

Teaching and Educational Methods

Mandatory Undergraduate Research: Unlocking the Potential of Students at a Latin American University

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Abstract

Through undergraduate research experiences (UREs), students develop important knowledge and skills, such as reading and understanding scientific literature, working independently, and communication skills. The acquired knowledge and skills apply to their professional life, regardless of whether students pursue a career in science. Because students choose to participate in these experiences, the overall satisfaction and perceived benefits of the experiences tend to be positively evaluated. The URE is a graduation requirement at the Panamerican Agricultural School (Zamorano University). To the best of our knowledge, no literature explores student satisfaction and perceived benefits in the context of mandatory UREs. In this teaching method article, we present details on the URE at Zamorano University, including its modalities, procedure, and required human and capital resources, student satisfaction, and perceived benefits for the 2023 agribusiness cohort, and the overall impact to society. The results suggest most students were satisfied or very satisfied with the experience and perceived moderate to significant benefits. However, mean satisfaction and perceived benefits were lower than non-mandatory UREs at other institutions. Finally, we present evidence of the UREs' contribution to faculty involved in advising and its benefits to society.

1 Introduction

Agri-food systems in Latin America have been recognized as successful for their contribution to feeding a growing population worldwide and their role in facilitating economic development. Nonetheless, significant challenges remain, such as environmental and health costs, rapidly growing urban populations, food insecurity, poverty reduction, and climate resilience (Morris, Sebastian, and Perego 2020). In this context, feeding a growing population while addressing shocks in the agri-food systems and ensuring the availability of resources for future generations is a significant challenge faced by current and future agribusiness professionals. Therefore, the industry demand for professionals in the field is significant, driving higher education institutions to continuously revise and adjust their academic programs (Morales et al. 2023). One tool available to universities to develop problem-solving and critical thinking skills to face the agri-food system's challenges is undergraduate research experiences (UREs).

This paper provides a brief literature review on the concept of UREs, the expected benefits, and the required components to be successful learning experiences. Then, we present the methodology of the URE at the Panamerican Agricultural School in Honduras (hereafter referred to as Zamorano University), including details on its modalities, procedure, estimates of the program's cost, and required human and capital resources. In the last section of the paper, we present data on students' satisfaction and their perceived benefits for the 2023 agribusiness cohort and some of the benefits to society that go beyond the URE itself. Zamorano University's URE is unique and worth discussing for an important reason. Compared to other programs where enrollment is optional, it has been a graduation requirement for all undergraduate majors since 2002.

2 Undergraduate Research Experiences (UREs)

Undergraduate research has long been considered a valuable learning experience for students. It enriches the college experience, prepares students for the industry demands, and can help students make decisions regarding their upcoming professional life. The Council on Undergraduate Research (2024) defines undergraduate research as “A mentored investigation or creative inquiry conducted by undergraduates that seeks to make a scholarly or artistic contribution to knowledge.” There are two main approaches to undergraduate research: Course-Based Undergraduate Research Experiences (CUREs) and UREs (Linn et al. 2015; Auchincloss et al. 2017). Broadly explained, CURE refers to any research projects students might complete within the context of a specific course, while URE refers to hands-on experiences where students are immersed in laboratories or research teams and outside the boundaries of specific courses. For the remainder of this paper, we focus only on the second approach, URE. While UREs might be mapped within a study plan for the benefit of students, they can benefit all involved, including faculty members who serve as mentors, the university, and society (Petrella and Jung 2008).

According to Lopatto (2009), students who participate in undergraduate research can develop skills that enhance their cognition, behavior, and attitudes, enabling them to address challenges and foster self-confidence and independence. At a deeper level, students develop interaction and communication skills (including leadership and teamwork), data collection and interpretation skills, reading and understanding primary literature, responsibility, knowledge synthesis, and computer skills. From another perspective, Seymour et al. (2004) defined seven benefits of undergraduate research, including increased confidence in a personal and professional capacity, learning to think and work as a scientist, improved overall skills, clarification or refinement of career path, a changing attitude toward the value of learning and working as a researcher, and other benefits such as a good summer job or access to laboratory equipment and learning to manipulate it.

Since UREs have many potential benefits, it is important to determine what makes them successful. Five essential features of undergraduate research have been described by an inquiry into faculty from several universities. For a successful URE, students should: (1) be prepared by reading relevant literature, (2) have the support of a mentor or learning community, (3) have the opportunity to design research, (4) have the opportunity to work independently, and (5) have an opportunity to communicate their work (Lopatto 2003).

