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Interdisciplinary Cohort-Based Undergraduate Research at the Ocean Research College Academy

Contained within the Council on Undergraduate Research's definition of undergraduate research is the phrase "original intellectual or creative contribution." Conducting original research in undergraduate institutions, particularly in community colleges, is challenging, however. To achieve original research, many undergraduate research models seek to mimic graduate programs in which small groups of students work under a faculty member who is exploring his or her own research (Lopatto 2010, 21). This article makes a case for a different approach to undergraduate research: engaging large groups of students in the open-ended, active process of undergraduate research.

One key to this approach is building a community of learners through relationship-rich opportunities and the utilization of student cohorts. A second key is the intentional integration of active learning and a focus on evidence to support one's ideas in all courses taken by the cohort of students. A third key is field-based research in the local watershed's drainage basin. The work is relevant to students and the local community, enabling students to share their findings at community events as well as at scientific conferences. From the beginning, these keys have guided faculty at the Ocean Research College Academy.

Now in year nine, Everett Community College's Ocean Research College Academy (ORCA) has firmly established an interdisciplinary, two-year, cohort-based learning community with original, student-led research as its focus. Recognized in 2012 as a finalist for a Bellwether Award for innovation in community-college instructional programs, ORCA's experience parallels key components of undergraduate research experiences that other institutions have developed over the last ten years.

Recommendations by the Boyer Commission Report (Kenny 1998) and work by George Kuh (2008) suggest that undergraduate research through inquiry, investigation, and discovery is a high-impact educational practice. Additional recommendations by Kuh highlight the importance of common, collaborative, and cumulative intellectual experiences through the use of learning communities, as part of a first-year experience, as pivotal practices for degree attainment. More recently, a focus on writing-intensive, community-based learning has been highlighted in recommendations from Liberal Education and America's Promise (LEAP) (Association of American Colleges and Universities 2012). Each of these practices is found in ORCA's cohort-based model.

Educational innovators who share similar convictions that students learn best when actively involved in constructing their own understanding are finding success applying these principles with their own undergraduate researchers. We are encouraged by the parallel work of James Hewlett at Finger Lakes Community College (2009) and Kalyn Owens and Ann Murkowski at North Seattle Community College (2009). Their experiences illustrate transformative work that engages community-college students in undergraduate research linked directly with academic coursework. Perhaps more important, this work illustrates a crucial paradigm shift: the recognition that research and teaching are not exclusive activities. Done deliberately, the process of conducting research becomes the foundation for learning. As Hewlett states, "research is teaching" (2009, 12).

ORCA embraces the same paradigm shift and core goals through a unique approach and design. ORCA was established by educators convinced that students learn best when they are actively involved in the learning process, building more complex understanding through scaffolded experiences that include failure and consistent student reflection on what and how they learn. The ORCA student experience is enhanced by interdisciplinary learning, an emphasis that has evolved over time.

Most interdisciplinary models come from K-12 settings and involve thematic approaches to blend core content. While the founders of ORCA tried some of these models, the process felt contrived at times, and traditional instructors struggled to make connections. Ultimately, we have instead focused on how the process and nature of learning in all courses is analogous to the process and nature of science. By sharing a language and defining what it means to summarize, analyze, and interpret in history, English, mathematics, and science, ORCA instructors and students are able to have a dialog with each other across disciplines and experiences. In addition, because cohorts of students work so closely with each other and with the same core group of faculty over two years, subject and thematic overlaps among courses and disciplines often emerge.

Another benefit of the ORCA cohort model is the ability to build an ethos of inquiry across disciplines, which we call the "ORCA way of questioning." Deliberate efforts by faculty to develop in students clear understanding of core terms such as analysis and interpretation have created rich discussions among faculty and greater potential for students to transfer skills from one class to another as well as to research in the field. In addition, evidence is central to work in history, humanities, English, oceanography, and marine biology (all are courses taken by students in their first year in the ORCA program. The focus on verifiable evidence and the various ways people interpret that evidence is central to rational intellectual debate and discussion, and it is key to the scientific process.

