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Students' Experiential Learning of Hydroponics and Local Markets on the Island of Roatán, Honduras

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Abstract

International experiences for students provide a means for globalization of higher education, promoting communication and understanding of real world issues. Undergraduate students participating in a 10-day short course study abroad to Honduras experienced first-hand entrepreneurial education by working directly with a farm business while learning applied science of water and light relations with regard to hydroponically grown plants on the island of Roatán. This paper describes the teaching methods the professors implemented in order to help improve students' understanding of complex issues related to science. Undergraduate students worked in pairs to collect greenhouse data and helped to harvest and package lettuce and mint to sell to local markets. The students were given a pre-test about water and light relations and were asked to respond to questions about issues they might encounter related to plant water uptake within a tropical greenhouse setting. The students participated in reflective sessions with the business owner after work experience, followed by post-tests after completing the exercises. These teaching methods were repeated for two years with a total of 20 participants. Overall, the post-test scores showed a gain in science knowledge. During reflective sessions, students commented that they enjoyed this unique mini-research experience and felt it was more valuable than just touring. Students appreciated the comprehensive interactions with the agricultural business and gained self-awareness related to entrepreneurship in agriculture. Study-abroad courses should try to include hands-on experiences for students to engage with local entrepreneurs and to apply science-based questions to promote critical thinking skills.

Keywords: Entrepreneurship, Greenhouse, Honduras, Hydroponics, Lettuce, Study Abroad, Tropical Agriculture

Introduction

International experiences for students provide a means for globalization of higher education, promoting communication and understanding of real world issues. For a student to step outside of his or her comfort zone is important because he or she will learn more and gain understanding of other cultures while embracing new phenomena (Harari, 1981). According to Arum and Water (1992), international education refers to the multiple activities, programs, and services that fall within international studies, international educational exchange, and technical cooperation. Overall, students benefit by immersing themselves in a foreign culture and by gaining new experiences that provide a different perspective on their worldview (Barton et al., 2009).

Very little research has been reported about how study-abroad experiences relate to students' engagement within the context of entrepreneurship intertwined with the complexities of research science (e.g., hydroponic production of specialty crops such as lettuce or mint). Better understanding how students respond to these types of short studies helps to provide insight for further development of short study-abroad courses and to encourage faculty to include these activities during their courses. This study reports the involvement of undergraduates in both research and experiential learning of entrepreneurship during a short-term study-abroad course to the island of Roatán, Honduras in Central America.

Purpose and Objectives

The purpose of this study was to assess the importance of students' engagement in experiential learning in helping them develop critical thinking skills through hands-on learning opportunities in science with local entrepreneurs in

Honduras. While this study of science could have been completed at the students' home institution, growers in the Midwest do not have to deal with extremely high relative humidity (RH), so the practical implications of producing a crop in such an extreme environment led to a quicker understanding of the effect of the water-potential gradient on water loss in plants. In addition, we wanted the undergraduates to relate the science to the business environment and culture of the country. Often, textbook-based teaching leads to regurgitation of text materials with low comprehension (Friedler, 1985; Cottrell, 2004). We hypothesized that teaching these concepts in a foreign environment would allow for more productive discussion of the environmental consequences of water relations for plant growth. The objectives of this study were to determine undergraduates' knowledge of agricultural issues and problems related to growing food crops within a greenhouse while integrating them into an entrepreneurial business. Our overall goal was to utilize experiential learning (Kolb, 1984) in a relatively short period to help students understand plant-water relations relative to entrepreneurial mentality.

Methods

This study was descriptive and qualitative. There were 20 participants, who enrolled in a 10-day experiential learning study-abroad course, conducted during spring breaks of 2008 and 2009. Students came from several different states in the Midwest region with backgrounds in agricultural economics, agronomy, animal science (pre-vet), industrial management, and plant science. Due to the small size of the group, results should not be extrapolated beyond the limits of the environment described within the study.

How do each of the following changes affect water uptake in plants? Give your answer based on the conditions in the greenhouse given below. Please evaluate each question independent from each other.