3 The Undergraduate Research Experience at Zamorano University

Zamorano University is an American international boarding school in Honduras focusing on tropical agriculture. As of 2024, its student body was composed of representatives of 17 Latin American countries. The university offers four undergraduate majors: agronomy, food science, environmental sciences, and agribusiness. A strong component of the instruction at the university is the learning-by-doing methodology, in which students in its undergraduate programs devote half their time to learning-by-doing modules. All undergraduate majors last four years, with each year consisting of three academic periods of 15 weeks each. All undergraduate students must complete an URE and an internship during their senior year as graduation requirements.

The official name of Zamorano University’s URE is Special Graduation Project, which consists of two learning spaces, each during the last two academic periods of the degree study plan. Each learning space is equivalent to a 15-week course, with three academic credits each. At the end of both academic periods, students receive a pass/fail grade. Each student is assigned a primary advisor from the department where they are pursuing their major and must have at least one secondary advisor. The secondary advisor can be a faculty member from the same academic department, another department, or a practitioner as long as this person holds a master’s degree and has topic-specific knowledge and

experience. Finally, students must choose one of three modalities for their URE: (1) research study, (2) project, and (3) products.

3.1 Modalities

The URE at Zamorano University has three modalities students might choose: research study, project, and products. In the research study modality, students are expected to directly apply the scientific method, collect data, and test one or more research hypotheses. Students choosing this modality usually belong to more technical majors, such as agronomy or food science, where they get direct access to research facilities, such as laboratory or production units within the university.

The project modality is designed for students with innovation and entrepreneurship inclinations who may want to start their own business after graduation or expand the family business. Students are expected to develop a technical and business plan for their projects in this modality. Because the business plan is a key component of this modality, it is more prevalent among agribusiness students than students from other majors.

In the product modality, students are not expected to apply the scientific method but to develop academic literature products, such as case studies, manuals, and literature reviews. Case studies and manuals are usually designed with the collaboration of the industry from previously established faculty professional networks.

3.2 Procedure

With minor variations in the execution, Table 1 shows the general pathway all students must follow to complete the URE. As a general timeline, students must complete steps 1 through 5 by the fall semester of their junior year, step 6 by the spring semester of their senior year, and steps 7 and 8 by the summer semester of their senior year. Students who complete their research projects early can move forward with steps 7 and 8 during the spring semester of their senior year. While the URE at Zamorano University mandates that all students write a technical report, data from Lopatto (2009) suggests that around 52 percent of students participating in UREs give a talk on campus, 46 percent write a paper to be read by a mentor, and 4 to 5 percent write a manuscript intended for a technical report of a student scientific journal.

3.3 Required Resources

Making every student go through the URE requires an important investment in faculty time, physical resources, and logistics. The following sections outline the human resources, budgetary, and physical resources historically used to facilitate this mandatory URE.

3.3.1 Human Resources

In each academic department, the staff required for the URE program consists of one URE Coordinator, all faculty in the department as every faculty member is required to mentor UREs, and administrative support staff. A professor in the Agribusiness Management Department at Zamorano University can expect to advise between five and eight students each year. The URE Coordinator is expected to spend three hours per student, the primary advisor 20 hours, and the secondary advisor five hours. On average, a single student would require 28 hours of faculty time throughout the entire URE. To provide some perspective, data from Lopatto (2009) suggests that mean weekly contact hours between students and faculty can be as low as 5.8 (SD = 2.9) in engineering and as high as 11.5 (SD = 10.2) in biology. For 2024, the senior group of students in the agribusiness major is 44, translating into an estimated 1,232 hours or 154 business days. Assuming a nominal faculty salary rate of US\$ 145/day, the program has an estimated cost of US\$ 507.5 per student and US\$ 22,330 for the 2024 agribusiness cohort, just in human resources.

