PURM
Perspectives on Undergraduate Research & Mentoring

Navigating a Radical Opening for Interdisciplinary STEM Collaboration and Mentoring Amid Challenge and Change

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Introduction

Engaging students in teaching and learning science, technology, engineering, and math (STEM) is critically important in an era of social and economic change (such as the graying workforce in the US) and an increased need for skilled workers, which has led to a "radical opening" to work collectively to engage students and help them grow into leaders (Myers & Berkowicz, 2015, p. 7). As Hall et al. (2020) noted, high-quality mentoring that focuses on clear expectations, building a sense of community, one-to-one mentoring, and acquisition of mentoring skills can result in a salient experience for both the students and faculty involved. As a collaborative team spanning both the STEM sciences and educational teaching and leadership domains, we share experiences of navigating a pandemic, creating new pathways for collaboration, and seeking to engage students at both the university undergraduate as well as K-8 levels.

In this article, we provide insights on both the design of the collaborative effort as well as how we benefited from the "radical opening" that presented itself in the form of a funded National Science Foundation (NSF) Research Experiences for Undergraduates (REU) grant called "An interdisciplinary approach to the marine sciences for first-year students". Our project and related findings are particularly relevant to both the STEM and the educational fields because they offer a pathway to better engaging learners – and their supporting faculty – at both the university and school settings. We offer multiple perspectives and strategies across institutions and disciplines in the context of historical change and challenge.

Context

The University of North Carolina Wilmington (UNCW) is a coastal regional university of about 18,000 students, over 14,000 of whom are undergraduates. The university's foundational educational experience is applied learning, defined as a "multi-disciplinary model that incorporates faculty- and staff-facilitated learning opportunities such as internships, study abroad, community-based projects, research, directed independent study options and other educational opportunities. Applied Learning inspires students to focus on creative inquiry, critical thinking skills, and written and verbal communication" (University of North Carolina Wilmington, 2022a). Furthermore, the Office of Applied

Learning and High Impact Practices seeks to "support the integration of applied learning across campus, sustain opportunities for innovation through funded projects and special initiatives… [and] share the success of applied learning with multiple stakeholder groups" (University of North Carolina Wilmington, 2022b).

One key stakeholder is the partnership lab school, D.C. Virgo Preparatory Academy. The school is in downtown Wilmington and enrolls about 200 students in grades K-8. Formerly a local public middle school, D.C. Virgo was re-opened in 2018 as a lab school as a result of North Carolina legislation in 2016 that required the University of North Carolina Board of Governors to "establish eight lab schools aimed at improving student performance in low-performing schools" which would provide the opportunity "to redefine and strengthen university partnerships with public schools, improve student outcomes, and provide high-quality teacher and principal training" (University of North Carolina System, 2022). Along with the sudden turnaround this legislation created for the UNCW and D.C. Virgo community, the unforeseen challenges of Hurricane Florence in the Fall of 2018 and the COVID-19 pandemic created unprecedented challenges and opportunities.

The research team was formed from the university and partnership school setting to focus on bolstering undergraduate research experiences and to acquire skills related to the areas of communication, mentoring, and engagement with underserved student populations. And despite the various challenges and changes that the pandemic caused in both the university and K-8 learning environments, initial findings confirm the importance and relevancy of the project goals and design.

Literature Review

Marine Sciences as a Learning and Leading Opportunity

The global ocean is a primary driver of life on Earth; in fact, the earliest life forms most likely evolved in the ancient oceans over four billion years ago (Weiss et al., 2016). The oceans cover 71% of the Earth's surface, hold 97% of the Earth's water, and are vital to moderating the Earth's climate (United States Geological Survey, 2019). Global per capita consumption of seafood reached a record 20.5 kg in 2019, which was derived from a wild harvest of about 92 million metric tons and an aquaculture harvest of about 85 million metric tons (Food and Agriculture Organization of the United Nations, 2022). In the US, 40% of the population lives in counties adjacent to the coastal shoreline, and these counties contribute more than 45% of the annual gross domestic product (National Oceanic and Atmospheric Administration, 2017). Despite this central role in the development and sustenance of life and society, marine resources are threatened by human-induced stressors at a variety of scales, from local to global. Understanding the function of the oceans, mitigating potential impacts of human activities, and developing innovative uses of marine resources require that future generations possess a basic knowledge of the oceans (ocean literacy) and that specialists are trained in the ocean sciences.