Current conditions: relative humidity 90%; light level 75% full sunlight; air temperature 85 °F; water pH 7.0

- 1) Light intensity increases to 90% full sunlight
- increased water uptake
 - decreased water uptake
 - no effect

What is your confidence in answering this question: 1 to 5 (highest)

- 2) Light intensity decreases to 50% full sunlight
- increased water uptake
 - decreased water uptake
 - no effect

What is your confidence in answering this question: 1 to 5 (highest)

- 3) Air temperature cools down to 50 °F
- increased water uptake
 - decreased water uptake
 - no effect

What is your confidence in answering this question: 1 to 5 (highest)

- 4) Relative humidity decreases to 70%
- increased water uptake
 - decreased water uptake
 - no effect

What is your confidence in answering this question: 1 to 5 (highest)

- 5) Root zone fertilizer concentration doubles
- increased water uptake
 - decreased water uptake
 - no effect

What is your confidence in answering this question: 1 to 5 (highest)

Figure 1. Pre- and post-trip quiz given to students participating in a study-abroad program in Honduras to assess their understanding of environmental effects on plant–water relations.

Pre-Course Preparation

VanDerZanden, Haynes, Nonnecke, and Martin (2007) documented that pre-trip preparation benefited student learning. Thus, before departing, students participated in a 4-week course that incorporated essential concepts including water relations and the environmental variables affecting plant–water relations. Students took a quiz (see

Figures 1 and 2) designed to determine their current knowledge of plant–water relations. This quiz was given as a pre-test (before departure) and as a post-test (after returning from Honduras). The quizzes were designed so that students would respond to theoretical changes in environmental conditions while being exposed to the specific units used for environmental variables.

□

Circle one number on each of the following scales to indicate the optimal value for a hydroponics lettuce production system in Honduras:

Light																
$\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	0	200	400	600	800	1000	1200	1400	1600	1800	2000					
Air temperature																
$^{\circ}\text{C}$	14	16	18	20	22	24	26	28	30	32	34	36	38	40		
$^{\circ}\text{F}$	50	55	60	65	70	75	80	85	90	95	100	105	110	115		
Relative humidity																
%	0	10	20	30	40	50	60	70	80	90	100					
Water temperature																
$^{\circ}\text{C}$	14	16	18	20	22	24	26	28	30	32	34	36	38	40		
$^{\circ}\text{F}$	50	55	60	65	70	75	80	85	90	95	100	105	110	115		
pH																
	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0					
Root zone electrical conductivity																
$\text{dS}\cdot\text{m}^{-1}$	0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0					
Root zone dissolved oxygen																
ppm	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	

Figure 2. Pre-test and post-trip quiz given to students participating in a study-abroad program in Honduras to assess their understanding of environmental effects on plant–water relations.

Study-Abroad Activities

While abroad, the students first participated in a tour of the facilities at Blue Harbor Plantations. The farm project (121 acres) began as a hobby for the owner and operator in 2002. Later, the farm began focusing on ways of supplying local resorts and restaurants with fresh, unstressed vegetables, lettuce, and herbs grown hydroponically, a relatively unknown production system in Central America, though common in the US. The greenhouse space is a 13,000-square-foot screen house, which is not cooled (cooling prevents lettuce from turning bitter and bolting on hot days). On the tour through the greenhouse, most of the discussion centered on two main topics: (1) control of heat and RH and (2) water composition and quality. Discussion also

addressed how water quality analyses could help growers make informed decisions that affect their business profitability.

Scientific Data Collection

Following the tour, the students formed groups of three for data collection. Environmental variables (temperature, dew point, RH, light intensity and transpiration) were measured throughout the day. One of the goals of the experience was to make the units used to quantify environmental variables more relevant to students. Prior to data collection, shade cloth of different intensities was placed at different areas within the poly house. Lettuce of the same variety and age was grown under each shade

