation, its impact on Cronbach's alpha was analyzed. However, removing this item did not increase the reliability index above 0.899.

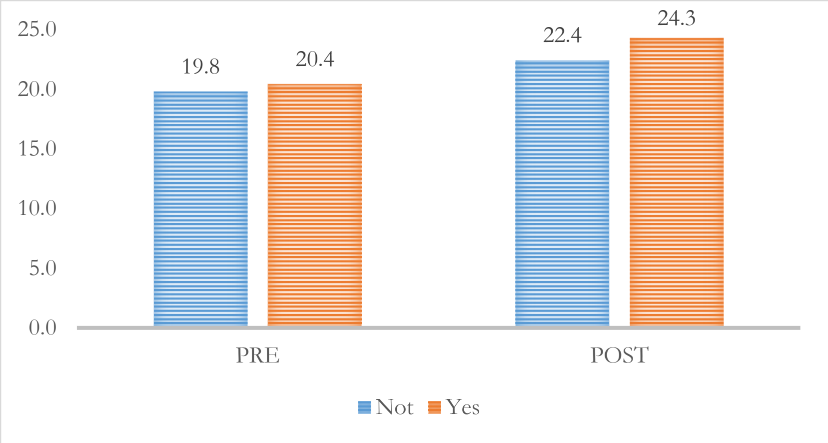

Figure 1. Self-efficacy level before and after the launch of students who did and did not participate in the launch

Table 10. Results of the Kolmogorov-Smirnov normality test for self-efficacy data before and after the launch

Measures		**Self-efficacy PRE**	**Self-efficacy POST**
Normal parameters	Mean	20.22	23.66
	Standard deviation	4.542	3.770
Test statistic		0.090	0.207
Asymptotic significance (two-tailed)		0.004	0.000

Table 11. Self-efficacy level before and after the launch by participation in the launch

Participation in the launch	**Self-efficacy level**		**Wilcoxon test**		**Friedman test**	
	PRE	**POST**	**Statistics**	**p-value**	**Statistics**	**p-value**
No	19.8	22.4	3.405	0.001	13.889	0.000194
Yes	20.4	24.3	7.311	0	66.176	0

RESULTS

For each self-efficacy indicator (a total of nine), the percentages of students who participated in the launch event and reported different levels of self-efficacy before and after the event were calculated. The majority of the indicators showed an increase in the frequency of reporting the highest level of self-efficacy ("Always") in the post-event period.

For example, for the indicator related to successfully handling academic tasks, the percentage of students reporting "Always" increased from 37.3% to 69.6% from the pre-event to the post-event measurement.

Similarly, the percentage change in self-efficacy was analyzed for students who did not participate in the launch event, before and after the event, across all nine self-efficacy indicators. All categories exhibited post-event variations, with some showing significant differences. For instance, in the confidence to face academic tasks indicator, the percentage of students reporting "Always" feeling capable increased from 30.8% to 48.1%.

Figure 1 compares the average self-efficacy level of students before and after a launch event, distinguishing between those who participated and those who did not. The data show an increase in self-efficacy for both groups—those who attended (Yes) and those who did not attend (No) the launch. However, the post-event increase was greater among the students who participated in the balloon launch.

Table 10 presents the results of the Kolmogorov-Smirnov normality test for the data before and after the balloon launch. Since the test was significant in both cases ($p\text{-value} < 0.05$), the null hypothesis of normality was rejected. Consequently, the data were analyzed using non-parametric tests, which are appropriate for data that do not follow a normal distribution.

Table 11 shows that student participation in the balloon launch has a positive effect on self-efficacy, as self-efficacy levels increase after the launch. Furthermore, according to Wilcoxon and Friedman statistical tests, this effect is significant ($p\text{-value} < 0.05$).

For students who did not participate in the launch but did receive the training, a significant effect was also observed, although the impact was lower compared to students who did participate in the launch.

