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An NIH- and NSF-Funded Program in Biological Research for Community College Students

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ABSTRACT

In a program supported by grants from the National Institutes of Health and the National Science Foundation, selected students in biology courses at Valencia Community College actively pursue the scientific method in a series of laboratory exercises. Results are then published as reports written in the format of a scientific paper. Faculty from the disciplines of biology and English composition evaluate students' work. Students are required to collaborate and present findings as if they are researchers. Students interested in science careers can subsequently enroll in a research training course, upon completion of which they are eligible for a summer internship at a partnering research university. Summer interns are required to present their findings to faculty of both the host and the parent institutions in accepted formats.

BACKGROUND

Biology faculty, like colleagues in other disciplines, must adapt to the rapid growth in information related to the field. Students in biology face an even more difficult struggle filtering through the mass of information which will confront them in their studies and beyond.

Faculty face a challenging dilemma in creating curricula for

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courses that serve both as prerequisites for science majors and as science electives for students not majoring in the sciences. While Honors Biology courses are designed to prepare science majors for further advanced study, the lecture component of the course, with its requisite theory and extensive content, may occasionally overwhelm them without piquing their intellectual interest. Recent trends suggest ways to arouse student interest through innovative forms of engagement.¹ Incorporating elements of other successful curricula and underwriting them with grant support, Valencia is in its third year of offering students a research-based biology experience.

If each student in freshman Honors Biology were to declare early his/her commitment to pursue biology through graduate school, then faculty could begin and end with the basics of biology, letting students' critical skills develop over the course of their higher education. However, the typical "Biology-1 Honors" student at this institution may not be planning a career in the sciences. The question is, how can students of varied interests experience in two semesters enough scientific practice to make informed judgments in the future concerning issues related to science?

Our goal is to provide students with experiences that demonstrate science as an active process necessitating the exchange of ideas. As a community college, we are committed to the goal of our students continuing their education at the university level. Through internships and workplace learning, students observe the process and practice of science. As a result of these experiences, they can make more informed decisions about their career paths. While many students may not apply to graduate programs in science, all students are shown that it is an option. Even if they choose to go no further, the students are now sufficiently literate to make better decisions when confronted with issues impacted by science. For those interested in pursuing further studies in science, this path leads to a bridge that extends to faculty mentors at a partnering research university.

METHODS

Drawing on the resources of multiple departments, Valencia Community College has established a three-level approach to encouraging scientific understanding and literacy in our students. First, students in first-year Honors biology are challenged to practice

the scientific method by emulating research scientists. Using reprints of journal articles provided by potential mentors, students learn the structure and format of peer-reviewed journal articles. From these articles students learn to extract techniques and emulate state-of-the-art laboratories featuring but not limited to techniques utilized in biochemistry and molecular biology.² Working in groups, students collaborate and peer-review laboratory reports which are modeled after relevant journal articles. A faculty mentor in Honors English Composition, with whom the students have previously studied, participates as a consultant, assisting students in structure and style. Logic and critical thinking skills are strengthened as students familiarize themselves with the subtle persuasion inherent in scientific writing. By mid-semester, students are designing their own experiments, often amid spirited debates involving how best to apply the scientific method. At this point the class examines contemporary articles in various mass media and scrutinizes them for scientific accuracy and integrity.

Upon completion of a minimum of one year of biology course work (chemistry was added in 1998) and with expressed interest in a career in the sciences, students can enroll in a special topics course of experimental research methods. This course is funded through grants from the National Institutes of Health (NIH) (1997-1999) and the National Science Foundation (NSF) (1999-2000). Admission is selective and requires an interview and a written goals statement. In fifteen laboratory sessions, students learn by hands-on practice research techniques often encountered only in university laboratories. This curriculum, developed by Valencia faculty in consultation with university faculty, requires students to keep a detailed lab notebook (like those used by graduate students). Grading is by competency exams involving mastery of fundamental techniques as demonstrated by carrying out a series of unassisted determinations using only their own notebooks. Topics include practice of the scientific method, biochemical techniques, advanced microscopy, bio-medical techniques and data presentation.³

Partnering institutions include the University of Florida, the University of South Florida and the University of Central Florida. Faculty mentors are selected to accept these students as summer interns upon completion of research training. The internships are paid by grant funding and last 5-8 weeks. Mentors are contacted to provide input on laboratory skills desired. Many provide reprints of their

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recently published journal articles, which are analyzed by the class prior to leaving Valencia for the universities. Student interests are matched closely with prospective mentors.