UNCW offers comprehensive undergraduate and graduate curricula in the marine sciences, spanning the basic and applied natural sciences, natural resource economics, and marine policy, and its coastal location is ideally suited for engaging in marine research. The education research literature highlights the importance of high-impact practices such as independent research for improving student comprehension and skill development, as well as for increasing interest in STEM careers and retention of STEM majors (Collins et al., 2017; Jones et al., 2010; Lopatto, 2007). The specific objectives for the UNCW REU program were to:

- Provide undergraduate students, especially from underrepresented groups and veterans, an opportunity to experience the excitement of research and discovery, and to work in a collaborative and interdisciplinary team.
- Enable students to develop scientific and research skills, and to hone their oral and written scientific communication skills, all of which are valuable for careers in science.

- Help students to evaluate the impact of their research and how to communicate that importance to a general audience, including K-8 students in a high-needs public school.
- Guide students through the application process for major national and international fellowships, and help them begin the process of applying for such awards.

Undergraduate Research as a High-Impact Practice and Integrative Pedagogical Approach

This UNCW REU program was designed to engage students who had completed one or two semesters of college instruction, to be equipped to conduct research in the interdisciplinary fields of marine science. Recruitment efforts focused on students in community colleges and minority-serving colleges to attract students from underserved communities as well as military-associated personnel. The undergraduate student would be paired with a marine science researcher who would work to create a learning environment. Undergraduate research (UR) has been identified by the American Association of Colleges and Universities (AAC&U) as a "high-impact practice" meant to engage students through "actively contested questions, empirical observation, cutting-edge technologies, and the sense of excitement that comes from working to answer important questions" (American Association of Colleges and Universities, 2022a). Walkington et al. (2020) describe this as a salient practice for "creating an environment conducive to student achievement through setting achievable targets and clear research goals to create authentic research opportunities" (p. 1524). Additionally, a component of the REU site involves engagement with a K-8 school. This program aimed to ensure both rigor and relevance for undergraduate students as they applied research and sought to convey the meaning of their work to others.

In other words, UR is also an integrative pedagogical approach and is not limited solely to producing an original, scholarly, or artistic contribution to knowledge (Council on Undergraduate Research, 2021). While the scholarship of discovery is a critical component of all UR at UNCW, we actively invite faculty and students to span multiple high-impact practices as well as forms of scholarship. (Boyer, 1990). In the case of this REU, we also integrated aspects of the scholarship of engagement and community-engaged learning through activities in which our REU students also engage with K-8 students at D.C. Virgo, a laboratory school supported by UNCW. Doing so serves several functions. First, it gets REU scholars to think about their learning and how they communicate their knowledge to others. REU scholars, then, are challenged to work up and down the social and discursive registers, presenting to established Ph.D. researchers in the marine sciences and bringing their knowledge to bear through discussions aligned with 5th-grade science students. Second, it provides a space for critical reflection on their positionality as recipients of a prestigious, fully funded NSF award. Third, it allows the REU scholars to not only be mentored but to serve as mentors and role models for students coming from a K-8 public school.

As an AAC&U member institution, UNCW is committed to integrative and applied learning and is "dedicated to advancing the democratic purposes of higher education by promoting equity, innovation, and excellence in liberal education" (American Association of Colleges and Universities, 2022b). UNCW is also a member of the Council on Undergraduate Research (CUR). The lead- and co-principal investigators, Drs. Boersma and Grove, have worked with other campus leaders to adopt the Council's updated definition of undergraduate research, the rationale of which states explicitly a "broadened scope for undergraduate research, scholarship, and creative inquiry as well as attention to equity, diversity, and inclusion" (Council on Undergraduate Research, 2021).

Overview of the UNCW REU Site

The REU Team

Dr. Nathan Grove served as the lead Principal Investigator (PI) and REU program director and is a professor of chemistry and Director of the Center for the Support of Undergraduate Research and Fellowships (CSURF). Dr. Jess Boersma served as the co-PI. In his role as Associate Dean of Student

Success and Applied Learning in the College of Arts and Sciences, he helped provide administrative and technical leadership and guidance to the effort.

Other principal investigators/ senior personnel played an integral role in ensuring the continuity and success of the effort. Dr. William Sterrett's role was as a connector. In his role as Associate Dean for Engagement, Professional Learning, and Scholarship in the Watson College of Education, Sterrett oversaw and supported aspects of the K-8 partnership school. Sterrett worked to cultivate interest and possible curricular collaborations between the teachers of D.C. Virgo and STEM colleagues at UNCW. His academic interests in K-12 leadership and STEM leadership helped frame and support the grant objective of helping undergraduate students evaluate the impact of their research and communicating learned experiences to students at the K-8 school. Dr. Jim Stocker, an associate professor of special education, brought expertise in evaluation and experience working at the school in areas related to early intervention and support. Dr. Shawn Bingham serves as a sociology professor and director of the Honors Scholars College and CSURF. He served to support student programming and services.

