International Coral Reef Research Experiences for Community College Students

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Introduction

Community colleges are evolving from their traditional roles of providing a two-year experience or a technical education into institutions capable of offering not just associate degrees, but career programs, professional and continuing education, language, and equivalency programs and beyond [1], [2], responding to the changing needs of communities and their economies. However, research practices are not inherent to the community college model and are rarely included as a component in student training or capstone experiences. Additionally, coral reef science is considered an emerging multidisciplinary field [3] that deserves considerable attention. To address these needs, the Student Cohort for Undergraduate Research in Marine Biosciences Abroad (SCUBA) was created by the University of Texas System Louis Stokes Alliance for Minority Participation (UT LSAMP) in 2019 to engage non-traditional community college students in coral reef research. The project benefitted from the cooperation of faculty and staff at the University of Texas at Arlington (UTA) and at Midland College (MC) to integrate engineering, marine sciences, and education. Compared to other programs or similar initiatives [4], [5], the SCUBA program stands out for its unique approach to engaging non-traditional community college students in meaningful research outside of a classroom or laboratory environment. This sets a precedent highlighting the value of research understanding, preparation, and hands-on experiences [6], [7] at the community college level.

Program Description

After two summers of pilot efforts, the SCUBA project was officially implemented in 2019 with Midland College serving as the lead campus. With Caribbean waters as the research field, this two-week summer research opportunity brought participating students together with highly trained faculty members to learn about the health of the marine environment by collecting water and coral reef samples to perform follow-up analysis stateside. For 7 years, the primary research site was Roatan, Honduras. Due to the COVID-19 pandemic and travel limitations, the group travelled to Bonaire in 2022.

Since its inception, the project has grown and solidified a multidisciplinary research agenda that intersects to improve the health of coral reefs and the effective implementation of educational initiatives. These multidisciplinary directions are: 1) the status of coral reef health and coral disease mechanisms, 2) ion nutrient concentrations, 3) coral mucus bacteria, 4) phytoplankton biomass, and 5) water quality parameters.

The students selected met the following qualifications:

1. Full-time status majoring in a STEM (i.e. Science, Technology, Engineering, or Mathematics) field at a UT System-affiliated community college,
2. Have completed at least 28 college credit hours,
3. Have at least 16 college credit hours in science,
4. Have a minimum 2.8 GPA,
5. Be certified for “open water” scuba diving down to a 60 ft depth (at time of departure),

6. Be 18 years of age (at time of departure),
7. Be a U.S. citizen or a permanent resident of the U.S.

Pre-program Preparation

Prior to the research experience, activities encompassed three main areas: 1) organization of the science research to be undertaken, 2) undergraduate student preparation, and 3) logistical preparation. Organization of the science research to be undertaken meant firstly, matching a research mentor with students having a proclivity for the mentor's focus (for example, placing a student with prior DNA extraction experience with the research effort to identify coral mucus bacteria). Secondly, determining what research materials (instrumentation, tools, and consumables) were required for the execution of the research and obtaining these materials well-ahead of time for the expedition. Thirdly, in some cases (i.e. DNA sequencing, water nutrient quantification) outside commercial contractors were utilized. Determination of which contractors fit the scientific and logistical criteria was required. When necessary, planning for sample transport to the U.S. was arranged. Finally, two months prior to the trip a detailed research diving schedule, coordinated with the local diving contractor, was determined.

Undergraduate student preparation prior to the trip was vital to successful outcomes. Since the expedition provided very limited time in the water, it was crucial that students be competent in their scuba diving. If students struggled during the active dive, the team's effort to execute research tasks in the water suffered greatly. Students were required to arrange for their own scuba diving training from a recognized organization (i.e. PADI, NAUI, SSI) and complete their certification two weeks prior to departure. Even though students were scuba certified, they had vastly different levels of scuba diving prowess. Hence, prior to departure, students were required to attend a scuba/marine science "boot-camp" held by MC. Students were tested by scuba instructors on their basic diving skills and, when necessary, remedial training was implemented on-the-spot. Students were then tutored in the specific diving skills that would be necessary to execute the research. These were: transect line placement and survey, water sample collection, coral mucus collection, in-situ sensor deployment and retrieval.