Table 12. Self-efficacy level before and after the launch by participation and type of home university

Type of university	Participation in the launch			
	No		Yes	
	PRE	POST	PRE	POST
Private	20.3	23.0	21.4	24.9
Public	19.7	22.3	20.2	24.1

Table 13. Fisher's repeated measures ANOVA for students who participated in the launch with the type of university factor

Source	Sum of squares	df	Mean square	F	p-value
Intercept	70,703.575	1	70,703.575	2,948.031	0.000
Type of university	32.046	1	32.046	1.336	0.250
Error	2,398.332	100	23.983		

Table 14. Self-efficacy level before and after the launch by participation and gender

Gender	Participation in the launch			
	No		Yes	
	PRE	POST	PRE	POST
Female	18.8	22.7	20.8	24.1
Male	20.5	22.2	20.3	24.4

Table 15. Fisher's repeated measures ANOVA for students who participated in the launch with the gender factor

Source	Sum of squares	df	Mean square	F	p-value
Intercept	86,495.842	1	86,495.842	3,560.094	0.000
Gender	0.783	1	0.783	0.032	0.858
Error	2,429.594	100	24.296		

Table 12 shows the variation in self-efficacy levels among students from private and public universities, before and after a launch event, segmented by their participation. An increase in self-efficacy levels is observed across all groups after the event, with a more pronounced effect among those who participated, regardless of the type of university.

To determine whether the type of university attended by the student who participated in the launch had a significant effect on their self-efficacy, Fisher's repeated measures analysis of variance (ANOVA) was applied (pre- and post-launch). The results in **Table 13** indicated that the type of university did not have a significant effect (p-value > 0.05) on self-efficacy.

Table 14 shows changes in self-efficacy levels before and after the launch, broken down by gender and participation. In all cases, self-efficacy levels increase after the launch, with slightly greater increases observed in women who did not participate and men who did participate.

To determine whether the gender of the student who participated in the launch had a significant effect on their self-efficacy, Fisher's repeated measures analysis of variance (ANOVA) was applied (pre- and post-launch). The results in **Table 15** indicated that gender did not have a significant effect (p-value > 0.05) on self-efficacy.

DISCUSSION OF RESULTS

The results obtained in this study confirm the hypothesis that participation in transdisciplinary research projects, such as the launch of stratospheric balloons with an astrobiological focus, increases academic self-efficacy in university students. This finding is consistent with previous studies suggesting that participation in applied research experiences enhances confidence in one's academic abilities (Ballen et al., 2018; Bangera and Brownell, 2014; Dolan, 2016). In particular, Bangera and Brownell (2014) argue that course-based undergraduate research experiences (CUREs) can make scientific research more inclusive and accessible, a key aspect considering that the participants in this study came from both public and private universities.

The significant increase in academic self-efficacy levels after the project reinforces Bandura's theoretical framework on self-efficacy (Hatlevik et al., 2018; McBride et al., 2020), which states that direct experience in a challenging and cognitively demanding activity strengthens beliefs in one's learning abilities. This result also aligns with research highlighting that self-efficacy not only predicts academic performance but is also influenced by participation in meaningful academic experiences (Doménech-Betoret et al., 2017; Honicke and Broadbent, 2016).

The finding that students who did not directly participate in the launch also showed an increase in self-efficacy suggests that indirect exposure to research projects can also generate benefits, albeit to a lesser extent. This phenomenon could be explained through vicarious learning, where observing others successfully perform a task enhances confidence in one's ability to perform similar tasks (Bandura, 1997). Similar results have been reported in studies on self-efficacy in scientific research, where participation in collaborative environments fosters academic confidence (West and Meier, 2019).

A relevant aspect is that no significant differences were found in the increase in self-efficacy based on the type of university (private or public). This finding is significant in the Peruvian context, where perceptions of educational quality may vary between institutions. However, our results suggest that well-designed practical experiences can benefit students equitably, regardless of the institutional environment. Previous research has suggested that access to research opportunities is a key factor in academic self-efficacy (McBride et al., 2020; Seng et al., 2020), reinforcing the importance of initiatives like the one developed in this study.

Finally, the absence of significant gender differences suggests that the positive impact of participation in research projects is not conditioned by this variable. However, previous studies have reported differences in self-efficacy between genders in certain STEM fields (Marshman et al., 2018; Seng et al., 2020). The present research suggests that self-efficacy in research could be strengthened equally in men and women when they are provided with equitable participation in practical research experiences.

