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THE INSIDERS: UNDERGRADUATES CRITICALLY EXAMINE THE PROS AND CONS OF A TEAM-BASED MARINE RESEARCH PROGRAM

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ABSTRACT

The Marine and Aquatic Research Experience (MARE) is a student-generated, faculty-guided not mandated, model for hands-on, team-based, environmental science research for undergraduates, of any class rank and any academic major. MARE is unique in many ways compared to traditional undergraduate research models. MARE was envisioned and established in the fall of 1998 as part of two Research-Based Learning (RBL) Critical Connection Courses (CCC) entitled Design of Inquiry in Science and Implementation of Inquiry in Science. The initial goal was to study the dynamic processes occurring in Winyah Bay, South Carolina. As we began to establish research directions, MARE members organized themselves into crews to allow collaboration between members with similar research interests. Currently, there are 28 members in MARE, composing five crews. As students involved in MARE since the beginning, we have witnessed the evolution of the team as a whole. We felt it was time for us to take a step back and critically examine ourselves. We have formulated a list of the benefits and challenges of working in a team doing scientific research as undergraduates. Following our presentation on student-driven team-based research, there was a roundtable discussion focusing on three main issues: how MARE is funded, what the personal benefits of team-based research are, and what are the roles of the individual members. Overall, we came to the conclusion that team-based research is possible and rewarding due to the unique research and learning opportunities it provides students. The rewards of this experience directly reflect the ideals of Critical Connection Courses and Research-Based Learning, illustrating the possibilities of these educational innovations.

INTRODUCTION

The Marine and Aquatic Research Experience (MARE) is a student-generated, faculty-guided not mandated, model for hands-on, team-based, environmental science research for undergraduates. The program is open to students of any class rank and any academic major. Funding for MARE is provided by the South Carolina Honors College and the Belle W. Baruch Institute at the University of South Carolina. The overall goal of MARE is to learn about a variety of marine and aquatic environments and to observe the impact of human activities on these environments. Through this experience, we are able to conceive, design, execute, and present original scientific research as well as improve leadership, organizational, teamwork, communication, and problem-solving skills.

¹ Researcher and author Traci J. Heincelman suffered a tragic and untimely death in an automobile accident on March 10, 2002. This research collaboration is published in her memory.

MARE is unique in a variety of ways compared to traditional undergraduate research models. MARE is neither part of a degree-granting program nor part of a professor's regular research program. MARE is not part of a dues-paying social club or scientific society. The program is maintained through time and effort volunteered by the student and faculty members. Students are responsible for recruiting faculty members as collaborators, not directors, to MARE research agendas. The student MARE members have ownership of their own data and assume genuine responsibility for their actions.

HISTORY AND EVOLUTION

MARE was envisioned and established in the fall of 1998 as part of two Research-Based Learning (RBL) courses called Critical Connection Courses (CCC) (Williams et al., this volume). The CCC's were entitled Design of Inquiry in Science and Implementation of Inquiry in Science. The initial goal of the program was to conduct oceanographic research in Winyah Bay, South Carolina, in order to understand the dynamics of the estuarine system located there. Four expeditions to Winyah Bay were conducted in the winter and spring of 1998-1999. The primary purpose of these expeditions was to gather preliminary data to aid in the formulation of future research hypotheses for Winyah Bay. The initial data collected contained information regarding nutrient concentrations, salinity and temperature distribution, bottom sediment types, and GPS locations. During the fourth expedition, we observed salinity values that strongly deviated from those measured on previous expeditions, which sparked questions about the forces and physical parameters behind the estuarine system. Subsequently, we decided to conduct a 30-hour sampling expedition over two complete tidal cycles and to look at the impact of stream flow and tidal forcing on the estuary. Since that expedition, our cruises have become smaller, more goal-driven, and focused. In the winter of 2001, MARE expanded its domain to include environmentalist aspects, outreach to freshman marine science classes, and collegiate extension. After gathering and analyzing a presentable data set, MARE has given several presentations across the country, including the Southeastern Estuarine Research Society (SEERS) in Tampa, Florida, the American Geophysical Union (AGU) in both Washington, D.C. and San Francisco, and many others.

Currently, MARE has 28 members, 18 in-state students, 10 out-of-state students; 16 women and 12 men. MARE includes members from all four class ranks from freshmen to seniors and also involves some graduate school members acting as informal advisors. Most members of MARE are marine science majors, but we also have a full range of members from other majors, including other science majors and liberal arts majors.