Logistical preparation involved securing the required research permits from the individual, sovereign nations visited. This is ideally done 9 to12 months prior to the research field trip. Making sure that all members of the group (students and research mentors) had the proper documentation to travel to the destination (i.e. Passport, 2nd picture I.D., health insurance, vaccination documentation, scuba diving certification identification) was essential. Additionally, securing transportation, lodging, meals, and research space was also procured 9 to 12 months before the trip. Packing and transport of instrumentation, tools, and consumables necessary to execute the research required planning and careful attention due to weight limits. The logistics of scuba diving equipment was also a required task. In most cases students transported their own personal mask, fins, and snorkel in their personal luggage. The use of personal dive computers was provided by the host institution. Buoyancy control devices (BCD's), weights and, when necessary, wet suits were rented at the local dive shop. Transport containers also required proper documentation inside for passage through customs (i.e. Single Administrative Documents (SAD's) in two languages). Additionally, international shipping requires special attention. In some cases, equipment was shipped to the field site ahead of the group's arrival. When required,

securing the analysis of samples with outside commercial contractors and arrangement of sample delivery was done four months prior to departure.

Early Mentoring

Orientation sessions with students began six months prior to the research trip. In most instances, students had no experience travelling abroad and limited experience travelling in the U.S. Orientation sessions were held to prepare students on the basics of air travel, packing personal items & equipment, passing through security and customs. These sessions also fully informed students of expected behavior, primarily the respect and observations of local customs, proper work ethic, and professionalism as part of a student group. Six months prior to departure, sessions were held to tutor students on aspects of coral reef ecosystems and the connection of their individual research project to these systems. When possible, students were encouraged to interact with their summer research mentor during the academic year to learn and practice the required research skills for their individual research project (i.e. DNA extraction). Occasionally, when academic year research training was not possible, a two-week science boot-camp was held at MC to drill students in specific theory (i.e. ion compositions, pH, coral anatomy) and skill sets (i.e. DNA extraction, spectrophotometry, etc.).

Hands-on Research

A specific dive schedule was agreed upon with the local dive contractor two months prior to departure. A typical day's schedule is included below as Figure 1.