These findings reinforce the importance of incorporating practical experiences into university education, not only as a teaching strategy but also as a mechanism for strengthening students' academic confidence. Future research could explore the sustainability of these effects over time and their impact on students' career choices in research or the development of professional skills.

Percent Distribution of Student Participants in the Launch by Self-Efficacy Indicator

The exploratory analysis reveals significant data about the perceived self-efficacy of students participating in a launch event, before and after the event. The percent distribution of responses to different self-efficacy indicators shows a clear trend: following the event, there is a notable increase in the students' confidence in their academic abilities. Specifically, the proportion of students who always consider themselves capable of successfully facing academic tasks soars from 37.3% in the pre-test to 69.6% in the post-test. Similarly, those confident in quickly understanding subjects rise from 40.2% to 70.6%. This trend is replicated across all statements related to the ability to face academic challenges, cope with teaching demands, and achieve academic success, where an increase in the "Always" category in the post-test is observed. This shift suggests that the launch event had a positive impact on students' self-assessment regarding their academic competence.

It could be inferred that the event provided experiences or information that reinforced the students' belief in their ability to succeed academically, which is crucial for motivation and future academic performance. Additionally, the fact that the percentage of students who never considered themselves capable remained at 0.0% is encouraging, indicating that even before the event, none of the students felt completely incapable in the academic realm. It is crucial to highlight that such self-perceptions are critical elements in academic learning and development, as self-efficacy can influence persistence in the face of challenges and resilience in the face of failures. The results possibly suggest that initiatives like this can be valuable tools for improving not only self-efficacy but also potentially academic performance.

Percent Distribution of Non-Participant Students in the Launch by Self-Efficacy Indicator

The same exploratory analysis shows the perceived self-efficacy by university students who did not participate in the stratospheric balloon launch, both before (pre) and after (post) the event. Overall, there is an increase in the perception of one's own ability after the launch in various self-efficacy indicators. For example, confidence in successfully facing academic tasks rose from 30.8% to 48.1% in the "Always" category. In addition, the proportion of students feeling they have the ability to quickly understand a subject increased from 30.8% to 53.8%. These changes suggest that even observing an academic event like a launch can have a positive impact on students' self-efficacy.

Level of Self-Efficacy Before and After the Launch of Students Who Did and Did Not Participate in the Launch (**Figure 1**). **Figure 1** illustrates an increase in the level of self-efficacy for both students who participated (Yes) and those who did not participate (No) in the stratospheric balloon launch. Before the launch, self-efficacy levels were lower for both groups, but after the event, a significant increase is observed. The change is more pronounced in students who directly participated in the launch, suggesting that the direct experience of the event had a stronger impact on their perception of self-efficacy. This supports the notion that active participation in practical projects can strengthen students' beliefs about their academic capabilities.

Level of Self-Efficacy Before and After the Launch According to Participation in the Launch (Table 11)

Table 11 shows that for both students who did not participate in the launch but received training (No), and those who did participate (Yes), there was a significant increase in the level of self-efficacy post-event. The results of the Student's T-tests, Wilcoxon, and Friedman indicate statistical significance in both groups, but there is a notable difference in the magnitude of the effect. For non-participants, the self-efficacy level increased from 19.8 to 22.4, while for participants, the increase was from 20.4 to 24.3. This increase is statistically significant in both cases, but the effect is greater for those who participated, as shown by the higher statistics in the applied tests. The statistical significance (p-value < 0.05) in all three tests suggests that the observed change is not random but attributable to the launch experience. The direct experience, in the case of the participants, had a deeper impact on their perceived self-efficacy in academic settings compared to those who only received training. This underlines the importance of practical experience in the development of academic self-efficacy, reinforcing students' beliefs in their ability to successfully engage in research and complex learning activities.