Table 1: Steps Involved in the Development of the Undergraduate Research Experience at Zamorano University

No.	Step	Description
1	Introduction to the URE	Details on the URE are presented to students by a faculty member who serves the role of URE Coordinator.
2	Assignment of primary advisor	Based on students' interests and faculty availability, students are assigned a primary advisor.
3	Agreement on the topic and secondary advisors	Students meet with the primary advisor, who helps them translate their interests and ideas into something doable within the time frame and with the available resources. At this point, secondary advisors are suggested and invited to participate.
4	Writing of a research plan	Students work on their own to develop a research plan. This plan must have an introduction, a literature review, and a methodology. During this step, the students might meet several times with their advisors. These advising sessions vary based on the students' needs but usually last between 30 and 60 minutes.
5	Plan approved/rejected	Only the students' advisors can approve the research plan. Hence, the research plan gets worked on until the advisors are satisfied and approve the students to move on to the next step.
6	Development of the plan	With a research plan approved, students take on data collection and analysis. In this stage, students work closely with the professor and their teams. In some specific cases, the URE may be developed outside [Latin American University], in which data collection requires additional efforts from faculty and other collaborators to ensure the student has the experience to collect data in the field.
7	Final paper writing	Students write their final paper after data collection and analysis, including results, discussion, and conclusions. During this step, students might meet several times with their advisors until the final paper is approved.
8	Presentation	All students must make a 15- to 20-minute public presentation of their paper, followed by 10 to 15 minutes of questions by a review committee.

3.3.2 Budget and Physical Resources

Due to the diversity of topics to be addressed during the URE, the required physical and economic resources greatly vary. Every student gets a budget of approximately US\$ 150, which they may or may not use. As part of the research plan, students must present a budget, which later helps the URE Coordinator make budget decisions and allocate more than US\$ 150 to other students if necessary and possible. Once again, using the 2024 agribusiness senior cohort as an example, the total cost in terms of budget is US\$ 6,600. For the agribusiness major students, this budget is usually allocated to travel expenses (visiting local communities, supermarkets, and field visits), production inputs (seeds, fertilizers, and irrigation), and exhibition displays.

Beyond the budget, students get access to all facilities at Zamorano University as long as activities are appropriately coordinated with the personnel in charge. For example, a student in the agribusiness department testing the technical efficiency of a new feed additive for tilapia (*Oreochromis niloticus*) would have access to the aquaculture pools to conduct their research trials at no charge but would have to purchase the fish and the feed from its budget plus any additional costs, and take on all the labor required for the experiment. This is possible because all facilities at Zamorano University serve multiple purposes, including production for sale, learning-by-doing, training (extension), and research.

Many research projects occur in partnership with local farmers, cooperatives, and processing plants. In those cases, the student takes advantage of the partner's facilities and conducts experiments and trials in situ. When this is the case, the cost of the URE is covered by the entity requesting the project. Also, before the COVID-19 pandemic, many students did internships before the URE, with many of those internships taking place at universities and research centers. During these internships, it was common for the students to get involved in research. As long as they fulfill all the URE requirements and the supervisor at the receiving institution agrees, students can present the fieldwork as part of their URE.

4 Programmatic Impact

In this section, we present the impact on students, measured as student satisfaction and their perceived benefits, as well as the impact on society, measured as scientific contributions.

4.1 Impact on Students

Since the 2024 cohort was still in the URE at the writing of this paper, we present data on the 2023 senior cohort of agribusiness undergraduate students. The 2023 cohort consisted of 52 students, of which 62 percent completed a survey evaluating their satisfaction with the URE, perceived benefits, and plans after graduation. No treatment for no response was conducted. The original survey instrument consisted of five sections to gain insight into the research experience and was adapted from the Survey of Undergraduate Research Experiences (SURE) developed by Lopatto (2004). However, we only present results relevant to this paper and make the complete survey available in Appendix 1 for those institutions seeking a deeper insight into their programs. Before completing the survey, students were provided with a consent statement in which they needed to agree to participate in the study. No identifiable data was collected.

4.2 Student Satisfaction

Overall satisfaction was evaluated with the question: What is your overall level of satisfaction? Students answered on a five-point Likert scale (1 = very unsatisfied, 2 = somewhat unsatisfied, 3 = neutral, 4 = somewhat satisfied, and 5 = very satisfied), plus a prefer not to answer option. The mean and median overall satisfaction of the 2023 cohort were 3.84 and 4, respectively (SD = 1.08). Most students (59.4 percent) have some level of satisfaction with the URE, 28.1 percent were neither satisfied nor dissatisfied, and roughly one in ten were somewhat dissatisfied. The overall satisfaction was lower than the value reported by Lopatto (2004), in which the mean satisfaction with the URE was 4.21. A one-sample t-test suggests that the mean found at Zamorano University is statistically different from the one reported by Lopatto ($t = 20.1161$, $p < 0.001$). Lopatto's study collected data on 1,135 undergraduates from 41 universities and colleges participating in summer undergraduate research programs.