Program Description

ORCA is a two-year, dual enrollment, early-college program that meets most requirements for high-school graduation and associate of arts and sciences degrees. Most students at ORCA begin their freshman year in college while still in the eleventh grade. Students stay together in seminar-style classes for two years and take a prescribed sequence of particular courses. Instructors use similar approaches to assessment and focus on a common language to describe inquiry in each discipline. For example, for each cohort of students the first quarter sets the stage for the introduction to inquiry through the use of analysis and interpretation. History utilizes primary documents and transitions students from summarizing to analyzing and interpreting. Mathematics instruction focuses on visual data analysis and linear regression graphs and formulas. Ocean technology introduces students to using oceanographic tools to measure data and then asks them to analyze and interpret their own graphs of temperature and salinity profiles. Humanities coursework explores the role of perspective and value in human conceptions of nature through analysis and interpretation of American nature writing. Table 1 shows the two-year sequence of required ORCA courses.

Table 1. ORCA Course Sequence

	Fall Quarter	Winter Quarter	Spring Quarter
Year 1	**Humanities:** Negotiating Nature **History:** US History 2 **Mathematics:** Precalculus 1 **Ocean Technology:** Tools for Estuarine Sampling	**English:** Composition 1 **History:** US History 3 Oceanography: Intro to Ocean **Mathematics:** Finish Precalculus 1, start Statistics	**English:** 20th Century American Literature **Biology:** Marine Biology of the Pacific Northwest **Mathematics:** Statistics
Year 2	**Political Science:** American Politics **Mathematics:** Precalculus 2 **Elective**	**Geography:** Cultural Geography **Mathematics:** Calculus **Elective**	**English:** Composition 2 **Biology:** Topics in Ecology **Elective**

Encouraging students to sign up for a two-year program requires a hook of some kind, and for many students ORCA's hook is the relevant field work. A "real world" research project that contributes baseline data of an understudied estuary has become the thread engaging students in active inquiry and construction of their own understanding, blending core content with classes in oceanography, mathematics, and English. (For more on this process, see Kveven 2009). The research is the central experience for ORCA students, and it allows for guided research practice, reliable long-term data gathering, and significant opportunities for students to develop an original research focus related to the local estuary.

Over the last nine years, this approach to undergraduate research has enhanced the undergraduate experience. High student graduation rates, significant numbers of students continuing in the STEM (science, technology, engineering, and mathematics) fields, and students' reflections about personal growth all point to a powerful experience, with original research at its core.

Methodology

Students' undergraduate research experience begins during quarter one at ORCA and is centered on a long-term environmental monitoring project in Possession Sound (the northeastern arm of Puget Sound), located 30 miles north of Seattle. Designed by faculty along with an early cohort of students, the State of Possession Sound (SOPS) project has been revised and improved by each new cohort. While SOPS was originally modeled after research conducted by a variety of Washington State agencies that were focused on restoring the health of Puget Sound by 2020, the field work is now fully integrated into the design of the ORCA program. At the heart of this research is blending oceanography course content with field work centered on students asking questions. Faculty reflection and student feedback continue to guide the evolution of this nine-year project, which has thus far produced an expansive data set; some of the data make an original contribution to oceanographic monitoring (see SOPS Updates at www.everettcc.edu/orca).


Josh Searle and students deploying equipment. *(Photo credit: Ardi Kveven)*

To introduce the 50 first-year students to the project, students read the excerpts of the latest Puget Sound Partnership publication (2009) on water-quality monitoring in the area. In addition to humanities, math, and history classes, the first quarter at ORCA begins with a two-credit Ocean Technology course focused on use of oceanographic tools in a field-based setting. Students learn the use of oceanographic instruments (such as multi-parameter sondes (YSI 85 and 650)) in the classroom and then deploy these instruments from a dock. The first quarter emphasizes three types of water measurements—of dissolved oxygen, temperature, and salinity, which we call DOTS data. Starting on a dock at the mouth of the estuary, students can observe evidence of tidal influences before they even begin sampling. Tides and freshwater inputs create density gradients that are modeled in lab (Karp-Boss et al. 2009) before students conduct field testing. Students are asked to hypothesize what they will encounter regarding temperature and salinity in the field. Any incongruities measured in the field (e.g., when cold fresh water layers on top of warmer salt water) are then reviewed and modeled back in the lab.