Level of Self-Efficacy Before and After the Launch According to Participation and Type of University of Origin (Table 13)

Table 13 presents comparative data on the level of self-efficacy in students from private and public universities, both before (PRE) and after (POST) their participation in a stratospheric balloon launch. The data suggest an increase in self-efficacy in all groups after the event. For private universities, those students who did not participate in the launch had an increase in self-efficacy from 20.3 to 23.0, while those who did participate had an increase from 21.4 to 24.9. In public universities, the increase was from 19.7 to 22.3 for non-participants and from 20.2 to 24.1 for participants. Although there is a statistically significant increase in self-efficacy across all groups, the differences in percentage points between participants and non-participants range between 2% and 3.5%, suggesting a moderate effect rather than a pronounced one.

This pattern aligns with previous research indicating that hands-on participation in research projects enhances academic self-efficacy, though the magnitude of change can vary (Ballen et al., 2018; Bangera and Brownell, 2014; Doménech-Betoret et al., 2017). Studies have demonstrated that experiential learning fosters self-efficacy by providing opportunities for mastery experiences, a key factor identified in Bandura's self-efficacy theory (Maddux, 2013). Furthermore, McBride et al. (2020) emphasize that participation in STEM research experiences has been linked to increased academic confidence and persistence, reinforcing the importance of integrating such activities into university education.

These findings suggest that participation in research activities like stratospheric balloon launches positively influences students' academic self-efficacy, regardless of their university type. While the effect size in this study is moderate, it is consistent with prior literature indicating that applied research experiences contribute to students' academic development by reinforcing their belief in their ability to conduct scientific inquiry (West and Meier, 2019; Dolan, 2016). Future research should explore the long-term impacts of such experiences on students' academic performance and career trajectories.

This pattern aligns with previous research indicating that hands-on participation in research projects *Fisher's Analysis of Variance of Repeated Measures for Students Who Did Participate in the Launch with the Type of University Factor (Table 13).*

Fisher's Analysis of Variance (ANOVA) for repeated measures indicates that, for students who participated in the stratospheric balloon launches, the type of university of origin (private or public) did not significantly influence their academic self-efficacy. This result is supported by the p-value (0.250) associated with the "Type of University" factor, which is above the common threshold of 0.05 for statistical significance. In Table 13, the "Intercept" has a very high F-value (2948.031) with an almost nil p-value (0.000), indicating that the overall mean of self-efficacy is significantly different from zero, which is expected.

However, the sum of squares associated with the "Type of University" is relatively low (32.046) and its corresponding F (1.336) is not sufficient to reach a level of significance, as reflected by the p-value of 0.250. This analysis suggests that interventions such as participation in stratospheric balloon projects can be equally effective in improving self-efficacy in students, regardless of whether they come from private or public higher education institutions. The "Mean Square" within the "Error" provides a measure of the variability within the groups of students, which is also considered in the ANOVA analysis to understand the dispersion of the data.

Self-Efficacy Level Before and After the Launch by Participation and Gender (Table 15)

Table 15 displays the levels of self-efficacy measured before and after the launch of stratospheric balloons, broken down by gender and participation in the launch. The results indicate an increase in self-efficacy in all groups after the launch experience. For women who did not participate in the launch, there was an increase from 18.8 to 22.7 in their level of self-efficacy, while those who did participate showed an increase from 20.8 to 24.1. In the case of men, those who did not participate in the launch experienced an increase from 20.5 to 22.2, and those who did participate saw an increase from 20.3 to 24.4.

It is noteworthy that both men and women who participated in the launch experienced similar increases in their self-efficacy (3.3 points for women and 4.1 points for men). However, an unexpected finding is the relatively high increase in self-efficacy among women who did not participate in the launch (3.9 points), surpassing even the increase observed in some participant groups. This suggests that factors beyond direct participation in the launch may have influenced their perceived self-efficacy.

One possible explanation is the vicarious learning effect, where observing peers engage in challenging academic and research-oriented tasks can enhance one's own self-efficacy (Bandura, 1997). This aligns with previous studies suggesting that role models and social learning environments can play a crucial role in fostering self-efficacy, particularly among underrepresented groups in STEM (Seng et al., 2020; West and Meier, 2019). Additionally, the preparatory training phase may have provided indirect exposure to the core aspects of the research project, equipping these students with a greater sense of academic capability despite their non-participation in the launch itself.