4.3 Perceived Benefits

The average perceived benefit (mean of the 19 statements) was 3.375 (SD = 0.5424) for all responses, with 40 and 49 percent of the responses as moderate to significant perceived benefits across the 19 statements. The overall mean of the 19 statements (3.375) was lower than that of the 3.72 reported by

Lopatto (2004). A one-sample t-test suggests these means are statistically different ($t = -12.5569, p < 0.001$).

At Zamorano University, the top three items for which students perceived the most benefit were: (1) understanding the research process in the discipline ($M = 3.53, SD = .57$), (2) skills analyzing data and information ($M = 3.50, SD = .62$), and (3) learning to work independently ($M = 3.48; SD = .62$). The three items for which the students reported the less perceived benefit were: (1) understanding how researchers think ($M = 3.25; SD = .80$), (2) becoming part of a learning community ($M = 3.23; SD = .84$), and (3) clarification of professional path ($M = 3.13; SD = .66$; Figure 1).

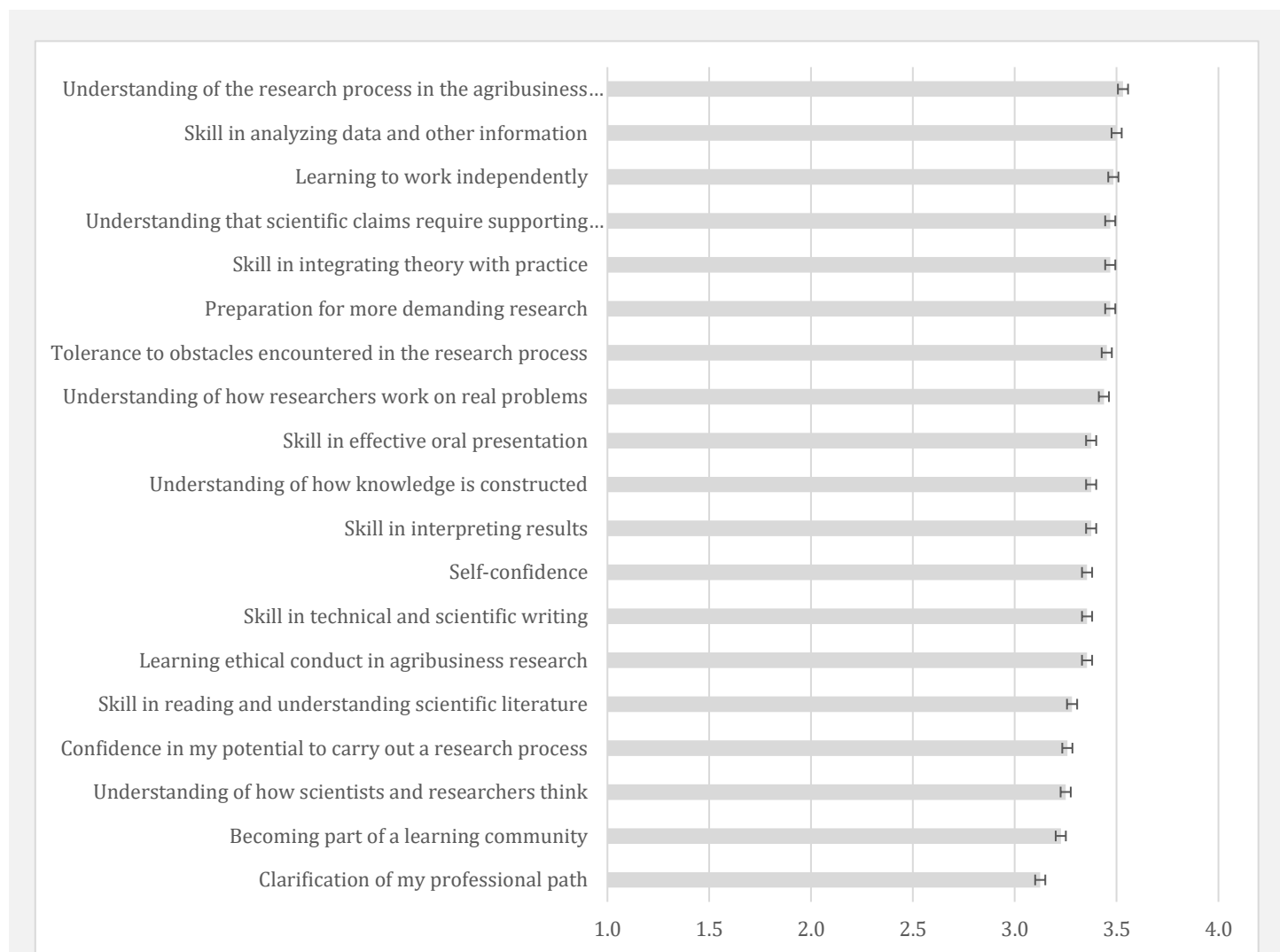


Figure 1: Mean Perceived Benefits by Students of the UREs.