Dr. Martin Posey and Dr. Chris Finelli, as professors of marine biology, brought content knowledge and grant expertise to the team, as well as the ability to recruit STEM colleagues from across interdisciplinary areas that might provide unique learning opportunities for D.C. Virgo and UNCW students alike. Dr. Laura Jennings served as the assistant principal of D.C. Virgo and worked to support teachers and students in engaged learning opportunities. Drs. Sterrett and Stocker worked closely with her in efforts ranging from the Faculty-in-Residence work (see Dempsey et al., 2021) to the U.S. Department of Education Green Ribbon Schools designation (see Jennings et al., 2022; Sterrett et al., 2022). She helped coordinate important aspects of the work, such as scheduling, mentoring, and on-the-ground logistical support.

The REU Projects

The REU projects ranged from DNA purification and transformation to benthic ecology. In their prepared introductory presentations, students described how they would study predator/prey interactions with GoPro technology, use technology related to tide sensors, observe strains of seagrass and how they adapt to their environment, snail behavioral observation and recording, biomarkers that accumulated in lake sediments, the effects of waves and wakes on water temperature and stratification, analyzing ecological data in a regional sound, temperature effects on seagrass; studying the variation of copepod orientation and predation, and the anti-inflammatory effects of brevenal compounds on human monocyte cells. This array of projects was reflected by the expertise of the UNCW STEM professors who agreed to mentor the REU students.

The UNCW mentors' expertise ranged from oyster aquaculture and ocean sensor network and data management to the genetic composition and marine ecology of salt marshes. It also included expertise in organic geochemistry with an emphasis on studying organic carbon in marine environments; interconnected regions and impacts on sediments and pollution; coastal ocean and estuary dynamics and ecological modeling; submerged aquatic vegetation; copepods in aquatic ecosystems; and drug discovery and development.

The mentors and first-year students worked closely together in the field on their respective topics, and they created research posters that overviewed their project's objectives, methodology, results, and conclusions. This interaction between students and mentors included discussion of the importance and basic background of the projects they were working on and often how these projects related to broader research efforts ongoing in the mentor's lab. It involved close interaction through all stages of the research not only with the mentor but with other students in the laboratories and

discussions of the exciting implications of the results of their research and how this may be a building block for further work.

Perspectives from the Researchers

As the leader of the UNCW REU marine science program, Grove helped steer the project through the uncertainties of a pandemic. Although this ultimately led to a delay in the start date of the project, "it afforded us the opportunity to ensure that the program started in the right way and that our vision was not compromised by limitations associated with COVID. We also had the time to think more creatively about how to attract as diverse a cohort of students as possible through leveraging our strong connections with many of North Carolina's community colleges and historically minority-serving institutions," Grove explained, "Indeed, 70% of the students that participated during summer 2022 self-identified as belonging to one or more groups that have been historically underrepresented in STEM."

Boersma remarked that while the university had prioritized undergraduate mentoring, this collaborative grant allowed the researchers to work with students earlier in their collegiate study (right after completing one year of college or university). As a lead Co-PI, Boersma said "this was an opportunity to work with faculty on mentoring younger university students rather than upper-level undergraduate students already in their major. These were first-year students." He added, "being intentional about bringing the REU scholars into the lab, introducing them to other colleagues in the lab, and welcoming them as equals, especially from the faculty mentor perspective, allowed the REU scholars to immediately feel like they were receiving one-on-one mentoring support." They did not have the same navigational capital since they were early-stage students, they nonetheless were able to quickly join an ongoing research effort and then transfer that learned experience into mentoring a K-8 student.

Sterrett worked closely with D.C. Virgo as a faculty member and administrator for four years. He remarked, "D.C. Virgo had not yet experienced 'normal' since its transition from a public middle school to a K-8 university lab school in 2018. We had Hurricane Florence in 2018 and the resulting disruption, the onset of the pandemic in Year 2, and the subsequent shift in modality, and the NSF REU effort was delayed in terms of implementation. However, we never really settled on "pushing pause" as the planning and envisioning continued. While we were in wait, we worked on developing relationships, from curricular-based field trips and green school efforts such as learning gardens, and from hands-on STEM exploration lab activities to after-school enrichment. By the time summer 2022 came, we had further developed university-school synergies that helped us maximize the experiences for both UNCW and D.C. Virgo students," observes Sterrett. This delay led to the further deepening of interdisciplinary collaborative relationships.