While interning at the universities, students continue to be mentored by Valencia faculty. Each student, in consultation with his/her university mentor, develops a project which will be completed in the allotted time. Students are required to function autonomously and to keep detailed notes. At the completion of the Internship, students must present their project results to the faculty and other students. Presentations are in one of three appropriate formats. Student interns at the University of Florida participate in a mock symposium where each student presents his/her results in a 15-minute seminar to the faculty mentors and a panel of graduate students. Students at the other institutions (USF and UCF) can choose to present in a similar symposium upon return to Valencia or to compete in the annual undergraduate research symposium's poster session. In addition, interns can submit their project findings in the form of a journal-format manuscript to their faculty mentors.

RESULTS

Since 1997, 54 students have completed all three components of this program culminating in a successful research internship. As part of our commitments to granting organizations, each student is tracked until a terminal degree is awarded or contact is lost.

For the years 1997-1998 and 1998-1999, support for the research methods course and the student internships was provided by the NIH. During the year 1999-2000 support was provided by the NSF. Under the NIH Bridges program, enrollment was limited to 25 students. Under the NSF grant, enrollment was limited to 15 students. Enrollment in the research methods course was open to all students at the college meeting the criteria. Honors Program students represented greater than 40% of each class. Minority students comprised greater than 60% of each class.

In the Research Methods course, Honors students having previous experience with our techniques were joined with other students to form collaborative groups. The more experienced students, acting as mentors, provided instruction, guidance, and support to the less experienced members of the group. This see-do-

teach approach is based on instructional and training strategies used in medical and graduate schools.

Many students have established contacts at the universities which resulted in employment after transfer. Most significantly, several have published and presented their work. Honors and awards for these students' work include institutional honors (The University of South Florida Student Research Symposium; Undergraduate Research Awards 1998, 1999) and national honors (The American Society of Biochemistry and Molecular Biology Annual Meetings; Undergraduate Student Research Awards 1999, 2000).⁴ Within two years of completing his associate of arts degree at Valencia, one student is beginning graduate course work at the Massachusetts Institute of Technology with a full fellowship.

Student Results 1997-2000	1997-1998	1998-1999	1999-2000
Qualified Applicants	28	30	26
Enrolled in Research Methods	25	25	15
Completed Research Methods	18	23	15
Research Internship	16	23	15
Transferred to a University	13	15	11
Returned to Valencia	5	8	4

DISCUSSION

These practices in student self-development of scientific understanding were implemented primarily outside the traditional lecture format. The emphasis on direct reading of scientific literature, active practice of the scientific method and communication by writing and presenting were all laboratory-based. Recent trends in undergraduate science education emphasize student inquiry.⁵ This curricular approach can augment text-based learning with computer-accessible resources such as CD-ROMs and web sites.⁶ We have chosen to follow this course at Valencia in Honors Biology. Laboratory curricula and instructional materials were developed mainly by our own faculty.

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As many institutions have done, Valencia has invested heavily in student-accessible computer laboratories and electronic classrooms. Utilizing these resources, students can explore a range of prepared tutorials and simulations in addition to accessing resources on the world wide web. In an effort to merge the components of lecture, laboratory and computer laboratory, eight computer stations in a network are located in an adjoining room to our Honors laboratory facility. A full-time laboratory instructor is available during normal class hours to assist students with computer-based assignments, CD-ROM tutorials, and any word processing, graphics or spread sheet construction. Honors students and students enrolled in the research methods course are expected to follow up on experiments in the laboratory after hours. An Honors resource facility is also available with similar support after hours.

CONCLUSIONS

Valencia has adopted as its core competencies four simple measures: How does what we do better prepare students to think, value, act and communicate? In science, thinking needs to be more than memorization, and three hours of laboratory a week is not enough time to act on the ideas we cultivate. Perhaps if we educate students on how to communicate matters of science, these students will be better equipped to think, value, and act in life. Additionally, understanding the process and practice of science by experiencing it during an internship can consolidate interest in further studies. Our partnerships with three major state universities have greatly enhanced our students' opportunities and provided a near seamless academic transition for them. The students complete Honors Biology during the first year at Valencia, the research methods training course in their second year, followed by the summer research internship at the partner institution. With planning, these students enroll as transfer students at the chosen university in the third year. In the third year of our program we are now beginning to see our former students accepted into science programs at these and other graduate and professional schools.

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