Notes: Likert-scale items with the following scale: 1 = no gain at all, 2 = some gain, 3 = moderate gain, 4 = significant gain, N/A = rather not answer/does not apply. Standard errors for 95 percent confidence interval of the mean.

4.4 Impact on Society and the Agricultural Sciences

The last step of the URE is when students deliver their research report to the university library. Per Zamorano University policy, all URE reports are publicly available through the university library website (biblioteca.zamorano.edu) with an Attribution-NonCommercial-NoDerivs Creative Commons license (CC BY-NC-ND). Additionally, all URE reports are indexed in the Food and Agriculture Organization’s International System for Agricultural Science and Technology (AGRIS) and can be found via popular

search engines such as Google Scholar. As a point of reference, from 2021 to 2023, Zamorano University graduated an average of 345 undergraduates each year and made more than 900 URE reports publicly available, with an estimated 18 percent prepared by agribusiness major students during that timeframe. It is important to note that these technical reports are the work of undergraduate students, with intellectual contributions from the faculty, but that has not gone through peer review.

Many faculty at the university are active researchers who motivate their students to continue their URE work and submit it to annual meetings or scientific journals. While this is not the norm and not mandatory, there are successful cases where agribusiness students have presented at the annual meeting of the Agricultural and Applied Economics Association, the annual meeting of International Agricultural Education and Extension, and published in Zamorano University's Scientific Journal Ceiba (Sandoval, Zapata, and Lemus 2021; Santillan and Sandoval 2021; Zacarias et al. 2021; Rodriguez and Sandoval 2023; Sandoval et al. 2023; Morales and Pérez 2024; Patt, Rendon, and Morales 2024). By our best estimate, between 5 and 10 percent of all UREs in the agribusiness program at Zamorano University reach conference proceedings or journal articles each year. This estimate is low compared to student self-reported communication and dissemination activities, where 28 percent of students report presenting a poster at a conference, 20 percent writing a manuscript for a professional journal (not peer-reviewed), 13 percent making an oral presentation at a conference, and 4 percent writing a manuscript and a student scientific journal (Lopatto 2009). Finally, while we cannot infer causality, UREs can be used to motivate talented students to pursue graduate degrees. In our sample, 37.5 percent of students reported having an interest in continuing to graduate school immediately after finishing their undergraduate degree, which is higher than the 22.5 percent reported by Lopatto (2009).

5 Conclusions

The primary objective of Zamorano University's URE program is to develop a set of research-related skills in the students, including the ability to read and understand scientific literature, collect and analyze data, independence, and verbal and oral communication skills. These skills also prepare students to better confront the agrifood systems challenges they will face once entering the workforce or pursuing graduate school. Students completing the URE and reaching the stage of presenting their project have been deemed acceptable by the primary and secondary advisors, suggesting that the learning objectives intended were fulfilled. It is worth noting that since the URE is part of the academic program and students pay for it in their tuition, all associated costs are accounted for, including faculty time. Therefore, similar programs should be implemented with properly assigned resources, especially faculty time.

Overall satisfaction and perceived benefits of the 2023 agribusiness cohort were positive. Most students were very satisfied with the experience and perceived moderate to very significant benefits. However, the results were lower than those reported for students who voluntarily decided to participate and enroll in UREs. This suggests that students who opt to participate in UREs may have higher satisfaction and perceived benefits than students who see the URE as another graduation requirement and have no research interests. Students who decided to participate in UREs likely have an inclination toward research or intentions to pursue a graduate degree and, therefore, view the entire experience as beneficial to their professional and career aspirations, rating their satisfaction and perceived benefits higher.