The data also suggest that although women started with a lower level of self-efficacy before the launch compared to men, both direct and indirect engagement with the project benefited them, contributing to a reduction in the gender gap in post-launch self-efficacy. This could imply that hands-on experiences in STEM contexts like this project can be particularly valuable for increasing self-efficacy in female students, as well as offering similar benefits to male students. Future research could explore the specific mechanisms behind vicarious learning and indirect participation in research projects to better understand their impact on self-efficacy development.

Fisher's Analysis of Variance of Repeated Measures for Students Who Did Participate in the Launch with the Gender Factor (Table 15)

Fisher's Analysis of Variance (ANOVA) for repeated measures indicates that the gender of the student who participated in the stratospheric balloon launch does not have a significant effect on the change in their academic self-efficacy. This is based on the p-value (0.858) associated with the "Gender" factor, which is well above the commonly accepted threshold of 0.05 for statistical significance. The details of **Table 15** show that the "Sum of Squares" for gender is insignificant (0.783) with a very low F-value (0.032), meaning the differences in self-efficacy due to gender are statistically non-significant.

Therefore, participation in the stratospheric balloon launch project had a positive effect on students' self-efficacy without significant differentiation between men and women. The value of the "Mean Square" within the "Error" provides a measure of the internal variability among the students, which is small and therefore reinforces the conclusion that gender is not a differentiating factor in the effect of the project on self-efficacy.

CONCLUSIONS

1. The study achieved its objective of evaluating the effect of a stratospheric balloon project with astrobiological purposes on the academic self-efficacy of university students. The data shows a significant increase in self-efficacy in both students who participated directly in the project and those who did not, although it was more notable in the participants. This indicates that practical experience in transdisciplinary research projects is effective in improving academic self-efficacy.
2. The study also found that participation in practical projects increases students' confidence in their academic abilities. No significant differences were found in changes in self-efficacy based on gender or type of university (public or private), indicating that the project experience was beneficial for all students in a similar manner.
3. For future studies, it would be interesting to explore the long-term impact of participation in transdisciplinary research projects on students' academic and professional trajectories. It would also be valuable to investigate how these practical experiences could influence other aspects of student development, such as leadership skills, teamwork, and creativity, and how these effects vary across different fields of study and educational contexts.

ACKNOWLEDGEMENTS

This study was fully funded by the Universidad de Lima, Peru. The complete financial backing provided by the University has been instrumental in all stages of this project, from conception to execution.

REFERENCES

Baker, T. N. (2017). *The impact of undergraduate research participation on research self-efficacy* (PhD dissertation). Boca Raton, (FL): Florida Atlantic University.

Ballen, C. J., Thompson, S. K., Blum, J. E., Newstrom, N. P. and Cotner, S. (2018). Discovery and broad relevance may be insignificant components of course-based undergraduate research experiences (CUREs) for non-biology majors. *Journal of Microbiology & Biology Education*, 19(2). https://doi.org/10.1128/jmbe.v19i2.1515

Bandura, A. (1997). *Autoeficacia: El ejercicio del control.* WH Freeman/Times Books/Henry Holt & Co.

Bangera, G. and Brownell, S. E. (2014). Course-based undergraduate research experiences can make scientific research more inclusive. *CBE–Life Sciences Education*, 13(4), 602–606. https://doi.org/10.1187/cbe.14-06-0099

Brown, G. T. L., Peterson, E. R. and Yao, E. S. (2016). Student conceptions of feedback: Impact on self-regulation, self-efficacy, and academic achievement. *British Journal of Educational Psychology*, 86(4), 606–629. https://doi.org/10.1111/bjep.12126

Chon-Torres, O. A. (2018). Disciplinary nature of astrobiology and astrobioethic's epistemic foundations. *International Journal of Astrobiology*, 20(3), 186–193. https://doi.org/10.1017/S147355041800023X

Chon-Torres, O. A., Macassi Zavala, D. A., Ramos Ramirez, J. C., Santos Jimenez, O. C., Lazarte Oyague, S. E. and Murga-Moreno, C. A. (2024). Transdisciplinary contributions in undergraduate university students through a stratospheric balloon project with an astrobiological focus. *International Journal of Astrobiology*, 23, e7. https://doi.org/10.1017/S1473550424000028