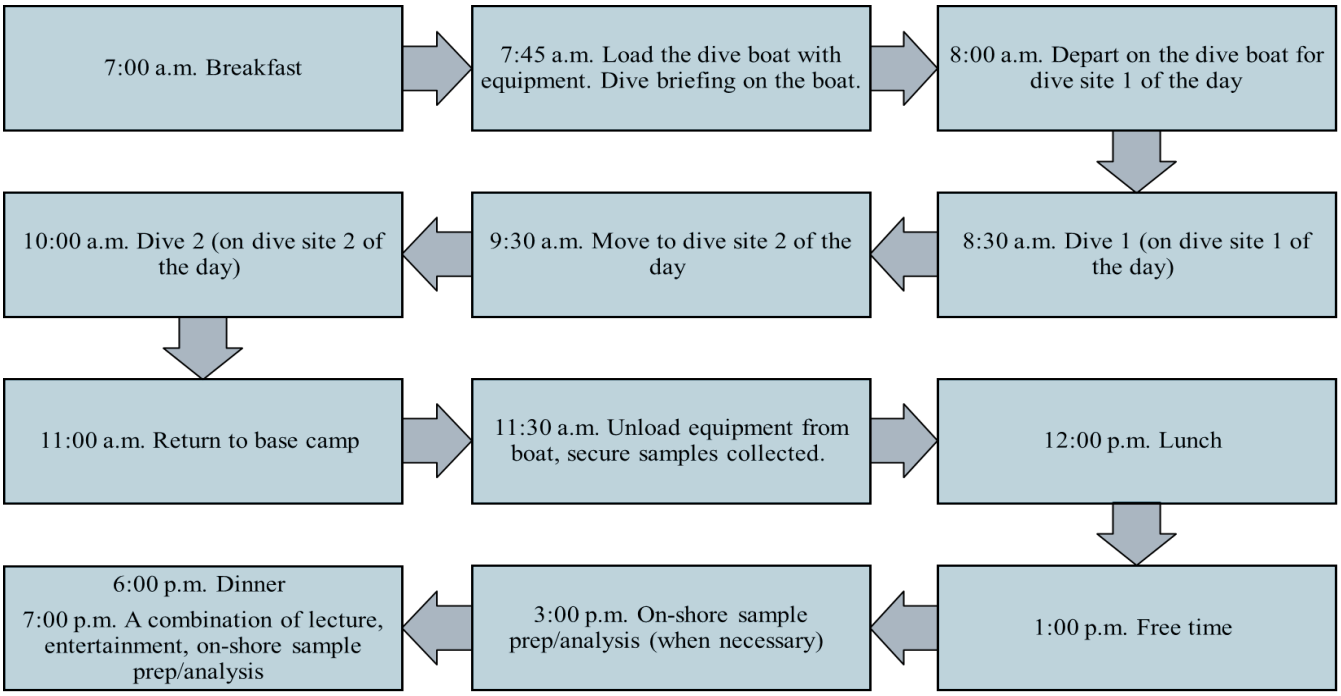

Figure 1. Daily schedule for research dives.

During the two-week program, students acquired data/samples as part of their marine science project and analyzed the data/samples collected. Typically, 90% of the sample/data analysis

occurred at the field site and the remaining 10% occurred stateside. Each student in the cohort was expected to present results from their marine science project at the annual UT System LSAMP Student Research Conference following their summer experience. Presentations at other national conferences were also encouraged. It is anticipated that this work will eventually be included in a peer-reviewed publication.

Assessment

Since 2017, 19 undergraduate students have participated in the SCUBA program. Table 1 provides an overview of the annual student participation in activities since the program's inception. At the conclusion of each SCUBA experience, the evaluation team conducted surveys and focus groups to assess participants' perceptions of the research experience and mentorship. While both surveys and focus groups were utilized, survey data was excluded to maintain respondent anonymity. Additionally, due to the small number of survey responses this paper focuses exclusively on the focus group data.

Table 1: Annual student participation by year
(*no activities due to COVID-19 pandemic)

2017	2018	2019	2020*	2021*	2022	2023	2024
2	2	1	N/A	N/A	5	5	4

The program's evaluation process has evolved over time. From 2017 to 2019, an external evaluator conducted the focus groups, which were recorded and transcribed for analysis. Following the external evaluator's retirement, internal evaluators assumed responsibility for the process, introducing changes to the focus group questions and opting not to record the sessions. Focus groups were held in person during the annual UT System LSAMP Student Research Conference in 2017, 2019, 2022, and 2023, and virtually in 2024 to accommodate out-of-state team members. Due to the COVID-19 pandemic, the program was unable to operate in 2020 and 2021. The 2024 focus group marked a shift to virtual facilitation, allowing greater flexibility for team members and participants. Figure 2 outlines the program's historical timeline, including changes to evaluation procedures and question formats.