As MARE began to establish research direction, the members decided to organize into crews in order to allow for greater collaboration among members with similar research interests. The biological oceanography crew is interested in studying species richness and diversity of both micro- and macro-organisms. This crew would also like to monitor the impact of anthropogenic activities on the distribution and concentration of organisms within the estuary. The nutrient chemistry crew measures the concentration of pollutants in Winyah Bay from both point and non-point source pollution as well as examines the basic constituents of the water in Winyah Bay in an attempt to determine the environmental health of the ecosystem. The geological processes and sediment dynamics crew is interested in studying the structure and geometry of Winyah Bay. This crew also studies the volume and type of suspended material in the water column. The physical oceanography crew is interested in the currents and circulation of water throughout the

estuary as well as the impact of watershed runoff and tidal conditions on salinity values within the estuary. The remote sensing crew uses aerial photography to observe the surface flow features of the estuary. In collaboration with the physical oceanography crew, the remote sensing crew is also trying to determine if surface features such as foam lines represent subsurface frontal mixing boundaries.

The authors of this manuscript have been involved in MARE since the first expedition conducted during our freshman year. On the first research expedition, we were primarily involved in data collection but not analysis. With each additional trip, we took on bigger roles and more responsibility. We also became more interested in the data analysis and interpretation, attended conferences as observers, and began to conduct our own research. On the fifth expedition, two of the principal leaders of MARE (seniors at the time) were unable to go, and so we had to assume, as sophomores, the overall responsibility for conducting the expedition. This experience proved to us that we were ready to take over leadership roles and also initiated the transition from the first to second generation of MARE leadership. In the future, the newer members will fill our positions as leaders.

Along with our own personal growth, the group has also undergone several transitions. As members graduated, the group structure had to adapt. This included a change-over not only in leadership but also in the direction of the research being conducted. Crew development became more dependent on the membership of the individual crews. Some crews rapidly became well established due to increased member involvement and ambition. The success of these crews served to motivate the other crews to excel. As a result of these evolutions, MARE has formed into a hypothesis-driven team of scientists, split into research crews that collaborate with each other in order to function as one larger research team.

BENEFITS AND CHALLENGES

As students involved in MARE since our freshman year, we have witnessed the evolution of the team as a whole. We felt it was time for us to take a step back and critically examine the benefits and challenges of team-based research. One of the main advantages of participating in a group like MARE is that all members are allowed to share and generate new ideas. We have created a forum conducive to communication of ideas by holding weekly meetings to discuss research directions and upcoming events. Having a diverse group of undergraduate members creates a broader learning base for students. This allows for a vertical exchange of knowledge across class rankings, maturity levels, and experiences from courses and time spent in the field. By working in a team, members are learning the importance of collaboration and cooperation. We recognize the necessity of maintaining a level of mutual respect for our colleagues. By becoming a member of MARE, more students gain exposure to actual research environments. Also, a single professor can deal with a greater number of students when the students have organized themselves into a research team. A very important aspect of working in a team is the ability to build character as well as gain and improve self-confidence and self-esteem. Furthermore, students improve their socialization, communication, and listening skills. Conducting and presenting our own scientific research gives student-scientists the opportunity to learn about professional courtesy, such as who receives credit for work, and proper conduct at conferences, aspects of science which cannot be taught in the classroom.

While there are numerous advantages to MARE and team-based research, it is not perfect, and we recognize that there are challenges inherent in this program. The main challenge

of working in a large group such as MARE is the lack of communication. Another challenge involves questions as to who is in charge, who takes responsibility for running expeditions, and who receives credit for the work. As student-driven, undergraduate research, the scientific process is inefficient at times. We are constantly figuring things out for ourselves and making mistakes along the way, but this is itself an important part of the learning process. We are further tasked with sustainability, both in terms of recruiting new members and securing financial support. As MARE is a model outside of the traditional apprenticeship model, faculty may be hesitant to become involved for fear of being overwhelmed. Moreover, within team-based research, some students may get taken advantage of and end up doing other members' work. There is also the potential for students to volunteer too much time and become over-committed, which may have repercussions on class performance. Also, inherent within any group, there will be personality conflicts and clashes. We are a fairly accepting group but it is always possible that we will run across people with whom we do not get along or with whom it is hard to work. While this may not be preferable, it adds to our professional and personal skills. Initiating a program like MARE is risky, for it is difficult and overwhelming to begin due to the scope of the endeavor. However, student-driven team-based research forces students to take responsibility for their own learning and growth. Furthermore, involvement in MARE may be stressful and intimidating to newcomers. Members are forced to compromise, to trust and rely on each other, and to deal with people with whom they would normally not associate. People who help but do not become involved in the science and people who use MARE for personal advancement only challenge us. The last challenge is more of a hypothetical one, which MARE has not experienced, but there is the possibility of having our ideas stolen by other students and professors.