Chon-Torres, O. A., Ramos Ramírez, J. C., Hoyos Rengifo, F., Choy Vessoni, R. A., Sergo Laura, I. S., Ríos-Ruiz, F. G. A., Murga-Moreno, C. A., Alvarado Pino, J. P. L. and Yance-Morales, X. (2020). Attitudes and perceptions towards the scientific search for extraterrestrial life among students of public and private universities in Peru. *International Journal of Astrobiology*, 19(5), 360–368. https://doi.org/10.1017/S1473550420000130

DasSarma, P. and DasSarma, S. (2018). Survival of microbes in Earth's stratosphere. *Current Opinion in Microbiology*, 43, 24–30. https://doi.org/10.1016/j.mib.2017.11.002

Dolan, E. L. (2016). *Course-based undergraduate research experiences: Current knowledge and future directions* (Paper commissioned). The Committee on Strenghtening Research Experiences for undergraduate STEM Students Board on Science Education, Division of Behavioral and Social Sciences and Education Board on Life Sciences, Division of Earth and Life Studies.

Doménech-Betoret, F., Abellán-Roselló, L. and Gómez-Artiga, A. (2017). Self-efficacy, satisfaction, and academic achievement: The mediator role of students' expectancy-value beliefs. *Frontiers in Psychology*, 8. https://doi.org/10.3389/fpsyg.2017.01193

Dominguez Lara, S. A. (2014). Autoeficacia para situaciones académicas en estudiantes universitarios peruanos: Un enfoque de ecuaciones estructurales [Self-efficacy for academic situations in Peruvian university students: A structural equation approach]. *Revista de Psicología*, 4, 45–53.

Dominguez-Lara, S., & Fernández-Arata, M. (2019). Autoeficacia académica en estudiantes de Psicología de una universidad de Lima [Academic self-efficacy in Psychology students from a university in Lima]. *Revista Electrónica de Investigación Educativa*, 21, e32. https://doi.org/10.24320/redie.2019.21.e32.2014

Freire, C., del Mar Ferradás, M., Núñez, J. C., Valle, A. and Vallejo, G. (2019). Eudaimonic well-being and coping with stress in university students: The mediating/moderating role of self-efficacy. *International Journal of Environmental Research and Public Health*, 16(4), 48. https://doi.org/10.3390/ijerph16010048

Gai, M., Guglieri, G., Lattanzi, M. G., Lombardi, A., Mana, M., Masserano, L., Musso, I. and Navone, P. (2014). A scientific mission based on a high altitude stratospheric balloon. *International Journal of Aerospace Sciences*, 3(1), 18–29.

Guzik, T. G. (2015). The High Altitude Student Platform (HASP) as a Model Multi-Payload Balloon Platform, in *Proceedings of the 2015 IEEE Aerospace Conference*, 7–14 March. Big Sky (MT): IEEE. https://doi.org/10.1109/AERO.2015.7118985

Hair, J. F., Anderson, R. E., Tatham, R. L. and Black, W. C. (1999). *Análisis Multivariante* [Multivariate Analysis]. Madrid: Pearson Prentice Hall.

Hatlevik, O. E., Throndsen, I., Loi, M. and Gudmundsdottir, G. B. (2018). Students' ICT self-efficacy and computer and information literacy: Determinants and relationships. *Computers & Education*, 118, 107–119. https://doi.org/10.1016/j.compedu.2017.11.011

Hernandez Sampieri, R., Fernandez Collado, C. and Baptista Lucio, M. (2014). *Metodología de la Investigación* [Research Methodology]. México D.F.: McGraw-Hill.

Honicke, T. and Broadbent, J. (2016). The relation of academic self-efficacy to university student academic performance: A systematic review. *Educational Research Review*, 17, 63–84. https://doi.org/10.1016/j.edurev.2015.11.002

Huerta, M., Goodson, P., Beigi, M. and Chlup, D. (2017). Graduate students as academic writers: Writing anxiety, self-efficacy, and emotional intelligence. *Higher Education Research & Development*, 36(4), 716–729. https://doi.org/10.1080/07294360.2016.1238881

Klassen, R. M. and Klassen, J. R. L. (2018). Self-efficacy beliefs of medical students: A critical review. *Perspectives on Medical Education*, 7(2), 76–82. https://doi.org/10.1007/s40037-018-0411-3

Maddux, J. E. (Ed.). (2013). *Self-Efficacy, Adaptation, and Adjustment: Theory, research, and application*. Springer Science & Business Media.