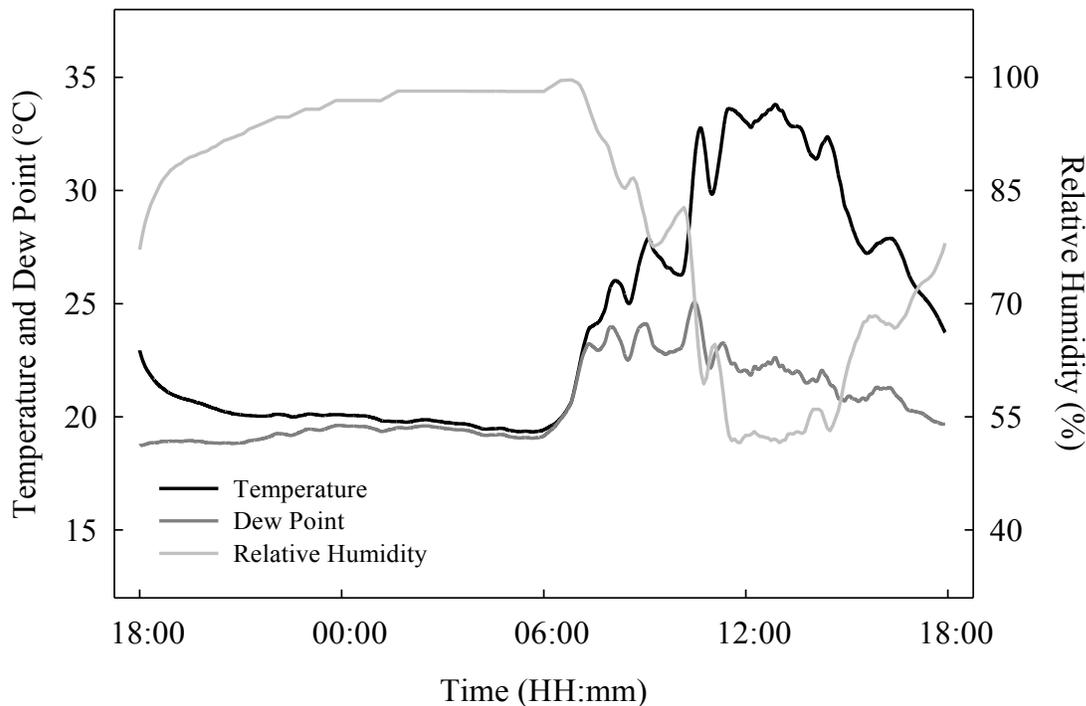


Figure 3. Temperature, dew point, and relative humidity during a 24-hour period in a hydroponics facility in Roatán, Honduras. During this period, the students on the trip conducted measurements of environmental variables and plant–water relations in the facility.

intensity so comparisons of plant growth and water loss could be made. As students toured the facility, they measured temperature, dew point, and RH and were shown how to measure this data in real time throughout the day (see Figure 3). One of the fundamental concepts discussed throughout the day was the effect of water gradients on water uptake and movement in plants. References were made back to the discussion of these concepts in pre-trip lectures. Students were shown the overnight and early morning data and were surprised to learn that RH was near 100% (see Figure 3), making water loss negligible in the lettuce crop.

Environmental variables that affect water loss in plants were expressed with units many students do not encounter on a

daily basis. One of the goals of the exercise was to allow students to measure some of these variables and thereby gain a better appreciation of the units. In both the pre- and post-trip quizzes, students were asked to estimate optimal environmental values for the hydroponics production facility. The goal of this portion of the quizzes was to allow students to become familiar with the units commonly used in measuring environmental factors. Light and temperature were measured throughout the day under the different shade intensities with portable data loggers (Onset Computer Corp, Bourne, MA). The shade cloth installed prior to the student tour provided sufficient contrast light levels so plant responses to light and RH could be discussed (see Figure 4A).