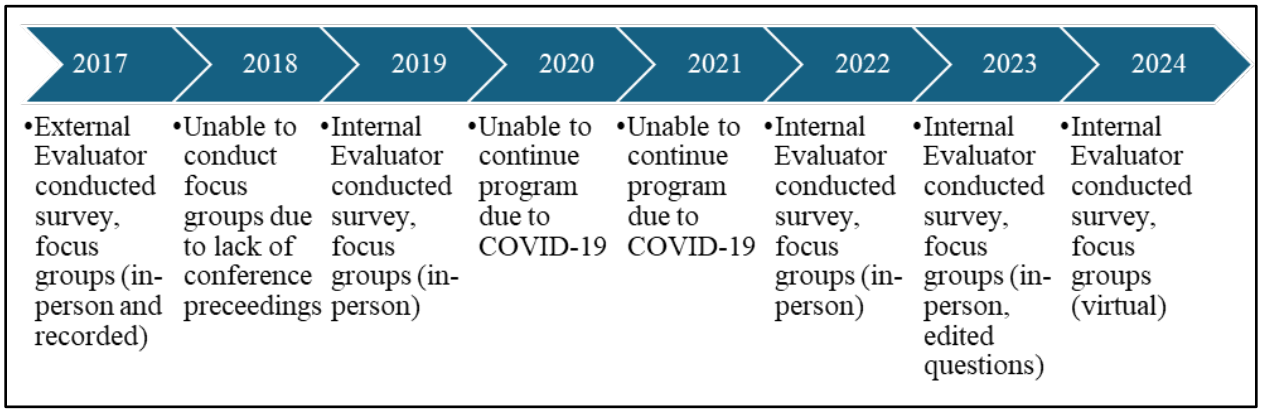

Figure 2. Historical timeline of evaluation activities from 2017 to 2024.

Evaluation Procedure

Prior to data collection, permission was obtained from the Institutional Review Board (IRB) at the University of Texas at El Paso. Upon entering the focus group sessions, participants were introduced to the evaluation team, provided with a brief description of the study, and informed about confidentiality measures. Participants were reminded that their responses would remain anonymous and that sensitive topics discussed during the session should not be shared outside the group. Additionally, they were assured there would be no penalties for opting out of any questions or discussions at any point during the data collection sessions.

These semi-structured focus groups lasted between 30 minutes to 1 hour. Depending on the year, sessions were either recorded and transcribed or documented through detailed notes. Evaluators facilitated discussions, summarized participant responses, and sought clarification to ensure accuracy and depth. They also ensured all participants had the opportunity to contribute. At the conclusion of each session, participants were invited to share additional thoughts and were thanked for their time. No compensation was provided for participation in these focus groups. Following each session, evaluators compiled their notes into a comprehensive document for thematic analysis.

Evaluation Measures

Participants completed an informed consent form upon acceptance into the SCUBA program. Focus group sessions began by asking participants about their perceptions of pre-program activities. These activities included events and tasks undertaken immediately after acceptance, such as obtaining scuba certification and attending lab training. Evaluators then inquired about participants' research experiences and mentorship experiences. Finally, participants were asked to describe the gains they perceived from participating in the SCUBA program. Table 2 outlines the focus group categories and sample questions.

Table 2: Categories and examples of the focus group questions

Pre-Program Activities Tell us about your pre-program experience (e.g., identification of a faculty mentor, connecting with the Program Director, accessing information you may need to plan your mentored research experience) … • What was helpful? • What information do you wish you had in advance? • What suggestions related to pre-program coordination do you have for future programs?
Research Experience Tell us about your research experiences… • What were some of the positive experiences you had when working on your research project? • What challenges did you face with your research? What tools, resources, or information did you utilize to manage challenges faced? • What recommendations do you have for future mentored research participants?
Research Mentor Experience

Tell us about your mentoring experiences…

- How often did you interact with your research mentor?
- What were some aspects of the mentoring that you most enjoyed? Was there anything that you wished you had received from the mentoring relationship but did not?
- Are there mentoring experiences you hope to have in the future?

Gains from Program Participation

Tell us about any changes you may have experienced as a result of your participation in the program…

- Have you experienced a change in your overall motivation to pursue future research or careers in STEM (e.g., an increase, decrease, or no change)?
- What skillsets do you feel you were able to build or refine during your program participation?
- What skillsets did you wish you could build or refine that you weren't able to during this experience?
- Are there new or additional supports you have identified to help you as you pursue research or a career in STEM?

After collecting the responses, the evaluators summarized participant responses. First, the research team carefully reviewed each entry to check for any inaccuracies or mistakes in data entry. For example, the evaluation team removed duplicate responses from the data set. Then, the evaluators read through the data and noted any initial ideas or thoughts about the data. Next, the evaluators identified and provided initial themes capturing important information related to the focus group questions. Finally, the evaluators created an evaluation report to be widely distributed.