As an evaluator of the NSF REU grant and co-PI of NSF funded, Virtual Access to STEM Careers (#185043, VASC), Stocker assisted in leveraging the assets of both NSF projects to facilitate learning and mentoring experiences between the REU undergraduates and D.C. Virgo elementary students between grades 2-5. The VASC curricular framework synthesizes problem-based learning and immersive virtual environments to remove the traditional barriers that separate underserved and underrepresented students from participating in authentic STEM learning opportunities. By applying the principles of Universal Design for Learning, VASC sparks student interest in pursuing a STEM career in marine, environmental, geological, and computer science. REU students had the opportunity to teach and interact with elementary students to complete the lab components of the VASC curriculum. Stocker asserts, "The great thing about REU is you have undergraduates involved in research under the guidance of a faculty mentor, and then they become mentors themselves by learning to communicate science and build bonds with children who may have been just like them less than 10 years ago."

Dr. Laura Jennings, assistant principal at D.C. Virgo Preparatory Academy, worked to connect the REU students with the D.C. Virgo students. She observed, “It’s about giving back and learning how to mentor and explain science to elementary students. Children look up to undergraduates who are going into STEM careers. We hope the young students can visualize themselves in the future doing the same.” Jennings had led efforts to infuse nature learning in curricular activities (see Jennings et al., 2022) and saw this collaboration as a further connection to that work.

In the earliest phases of the project, Finelli worked in his capacities as a marine scientist, university administrator, and participant in several national reform efforts to leverage professional networks to recruit faculty mentors to the project and to develop student recruitment partnerships with in-land institutions, including minority-serving institutions. He observed that “being intentional in recruiting was the only way to meet our project goals. A laissez-faire approach would not be successful with the challenges that we faced. Notably, research activity at UNCW had been severely disrupted by Hurricanes Florence (2018) and Dorian (2019) and the Covid-19 pandemic, such that faculty acutely felt the need to maximize research productivity during their summers. Direct outreach to faculty colleagues with successful mentorship records and appealing to their strong commitment to student success was required to ensure that a variety of projects were available for incoming students. Similarly, a strategy of direct engagement was pursued with colleagues at in-land and minority-serving institutions to provide students with direct recruitment pathways. Students from in-land communities for whom marine science is unfamiliar or students at minority-serving institutions who know UNCW only as a predominantly white institution may have difficulty envisioning themselves as part of our marine research community. The recruitment effort, therefore, was intentional in helping students connect prior knowledge and skills to the marine realm and helping them to connect to UNCW through people that they trusted.

Early in the project, Posey worked along with Finelli to identify faculty who could serve as student mentors. Posey had previously served as Director of the UNCW Center for Marine Science as well as a previous chair of the Department of Biology and Marine Biology. This provided a perspective on the diverse array of research that could easily incorporate undergraduates from a diverse set of backgrounds. Posey also led the introductory tour of the Center for Marine Science (where most of the students were located for their research time), organized, and led a full-group offshore excursion (the first time many of the students had been beyond the beach), informally met students throughout the summer, and was a mentor for one of the students. One of Posey’s takeaways from this experience was the enthusiasm of both the mentors and the students, the willingness of mentors to engage students to the edge of their experience, and the strong cohort feel developed by the students which allowed them to share experiences and become enriched by the broader experience. At an informal lunch provided by the Center for Marine Science near the end of the program, the students expressed their excitement about what several felt would be a transformative experience. Bingham described this work as “a model for interdisciplinary collaboration- this will benefit the REU scholars down the road, to push them to think of new areas of research they may explore as a faculty member or as a grant-seeker.” Students and faculty came together from myriad majors and, Bingham observed, “this work helped light a fire for students who may not have had the opportunity to be so involved in a research project like this.” He also observed that this work helped the REU scholars “tell their story” and develop their voice about their work. "They had to explain what they were doing and learning to education professors, sociologists, a foreign language professor, and K-8 students- what a varied audience!” Other connectors at the university helped make vital connections. For example, Dr. James DeVita serves as Director of High Impact Pathways and leads the Community College Undergraduate Research Experience (CCURE), which is a partnership between several community colleges and UNCW to provide current community college students with a faculty-mentored UR experience prior to transferring (see DeVita et al., 2021). DeVita helped connect with

community colleges across the state to foster a pipeline of communication and recruit a diverse pool of community college students to participate in the REU.

Evaluative Findings

Program evaluation consisted of piloting a pre/post survey and creating a formative assessment portfolio of student work products. The pre-and post-surveys blended and modified questions from the Student Attitudes Toward STEM Survey (Friday Institute for Educational Innovation, 2012) and the STEM Transfer Model (Wang, 2017; Wang & Lee, 2019) to create a new instrument designed for the REU experience. The pilot survey involved gathering feedback on the program in the four following areas: (a) STEM content interests, (b) STEM career interests, (c) self-regulation, confidence, and efficacy in STEM coursework and tasks, and (d) the value of mentoring.