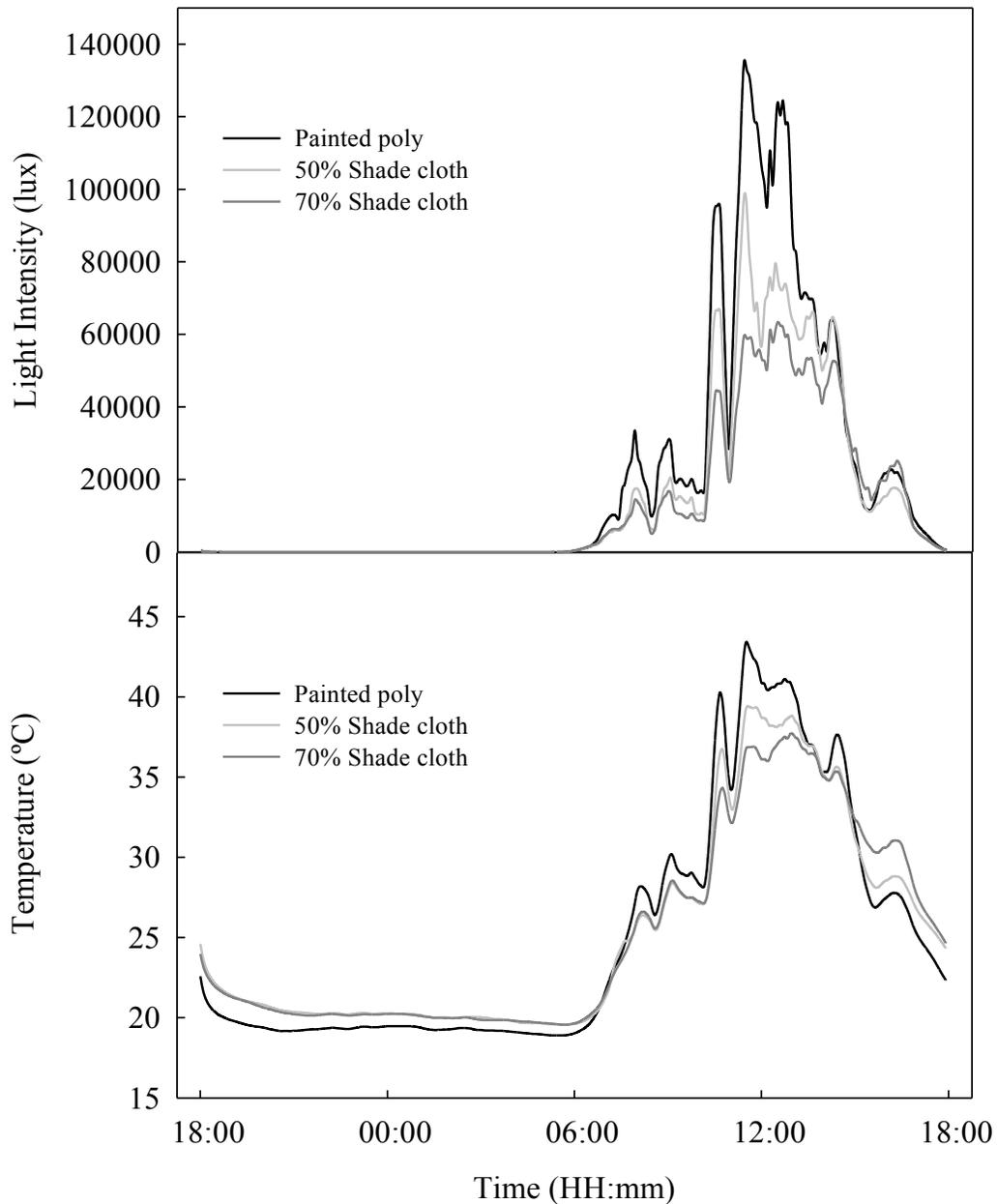


Figure 4. Student measurements of light intensity (A) and temperature (B) at crop level under a painted polyethylene covered greenhouse, 50% shade cloth, and 70% shade cloth by students participating in a study-abroad program in Roatán, Honduras.

Temperature did not differ significantly under the different shade intensities at the beginning of the day, but midday

temperatures were affected by light level (see Figure 4B). In groups of three, students measured light levels and transpiration

throughout the course of the day with one of the instructors. The discussion during these measurements focused on both the units used to quantify environmental variables and how to measure plant response. Students measured light directly with a hand-held light meter (LI-250A, Li-Cor Biosciences, Lincoln, Nebraska). Students first measured light levels outside the poly house, then under the treated poly, 30% shade cloth, and 50% shade cloth (see Figure 5B). Students measured transpiration of individual lettuce leaves under the three light levels in the poly house using a single hand-held porometer (Decagon Devices, Pullman, WA). This porometer utilizes the steady state method, whereby the vapor gradient near a leaf is used to estimate transpiration. This was an excellent tool to use in this situation because the concept of water concentration gradients driving water loss at the leaf level was easily explained to students. Furthermore, the fact that this exercise was conducted in a very high RH environment allowed the instructors to discuss how the magnitude of the water-potential gradient affects plant-water movement and loss. In this case, the instructors were able to discuss how high RH reduces the gradient, thereby reducing nutrient uptake in plants, and the management strategies that need to be employed to deal with this issue. The instructors noted that in the discussions the students appeared to understand this concept well.