Ardi Kveven captaining the small boat for river sampling. *(Photo credit: Josh Searle)*

After the dock-based sampling, students prepare to take measurements from a boat. Students spend the day before the outing prepping and calibrating instruments, increasing familiarity and building confidence. On each trip, a local passenger ferry provides the platform for a suite of oceanographic sampling. Divided into seven groups situated in different sections of the boat, students collect DOTS data, as well as data on ocean acidity, relative chlorophyll concentration, nutrients, fecal coliform, heavy metals in sediments, plankton, marine birds and mammals, weather, visibility and organisms on the seafloor. On the first two cruises of the year, second-year students mentor the first-year students on deployment and recovery of the instruments.

After the cruise, students enter and graph their data in an Excel spreadsheet. Two days later the instructor leads small

Ardi Kveven teaching "dock" oceanography: how to deploy sampling instruments.
(Photo credit: Josh Searle)

groups through a seminar to discuss their findings. Written data analysis will be submitted and revisions will be made for each successive SOPS cruise as students develop their skills at analysis of spatial and temporal data. Students will stay in the same group and at the same SOPS station for three cruises and will present their findings to their peers at the end of the term. The next quarter they will rotate to a new station and become the experts in that subject area (again, they have a peer mentor at the station to guide them through the protocols), repeating the process and building a more complex understanding of estuarine dynamics through the lens of core oceanography content in the winter quarter and marine biology content in the spring.

From a programmatic perspective, the involvement of all ORCA instructors on the vessel to help students solve problems, as well as on the Fridays after a cruise, helps build the ethos of inquiry and culture of collaboration across disciplines.

Past cohorts of ORCA students have contributed to a now-impressive database; students collect, store, and analyze data according to a suite of oceanographic parameters. As students progress through their first year of classes, and as they gain more content knowledge in algebra and statistics, they are expected to increase their ability to analyze their own data and the data collected by previous cohorts. Instruction and expectations are deliberately scaffolded to support students in the process of conducting undergraduate research. Some cohorts, more than previous cohorts, embrace greater responsibility for refining procedures and analyzing and comparing data. The strength of SOPS is that it allows for flexible instruction without endangering the key components of the long-term data set. In other words, research in this case is teaching at the same time.

The ORCA context extends well beyond this first-year experience into a more independent second year of opportunities. After students' foundational experience in nine day-long cruises, they have the opportunity to continue SOPS-related research with an original question of their own design. In the second year, students use the skills they have developed for asking testable questions, designing sampling methodologies, and interpreting data, but have more freedom to explore topics of personal interest. Some examples of previous student research include sampling for heavy metals near storm drains (with the samples analyzed at a laboratory approved by the Environmental Protection Agency), measuring zooplankton response to changes in salinity, detection of heavy metals in harbor seal scat, and study of osprey density and nesting sites along the Snohomish River. Students take a research seminar in the winter of the second year to support the development of the research projects, and they receive credit for composing a formal research paper, which they write in their final quarter's Composition 2 class.

Recent National Science Foundation (NSF) funding for a research training laboratory and equipment, as well as support for professional development from the Community College Undergraduate Research Initiative (CCURI), have increased the opportunities for second-year students to probe more deeply into an original research question inspired by the first-year experience. This research is typically in a STEM field (although some students do choose topics in other disciplines). Many of these students present posters at scientific conferences and undergraduate research symposia. At the heart of their research, however, is the central notion of asking questions, designing a method to test those questions, careful collection and analysis of data, and finding ways to effectively communicate results to others. It is the process of science.