When compared to STEM coursework taken before the summer, the undergraduates shared that the REU experience provided more opportunities to interact with professors and peers in academic activities and groups. The undergraduates encountered faculty more frequently for discussion related to discipline-specific content outside the traditional course and lab framework associated with a STEM major. These findings are most likely attributed to the intensity of working full-time in applied research experience. Other highlights from undergraduate feedback included gaining more confidence in technical writing skills, writing lab reports, and performing tasks that they believe will promote success in advanced STEM coursework and early career opportunities. The undergraduates placed a high value on mentorship as additional support to help navigate through the academic rigor associated with STEM majors and starting a career. The undergraduates further suggested that younger students interested in STEM majors and careers would benefit from having a mentor as "someone to look up to."

As part of the program requirements, each student created a portfolio that included a resume, curriculum vitae, and research poster. The portfolios served as a method for faculty to evaluate program efficacy from the quality of work produced. The undergraduates participated in weekly Friday seminars that lasted 90-120 minutes long. Faculty provided instruction to start developing each item and as part of the process received iterative feedback via individualized and group discussion. During the final week of the REU experience, the undergraduates worked directly in third, fourth, and fifth grade classrooms, exploring the roles and responsibilities of STEM careers related to sea turtle conservation. The undergraduates worked with the elementary students in small groups focusing on sea turtle life cycle and anatomy, rescue activities, and nest protection. On day three, the young students participated in a "Grand Challenge" applying what they learned using virtual reality headsets. In the Grand Challenge, students assumed the role of a park ranger who had to solve a problem-based scenario. As part of the challenge, students (a) identified the species of sea turtle by its tracks and physical features, (b) measured the carapace (shell) and flippers of the sea turtle, (c) conducted an emergency relocation of a nest where the students needed to extract and count the number of eggs, (d) moved the eggs to a safe location, (e) prepared a new nest to deposit the eggs, and (f) set up a safe perimeter. Most of the undergraduates recommended that more time be spent at D.C. Virgo in future summer cohorts.

Conclusion and Recommendations

This interdisciplinary effort thrived amid unexpected challenges due to commitment to the collaborative relationship between the university and the laboratory school, the ongoing nature of existing projects such as the virtual access grant, a commitment to bolster access to learning experiences for first-year university students, and a willingness to explore new opportunities for collaboration that involved STEM faculty and K-8 teachers. Whereas many mentoring relationships develop over multiple semesters, this effort spanned eight weeks over the summer. Here are three recommendations that the research team identified:

1) *Clear introduction to the research environment.* The research team saw great value in being intentional about introducing the students to the lab and learning environment. This helped ease their way into the quickly moving apparatus of an active research project. Introducing people, explaining learning spaces, and overviewing relevant equipment and learning spaces allow for clarity of purpose, encourage safety and belonging, and maximize time spent in the learning environment.
2) *Partnership outreach*. Connecting with a partner school provides an outlet for the REU scholars to reflect on their learning and leadership skills as well. Communicating authentic teaching and learning experiences allows rich discussion and synthesis of learning (Sterrett, 2016). Finding ways to connect undergraduate research to impactful learning experiences in the community can foster a sense of purpose in the work that extends beyond the research itself.
3) *Building an interdisciplinary team*. Involving a diverse cadre of scholars on the NSF REU team (Principal Investigators spanned Colleges of Education and Sciences, various ranks, and included those in administrative roles as well) was a benefit in being able to adapt from multiple perspectives and pivot points. This interdisciplinary collaboration can lead to further research efforts that are mutually beneficial to the researchers, partners in the field, and ultimately to the students engaged in the work.
4) *Encourage student engagement in dissemination efforts*. Undergraduate researchers play an important part in contributing to research dissemination efforts. For example, this NSF REU program was cited in an Oceanography paper co-authored with the UR student (See Bresnahan et al., 2022). From papers to poster presentations, students can learn from their mentors how best to contribute their findings in academic outlets.

These initial observations address the radical opportunity of maintaining a course for collaboration and prioritizing the unique experiences of mentoring first-year university students who will, in turn, share lessons learned with K-8 students. The localized context of a coastal, regional university and partnership K-8 school offers a pathway for similar efforts in a context that values this interdisciplinary approach to teaching, mentoring, and collaboration. Fostering a sense of belonging through welcoming the REU scholars and empowering them to share with K-8 students helped create a pathway for future openings and interdisciplinary efforts.

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