As expected, transpiration rates were low in the early morning when RH was very high and in the late afternoon when high temperatures resulted in closed plant stomata (see Figure 5A). Students were able to make measurements in both the morning and afternoon so the changes in environmental variables over the course of the day could be discussed (see Figure 4 and 5). Inquiry-driven approaches to teaching plant physiology are likely more successful

than traditional lab approaches where students are given a set of measurements to conduct (Joly et al., 2000). While it was not possible in the short timeframe to allow instructors to develop a completely inquiry-driven approach, students were asked to predict plant response, based on environmental variables they measured, prior to measuring transpiration. This approach and the discussions that occurred during measurements appeared to greatly enhance the student's ability to understand plant-water uptake and loss.

Entrepreneurial Integration

To better understand the entrepreneurial experience, students were asked to harvest and package lettuce and mint to sell to local markets. The students also participated in reflective sessions with the landowner and operator and other local businesses to reflect upon their scientific processes and to learn about the business operations. This discussion addressed inputs, outputs, associated costs and the number of employees employed to help with harvest and distribution.

Findings/Results

Overall, the students said that they felt this experience expanded their worldviews on food production and business management, which echoes the work of Barton et al., (2009), where students immersed themselves in a foreign culture and gained new experiences that provided a different perspective on their worldview. According to pre-test results, students felt most confident in answering questions related to light relationships within a greenhouse. They had relatively low confidence on questions related to RH and root-zone fertilizer concentrations.