Within this list of challenges, there are some that MARE can clearly improve upon and there are some that are inevitable within any group. For those that we believe can be improved upon, we are working on solutions. For instance, we have sign-up sheets for equipment and hold weekly meetings to improve the communication within our group. To make the organization less complicated, individual members or crew leaders must now present a float plan for upcoming cruises and follow up each expedition with a cruise report. Along the same lines, a member must illustrate worthy need for resources in order for them to be allocated. We are naturally becoming more efficient by gaining familiarity with sampling protocols and location. Furthermore, to ensure the sustainability of MARE, we have documented our protocols and are working on teaching data analysis and interpretation skills to newer members. By demonstrating our professionalism, we are slowly developing the trust of hesitant faculty, and finally, we are writing proposals that are more hypothesis oriented, to combat our funding problems. Nevertheless, there are those challenges, such as personality conflicts, riskiness, stress, volunteering too much, getting taken advantage of, and trust issues that we will never see totally disappear.

ISSUE REACTION

Three main issues were addressed by discussion participants. They were how MARE is funded, the personal benefits of team-based research, and the roles of the individual members. The issue of funding was raised as to what other sources of funding are available. Initially, MARE was funded by personal funds from Dr. D. Williams. Currently, MARE is funded primarily by the South Carolina Honors College, which provides \$5,000 with matching funds

from the Belle W. Baruch Marine Laboratory in terms of technical support and data analysis. In terms of both the educational impact and research conducted, MARE is a very cost-effective program. Nevertheless, with increased funding the scope of MARE can expand, and suggestions were made as to ways to increase MARE's funding. A suggestion was made about the possibility of working with faculty to trade monetary funds for research while still maintaining a student-run structure. Another suggestion was to attach MARE to a bigger effort. MARE may be able to provide data to a larger study, such as those conducted by government and environmental agencies, and obtain funding to support MARE's effort. However, when questioned about the possibility of formalizing MARE into a university funded academic program, we concluded that it was not the ideal way to increase financial support. We felt that if MARE were to be formalized it would be restricted in terms of membership, and students would be forced to adhere to a curriculum designated by the university. Thus, the formalization of MARE would result in a loss of spontaneity of commitment, and the beauty of a student-driven team-based research program would be lost.

The next main topic of discussion centered on what we as students personally gain from our involvement in MARE. Involvement in MARE connects directly to our career plans by giving us an opportunity to practice our professional life skills, research skills, team-working skills, and presentation skills. By helping other members with problems, MARE members improve their problem-solving abilities and interpersonal relationships. In addition to these practical skills, by attending scientific meetings, we have developed a network of faculty and researchers from around the nation. Being involved in MARE is gratifying because the work is our own, and we are able to make connections between the classroom and the "real world," providing us with a sense of accomplishment and personal growth. One student commented that before becoming involved in MARE, "I was just getting a degree, now I'm getting the most out of my education."

The last main topic discussed was the specific role that members play within the organization. Individuals can only benefit from MARE if they decide to put in time and effort. No one works for anyone else within the group. The data collected are available to all members, regardless of class rank, and while the entire group receives acknowledgement for their contributions, it is those who take the initiative to analyze the data and draft proposals who receive the scientific credit. The menial tasks associated with our research, such as cleaning the boats and acid-washing bottles, etc., are not assigned exclusively to the freshmen or newcomers but shared among all members. There is no punishment for being the new member. Hypotheses are decided upon based on the research objectives of individual crews, but each crew has to persuade the whole team to allocate our limited resources to work on their research idea. Even though the crews work on different projects, the data are shared amongst all.

CONCLUSIONS

Team-based research is possible and rewarding. It is not easy, and there are many challenges. As a result, student-directed research requires highly dedicated and motivated people to succeed. With a group of this nature, however, the rewards are numerous. Students are able to generate, design, and implement their own research agenda. Many students are able to gain valuable hands-on experience as well as gain a new outlook on science and how it is conducted. This experience also reinforces and excites our interest in regular classes, which we feel is one of the most fulfilling aspects of MARE. Ultimately, in devising this list, we realized that these

rewards directly reflect the ideals of Critical Connection Courses and Research-Based Learning, illustrating the extreme possibilities of these educational innovations.

ACKNOWLEDGMENTS

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AUTHOR BIOGRAPHIES

Traci Heincelman, from Derwood, MD, was a junior in the Marine Science Program and South Carolina Honors College at the University of South Carolina and the recipient of a McNair Scholarship.

Edward Majzlik is a native of Aiken, SC, and currently enrolled as a junior in the Marine Science Program at the University of South Carolina. He is also the leader of the Physical Oceanography crew of MARE. Following graduation from USC, Edward plans to attend graduate school in oceanography.

Christie Robinson is from Great Falls, MT, and currently is a junior in the Marine Science Program and South Carolina Honors College at the University of South Carolina. Within MARE, she works with the nutrient chemistry crew and the biological oceanography crew. Ultimately, she would like to go to graduate school and study deep-sea ecology.

Lindsey Wise is a junior at the University of South Carolina double majoring in Chemical Engineering and Marine Science. Her focus in MARE is examining the human impact on the health of the Winyah Bay system, including point (International Paper discharge) and non-point (farm run-off) sources of pollution into the bay and rivers.