Since the URE intends to develop student skills, the communication of the results is built within the experience, and the number of projects that reach conference proceedings and journal articles is low. At Zamorano University, it is up to the professor to motivate their students to continue their work and prepare it for conference proceedings or scientific journals. Considering that Zamorano University is a primary teaching institution, this requires additional effort by faculty. While Zamorano University offers graduate programs in agribusiness, these are professional degrees with non-thesis requirements. Hence,

faculty with established research lines usually use the URE to advance their research. It is recommended that primary teaching institutions incorporate UREs to provide faculty with opportunities to foster research and build their research agenda. It is unlikely that individual UREs will produce high-quality research, but if adequately managed, they can produce exploratory studies and preliminary results, and build over-time publishable material.

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Appendix 1. Survey Questions

Section 1: Students Perceived Overall Experience

Item	Statement
1	The research experience was more stressful when I did not have research hours assigned to my schedule. ¹
2	The university and the department should respect the research hours assigned and not ask for mandatory activities during those hours. ¹
3	While conducting my research, it was difficult to balance my other academic responsibilities. ¹
4	While conducting my research, it was difficult to get enough time with my advisor to discuss my research. ¹
5	While conducting my research, it was easy to plan and schedule my research activities. ¹
6	Overall, I find doing a research project more interesting than doing assignments and other academic activities. ¹
7	I learned more from my other academic activities than from my research experience. ¹
8	Regarding the expectations before starting the research experience, how difficult was it to conduct research? ²

Notes. ¹ Likert-scale items with the following scale: 1 = strongly agree, 2 = agree, 3 = disagree, 4 = completely disagree, and 5 = rather not answer/does not apply.

² Multiple-choice items with the following options: 1 = the experience was significantly less difficult than expected, 2 = the experience was less difficult than expected, 3 = the experience was as difficult as I expected it to be, 4 = the experience was easier than expected, 5 = the experience was significantly easier than expected, and 6 = rather not answer/does not apply.

Section 2: Students Perceived Benefits

Item	Statement ¹
1	Clarification of my professional path.
2	Skill in interpreting results.
3	Tolerance to obstacles encountered in the research process.
4	Preparation for more demanding research.
5	Preparation for more demanding research.
6	Understanding of how knowledge is constructed.
7	Understanding of the research process in the agribusiness discipline.
8	Skill in integrating theory with practice.
9	Understanding of how researchers work on real problems.
10	Understanding that scientific claims require supporting evidence.
11	Skill in analyzing data and other information.
12	Learning ethical conduct in agribusiness research.
13	Skill in reading and understanding scientific literature.
14	Skill in effective oral presentation.
15	Skill in technical and scientific writing.
16	Self-confidence.
17	Understanding of how scientists and researchers think.
18	Learning to work independently.
19	Becoming part of a learning community.
20	Confidence in my potential to carry out a research process.

Notes. ¹ Likert-scale items with the following scale: 1 = no gain at all, 2 = some gain, 3 = moderate gain, 4 = significant gain, and 5 = rather not answer/does not apply.

Section 3: Alignment with Essential Features of Undergraduate Research (Internal Assessment of the Methodology)

Essential Feature of Research	Student Survey Instrument	Faculty Rubrics
Students should be prepared by reading relevant literature	N/A	Document rubric, ³ Criterion No. 2. Introduction, literature review, problem statement, and research objective
Support of mentor	<ol style="list-style-type: none"> 1. Think about the person who was your main advisor.¹ 2. Think about the person who was your secondary advisor, if you had more than one, choose the person most relevant to your research.¹ 	N/A
Opportunity to design research	N/A	Document rubric, ³ criterion No. 3, Methodological design
Experience working independently	<ol style="list-style-type: none"> 1. Library tools for students² 2. Reference style workshop² 3. Research databases available at library² 4. Logistical support from the department² 	Document rubric, ³ criterion No. 6, Knowledge and technical ability
Opportunity for communication	N/A	Overall grade of the oral presentation rubric ³

Note.

¹ Multiple-choice items with the following options: 1 = my mentor was not a good professor or mentor, 2 = I feel my mentor was below average as a professor or mentor, 3 = I feel my mentor was an average professor or mentor, 4 = I feel my mentor was above average as a professor or mentor, 5 = I feel my mentor was an outstanding professor or mentor, and 6 = rather not answer/does not apply.

² Likert-scale items with the following scale: 1 = very useful, 2 = useful, 3 = of little use, 4 = nothing useful, and 5 = rather not answer/does not apply.

³ Assigned grades by faculty ranging from 0 to 100 points.

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