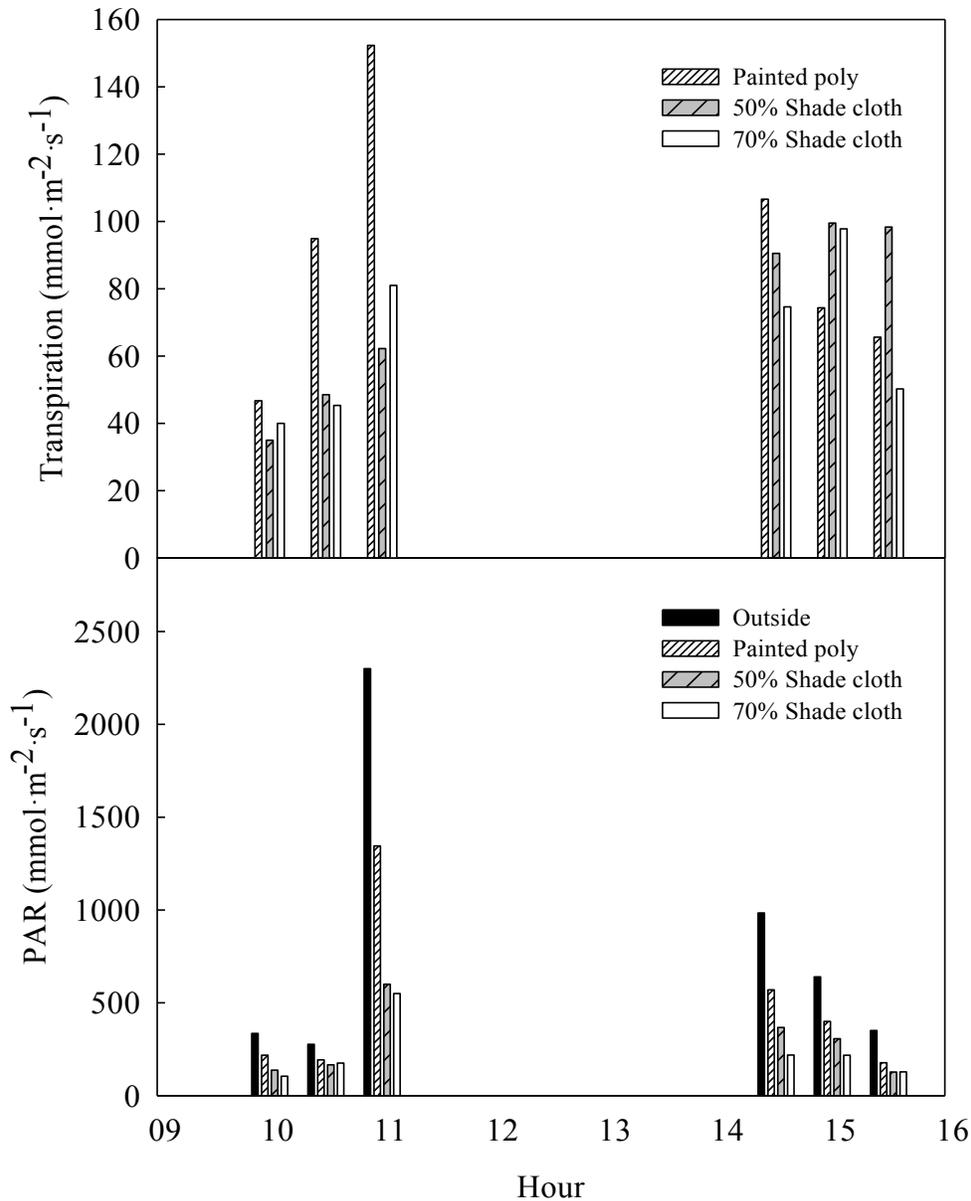


Figure 5. Student measurements of transpiration (A) and light levels (B) during the morning and afternoon period outside the shade house (PAR only), under a painted polyethylene covered greenhouse, and with additional 50% or 70% shade cloth added above the crop.

Several students wrote, “don’t know” next to the questions involving RH. The average for the pre-test score was 62.8%. The post-test scores increased to an average of 70.8% (an 8% increase from the pre-test score with

a standard deviation of 5%). The range of average pre-trip confidence for all questions was 1.9 to 2.7 (where 5 = very confident), whereas the post-trip confidence range was 3.3 to 4.4 (where 5 = very confident).

Even though the students' scores were not as high as the professors would have liked, the students' confidence in answering the questions increased, and the student felt more comfortable contributing and reflecting on why and how things may be different, showing evidence of the development of critical thinking skills. The students reflected heavily on how they originally did not realize where supplies of fresh salad and mint came from and what preparations it took to put in place a business plan and get these products to restaurants and stores. In addition, the students commented that having locally grown produce helps supply valuable nutrients both to locals (who might otherwise have to buy more expensive imports from the main land) and to tourists, who tend to demand specialty salads and "mojitos" (mint-infused drinks) during their island vacations. Overall, the students' experiences were positive and they enjoyed having this unique mini-research experience. They felt this was a more valuable experience than just touring a farm. The students commented that the farm was a good example of how problems can be overcome. They realized the importance of sustainability and of recycling water, even in tropical humid environments. Later in the day, the students enjoyed a fresh-grown salad, which they had picked, packed and helped deliver to the local restaurant in which they had lunch. Prior to their morning's experience, the students had intended to avoid eating salad greens in fear of "Montezuma's revenge," as they commented in their reflective session. The following are some of the students' reflections: (P1) "The hydroponic farm was my favorite part of the trip in order to understand both science and entrepreneurship working together"; (P2) "I loved the hydroponic farm—the operation and the owner was extremely interesting and

entertaining"; (P3) "The hydroponic farm experiments were really well structured"; (P4) "Everyone should have this experience"; (P5) "Most definitely an enjoyable course; (P6) "One of the best experiences I've ever had; the visits to the local schools and walks within the communities opened my eyes to how people really live."

Conclusions, Recommendations, and Implications

Students often struggle with concepts of water relations, partly because they don't clearly understand the environmental variables affecting water loss and movement in plants. We found that using a combination of written materials (quizzes), detailed discussion from a grower's perspective, and actual measurements of both environmental factors and plant responses helped increase student retention of the subject content.

Study-abroad short courses should try to include hands-on experiences for students to engage with local entrepreneurs and to apply science-based questioning that promotes critical thinking in an international setting. Instructors in such settings should be prepared to address the challenges and differences in world-view students encounter. Further, pre-test and post-test exercises help assess student performance; however, they are not the only means of evaluating student performance. Students' reflections allow instructors to listen to critical aspects of their experiences, helping to highlight student impact. Exposing students to the entrepreneurship mentality is crucial for this type of short-term study-abroad courses; however, at times these types of opportunities may be difficult to achieve. Researchers must take into account how individuals learn and how different modes of learning influence opportunities to identify with entrepreneurship and to practice critical thinking (Corbett, 2005).

Exposure to short-research data collection also helps develop students' critical thinking about how to address climate and water issues.

This type of experience can also be useful to teachers of agricultural sciences at the secondary level if they incorporate some of the data students collect into their teaching methods. The examples within this paper demonstrate how data plays a role in real-life agricultural business and impacts the issues businesses encounter.

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