It is clear from our ongoing assessment of this cohort-based approach to research that students are energized, excited, and engaged in field research that is relevant, purposeful, and real. Thus far, ORCA graduation rates are unparalleled in community colleges: after the two-year program, an average of more than 80 percent of ORCA students earn the associate of arts and sciences degree, with focus on a STEM field. After graduation from ORCA, 95 percent of students matriculate at a baccalaureate institution, and 66 percent pursue a STEM field. All annual and alumni survey data point to the SOPS work as pivotal for the ORCA participants' development as scholars, but responses also point to increased higher-order thinking about students' own learning (see free responses below).

Student Survey Responses to ORCA

Each quarter, students fill out a survey anonymously reporting on their academic development, using a Likert scale, and also fill out a free-response section. Below are some free-response highlights.

Prompt: Most important thing you learned from this science course:

- *The idea of asking questions and the fact that it's okay to say we don't really know, but we have more questions and ideas for improvement.*
- *How to do research.*
- *How to problem solve along the way.*
- *How to improve my science writing.*
- *How to set up and answer a field research question.*
- *The most important thing I learned was how to analyze and interpret data.*
- *Doing what we wanted to do for our experiment even if it failed.*
- *How to work with team members, and how to try and be as random as possible in data collection.*
- *How challenging research is.*
- *How difficult it is to get good data to form conclusions.*

Prompt: What did you like best about ORCA this year?

- *I liked the strong sense of community that ORCA develops. There is a feeling of team work and camaraderie which makes the challenging tasks not as difficult.*
- *I liked how personalized the teachers were and how I felt they wanted me to be successful.*
- *ORCA pushed me to that limit when I questioned myself and my abilities. I became much more involved with my work and became a better student.*
- *What I liked best about this quarter at ORCA was the opportunity to build relationships with my instructors; the room to question is appreciated.*
- *I like that I have begun to look at science more analytically, rather than just as facts. I think more deeply about things inside and outside of school.*
- *The people: students and faculty. Also the trips plus the whole learning community.*

Prompt: What suggestions do you have for improvement?

- *A night for parents to come and have us present SOPS work to them so they can get a better idea of what we are doing.*
- *More time with pods (name for smaller cohort groups) together for SOPS.*
- *I would suggest more cross-pod interactions, more subgroup meetings and more cruises.*
- *There isn't much I could improve, maybe have SOPS trips more often than once a month?*
- *I suggest having more seminars, as we did at the beginning of fall. I believe that they would really help, especially with English, history and SOPS.*

Asking students to reflect on their learning is standard practice at ORCA. It is indicative of the culture at ORCA, which is designed around experimentation and learning by asking questions. The efficacy of our approach to teaching and learning resulted in local, state, and federal support for a new building designed around supporting students and faculty engaged in undergraduate research. The new facility's location on the waterfront and innovative use of classroom, lab, and office space have enhanced efforts to create a collaborative, effective undergraduate research experience.

Lessons, Challenges

The ORCA model of undergraduate research offers a number of obvious advantages. Student cohorts have common experiences from the beginning. Faculty members have greater control over class schedules, emphases in course content, and learning over time. Faculty can get to know students better over two years, which allows them to more deliberately work with students to identify academic strengths, weaknesses, and interests. From the beginning, ORCA faculty have been inspired by the pioneering work compiled in the National Research Council's How People Learn (2000) and by the Committee on Facilitating Interdisciplinary Research (2004), which points to rethinking traditional disciplinary boundaries since most real-world environmental issues are interdisciplinary and require multifaceted solutions.

In practice, ORCA's interdisciplinary, two-year program allows faculty and students to share a common purpose and work toward a clear set of outcomes. The cohort model may appear daunting because essentially it requires students to commit to a specific set of courses over two years in order to gain an associate's degree. Although students can opt out of the program at any time, the carefully scaffolded experience does not allow students to enter the program at any point other than the beginning of each cohort's experience. These are clear trade-offs, especially in community-college environments focused on providing maximum flexibility for people with busy lives beyond the campus. However, our two-year graduation rate (>80 percent), matriculation rate to universities (95 percent) and the number of students reporting they are continuing in STEM fields (66 percent) suggest these trade-offs are worth the effort.