Marshman, E. M., Kalender, Z. Y., Nokes-Malach, T., Schunn, C. and Singh, C. (2018). Female students with A's have similar physics self-efficacy as male students with C's in introductory courses: A cause for alarm? *Physical Review Physics Education Research*, 14, 020123. https://doi.org/10.1103/PhysRevPhysEducRes.14.020123

McBride, E., Oswald, W. W., Beck, L. A. and Murray, A. V. (2020). "I'm just not that great at science": Science self-efficacy in arts and communication students. *Journal of Research in Science Teaching*, 57(4), 597–622. https://doi.org/10.1002/tea.21603

Miyahira Arakaki, J. M. (2009). La investigación formativa y la formación para la investigación en el pregrado [Formative research and research training in undergraduate studies]. *Revista Medica Herediana*, 20(3), 119–122. https://doi.org/10.20453/rmh.v20i3.1010

Nordlie, J., Straub, J., Theisen, C. and Marsh, R. (2014). Solar ballooning: A low-cost alternative to helium balloons for small spacecraft testing. *Space Vehicles Commons*.

Panadero, E., Jonsson, A. and Botella, J. (2017). Effects of self-assessment on self-regulated learning and self-efficacy: four meta-analyses. *Educational Research Review*, 22, 74–98. https://doi.org/10.1016/j.edurev.2017.08.004

Pont, G. (2006). The STRAtospheric PLatform EXperiment (STRAPLEX) A low-cost solution for near-space experiment, in *Proceedings of the 57th International Astronautical Congress*, 29 September–3 October. Valencia: AIAA|ARC. https://doi.org/10.2514/6.IAC-06-E1.1.03

Roney, L. N., Westrick, S. J., Acri, M. C., Aronson, B. S. and Rebeschi, L. M. (2017). Technology use and technological self-efficacy among undergraduate nursing faculty. *Nursing Education Perspectives*, 38(3), 113–118. https://doi.org/10.1097/01.NEP.0000000000000141

Seng, C., Jonson Carlon, M. K. and Cross, J. S. (2020). Research self-efficacy of Cambodian undergraduate students at province-based universities. *International Journal of Sociology of Education*, 9(2), 154–190. https://doi.org/10.17583/rise.2020.4267

Smith, D. J. (2013). Microbes in the upper atmosphere and unique opportunities for astrobiology research. *Astrobiology*, 13(10), 981–990. https://doi.org/10.1089/ast.2013.1074

Voss, H. D., Dailey, J. and Snyder, S. J. (2011). *High-Altitude Balloon Launches and Hands-on Sensors for Effective Student Learning in Astronomy and STEM*. Indiana: Astronomical Society of the Pacific. https://doi.org/10.31274/ahac.8337

Walker, R., Galeone, P., Page, H., Castro, A., Emma, F., Callens, N. and Ventura-Traveset, J. (2010). ESA hands-on space education project activities for university students: Attracting and training the next generation of space engineers, in *Proceedings of the EEE EDUCON 2010 Conference*, 14–16 April. Madrid: IEEE. https://doi.org/10.1109/EDUCON.2010.5492406

West, J. and Meier, C. (2019). Pre-service teachers' self-efficacy, attitudes and academic performance with regard to undergraduate research modules. *South African Journal of Higher Education*, 33(2), 268–283. https://doi.org/10.20853/33-2-2615

Witze, A. (2018). Scientific ballooning aims for the stratosphere. *Nature*, 553(7687), 135–136. https://doi.org/10.1038/d41586-018-00017-5

Zulkosky, K. (2009). Self-efficacy: A concept analysis. *Nursing Forum*, 44(2), 93–102. https://doi.org/10.1111/j.1744-6198.2009.00132.x