Results

Overall, students emphasized the importance of pre-program preparation, describing it as a critical component to their development as researchers. Many students highlighted that the pre-program preparation was where meaningful connections, and a strong sense of camaraderie began to form. During focus groups, it was evident that these bonds endured throughout the program, as participants frequently supported and encouraged one another. However, some participants noted that delayed notifications about program acceptance hindered timely pre-preparation and increased the financial strain. To address these issues, earlier notifications, streamlined lab bootcamps, and financial assistance were common recommendations.

Fostering Group Cohesion

During the research phase, hands-on activities such as diving, sensor building, and marine biology research were highlights of the program. Students valued teamwork and problem-solving opportunities, as well as the positive interactions with external organizations like regulatory agencies overseas. However, challenges included insufficient lead time for permits, equipment malfunctions, uneven workload distribution, and unclear roles. Limited supervision and inconsistent mentoring from some faculty members further compounded the difficulties. Recommendations for improvement include timely permit acquisition, clearly defined roles and expectations, increased mentoring support, and peer mentorship to provide additional guidance.

The abroad experience offered students practical skill-building in diving, data collection, and marine identification. Night dives and teamwork during research enhanced camaraderie, while adapting to environmental challenges, such as strong currents, choppy seas, and unexpected physical demands, fostered resilience. Nevertheless, physical exertion and dehydration were issues for some students, and equipment malfunctions led to data inaccuracies. Encouraging physical fitness preparation, emphasizing hydration, providing anti-nausea medication, and improving logistical planning are suggested to address these challenges.

Effective Mentoring

Mentoring and program interactions were a significant aspect of the program, with certain faculty mentors consistently praised for their exceptional guidance and support. The main project director was highly praised as someone who was not only knowledgeable and good at teaching, but also an inspirational leader. Weekly meetings provided structure and accountability, but inconsistent engagement from other faculty mentors led to uneven support, and limited collaboration between research groups hindered shared learning experiences. Strengthening faculty mentor involvement and fostering better integration among research teams is recommended to enhance the program's impact.

Program Outcomes

We collected survey data on specific participant outcomes, including their perceptions of scientific skillsets and professional development. As mentioned before, due to the small number of student respondents, we chose not to report these findings to maintain participant anonymity. Additionally, we were unable to collect pre- and post-experience data on these outcomes; instead, data were collected only after the experience had concluded.

Participants reported significant gains after completing the program, including the development of technical skills in diving and data collection, as well as teamwork, adaptability, and confidence in presenting research. Many students reported heightened interest in STEM careers and marine biology, with some expressing renewed or a newfound enthusiasm for pursuing advanced degrees. The program also inspired participants to consider alternative career paths within STEM. In future iterations, implementing a pre- and post-survey approach would provide a more comprehensive assessment of changes in these outcomes over time.

Conclusion

Overall, the SCUBA program demonstrated a strong foundation of impactful experiences, with room for improvement in communication, financial support, mentoring, and logistical planning. The program's structure favors a group of 4-5 students and accommodates non-traditional students by allowing them to balance research with other life commitments. Since the inception of the program, all participating students have been considered non-traditional.

Prior to summer departure, students built foundational research skills through lab bootcamps, culminating in their intensive two-week research experience over the summer. This flexibility

contrasts with other summer research or study-abroad programs, which often require full-time commitments that preclude outside jobs, course enrollment, or family obligations. Engaged mentorship also stands out as an important aspect of this project. Post-program reflections and structured follow-ups are recommended to help students integrate their experiences into future career goals.

The findings highlight the importance of pre-program preparation, hands-on research, effective mentoring, and fostering group cohesion in creating meaningful and enduring impacts on participants. By addressing these areas, future iterations of the SCUBA program can further enhance its transformative potential for students. Finally, the experiences documented in the different iterations of the UT System LSAMP SCUBA program can serve as a potential model for collaborative undergraduate research that is highly replicable across institutions.

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