Within the program, ORCA faculty made a number of adjustments to respond to student and faculty frustrations and concerns. Primarily, the program became more deliberate in its structural scaffolding of coursework for students. This meant two specific course changes for students in their first quarter at ORCA. To allow for more development in critical thinking and composition, ORCA faculty created a new humanities course focused on the study of nature in America. This course has become an important precursor to English 101, but it has also reinforced the interdisciplinarity of the program overall. Equally important, students begin their science with a two-credit ocean technology class prior to taking Oceanography 101. As noted above, the ocean technology course develops students' familiarity with the tools for research in our estuary, as well as introducing students to the process of scientific research. Whereas the State of Possession Sound (SOPS) project began as an addition to regular course work, it is now integral to students' coursework.

Another challenge to the cohort model focused on undergraduate research is the reality of coursework expectations in higher education in general. ORCA has navigated the associate-degree requirements, but students must still navigate a maze of prerequisites for entry into a major at their universities. The ORCA design allows some flexibility for students in the second year of the program so they can begin or finish the initial chemistry series and calculus series, but these requirements reduce the time available for independent research. Often these students won't have the opportunity to conduct independent research again unless or until they enter a graduate program. Adding additional pressure is the financial reality: As states continue to reduce funding for their colleges, tuition rises, making it more difficult for students to pay for an extra one or two research-course credits they don't necessarily need to attain an associate's degree. ORCA has attempted to ameliorate this issue through raising funds for private scholarships and other creative approaches, but it remains a challenge to the cohort-based model.

A final challenge is the inherent tension between ensuring reliable data collection from cohort to cohort and allowing students greater autonomy in experimenting with their own methods and ideas. Early data from the SOPS project are largely unreliable for this reason. Though students collect and identify plankton samples each month, these data provide information only on the relative abundance and distribution of plankton rather than providing specific and reliable counts of each individual type of plankton, making it difficult to compare year to year. ORCA faculty have essentially settled on a compromise: Protect the viability of a small but important set of data that can be reliably used from cohort to cohort and that can be used as a model for data collection, and allow students to experiment, fail, and succeed on their own with the rest of the data collected.

This last challenge brings our discussion back to the question of original research. The drive to ensure original undergraduate research poses a number of challenges for undergraduate research programs, and although such contributions are worth aiming for, the mission of the undergraduate institution is to teach, and in our case to inspire students to view the world as researchers. Like the scientific process itself, the outcome of an original contribution to science is never assured but is a necessary and worthy goal. In the meantime, the undergraduate research experience must provide multiple opportunities for original research while maintaining a clear focus on the process of transforming students into inspired, careful, and thoughtful researchers.

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Ardi Kveven is the founder and executive director of the Ocean Research College Academy (ORCA), an innovative early-college program at Everett Community College. Kveven earned her bachelor's degree in biology with a marine emphasis, along with her teaching certificate, from the University of Washington. She holds a master's degree in science education from Western Washington University and a United States Coast Guard 50 ton Master's License. Focused on introducing students to the marine biology of the Pacific Northwest, she taught marine science and oceanography from high-school to the college levels for fourteen years prior to developing ORCA with a grant from the Bill and Melinda Gates Foundation. Kveven views science as an active process….one all students should have an opportunity to experience. She continues to explore powerful examples of teaching and learning in STEM disciplines, and serves as a Geosciences Councilor for the Council on Undergraduate Research. Innovative work with engaging students in experimental research in the local estuary led to a National Science Foundation grant and the lead chapter of Inquiry: The Key to Exemplary Science (NSTA press 2009). She was a finalist for the 2012 Bellwether Award for innovative community-college instructional programs.

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