

Capstone Research at a Community College – A Cross-Disciplinary Model with Discipline-Specific Projects

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Piedmont Virginia Community College has developed an award-winning curriculum model in which all students enrolled in the A.S. in Physical & Natural Science degree conduct a semester-long, faculty-mentored research project as a graduation requirement. The two-credit research course serves as a capstone project in which students design and conduct authentic scientific research. One science faculty member carries teaching credit for the course and leads combined meetings on proposal writing, data analysis, poster construction, presentation skills and abstract writing. Additional full-time science faculty mentor 1-3 students per semester in their discipline. Students present their findings at an end-of-semester poster session open to the wider college community. Since the program's formal implementation in 2009, our students have successfully presented their findings at national meetings, collaborated with community and university partners, made new contributions to science, and transferred to 4-yr institutions as science majors. The mini workshop will lead participants in a discussion of the benefits and challenges of this model and of implementing mentored research at undergraduate institutions where faculty time, student preparation, funding and space may be limiting.

Keywords: capstone course, undergraduate research, community college, associate's degree

Introduction

The American Association for the Advancement of Science strongly recommends that students be exposed to authentic research experiences early in their undergraduate biology careers to promote achievement and persistence in science (AAAS, 2015). This is often seen as a laudable but difficult goal at community colleges, where constraints on faculty time, facilities and student preparedness can limit research feasibility. Piedmont Virginia Community College has developed a model in which all our students enrolled in the A.S. in Physical & Natural Science degree conduct a semester-long, faculty-mentored research project. The two-credit research course serves as a capstone project that fulfills the following student learning outcomes: 1) students will conduct hands-on scientific research and 2) students will synthesize the content of their science courses and create new knowledge. A strong course organizational structure, consistent expectations across faculty, meaningful deadlines for students, a supportive environment and a ready set of research modules/model organisms to allow us to mentor

up to 27 student projects a semester with nine full-time science faculty plus three laboratory staff.

Rationale for Capstone Project

Conducting original research at PVCC allows our students, many of whom are first-generation college students, older students, and students from historically underrepresented minorities, the opportunity to develop as scientists and to experience the successes and challenges of scientific research. Many of our students transfer to colleges and universities where undergraduate research opportunities are available for highly motivated, confident, well-prepared students. Former students have indicated that the capstone project gave them the confidence and experience both to choose a science major after transfer and to actively pursue research opportunities at their transfer institution. Since the course's inception in 2009, two alumni have entered Ph.D. programs in the sciences, with one recently graduated and another nearing completion. Other students have gotten jobs in the sciences and science education after completing their bachelor's degrees and several have gone straight to work in science technical jobs upon completion of their A.S. degree.

Student Outline

Semester Objectives

- Choose a research topic
- Conduct background literature review on research topic
- Write a research proposal
- Conduct independent, faculty-mentored research project in chosen discipline
- Analyze data from research project
- Write a scientific conference style abstract
- Design and present a scientific poster at a college-wide science symposium

Introduction

During the first week of the course, you will be matched with a faculty mentor in your academic discipline and will work with that faculty to choose a research topic. You will write a research proposal for your project and work to revise the proposal with your faculty mentor. During the middle part of the semester, you will conduct original scientific research under the supervision of your faculty advisor and laboratory staff. Upon completion of your research, you will analyze and interpret your findings, prepare a conference-quality scientific poster and abstract and present your findings to the college community in the end-of-semester Science Symposium. Throughout the semester, you will meet with the coordinating faculty member and classmates for information sessions on various topics related to scientific research. You will provide periodic oral and written updates to the rest of the class and to your faculty mentor.

Semester Schedule (16-week semester)

In-person, whole-cohort meetings (60 minutes)

- Week 1: Organizational meeting, match with faculty mentor, discuss ideas, introduction to proposal writing
- Week 2: Idea refinement / Alumni presentation I
- Week 3: Revised/approved proposals due. Proposal presentation to group
- Week 7: Mid-semester written progress report due and oral progress report to group / Alumni presentation II
- Week 9: Data analysis / Abstract writing
- Week 12: Poster design workshop
- Week 15: Poster images due, oral poster practice to group
- Week 16: Symposium: Researcher Lunch followed by Poster Session open to college community (last week of classes)

Students will coordinate with faculty mentors and laboratory managers to determine research schedule in the lab/field. Active research should be finished by the end of week 13.

Science 299 Proposal Format (Biology, Geology, Chemistry, Physics)

Name:

Faculty Advisor:

Title of Project:

Please address the following points, in the stated format, in your Science 299 proposal:

1. Scientific Background: In two-well developed paragraphs: Provide a brief background to the question you will be addressing. **Summarize the most relevant research findings** that have been reported in your specific area of interest. Why is this an important topic? What is known about the topic? Cite at least **three** primary sources (more may be required by your faculty advisor). List sources using APA format. These two paragraphs should lead your reader to your specific question. End your second paragraph with a clearly stated hypothesis.

2. **Methodology:** In one or two paragraphs, explain the general methods you will be using. These do not need to be as detailed as the methods section of a scientific report, but should indicate that you have thought out the methodology of your project. Provide citations and/or attach protocols for these method(s).
3. **Timeline:** Please outline (may be a list) approximate dates by which you intend to accomplish the steps of your project.
4. **Possible Outcomes:** In one or two paragraphs discuss *set of results that would support* your hypothesis and a *set of results that would refute* your hypothesis. List *potential challenges/problems* you anticipate. If possible, indicate how you might address those issues.
5. **Safety and Ethical Considerations:** Describe any *safety and/or ethical considerations* concerning your project and the names of PVCC personnel with whom you will discuss these concerns.
6. **Scientific Preparation:** In the last paragraph, you should briefly explain your own scientific preparation to undertake this project. What methods have you used in previous courses? What courses have you taken that specifically prepare you to complete this project?
7. **Literature Cited:** APA formatted bibliography.

Specific Grading Criteria for Course

1. **Proposal (20% of Course Grade):** The proposal should be feasible, logical, well-researched using primary peer-reviewed references, well-reasoned (demonstrate clear understanding of background and where your project fits into existing literature). It should include a thorough methods section with specific protocols that will be used and a list of supplies that indicates what is available at PVCC and what needs to be ordered. See required proposal sheet on our Blackboard site and due date in the schedule below.
2. **Abstract (10% of Course Grade):** See submission date on the schedule below. Each abstract will be included in an abstract booklet to be made available on the day of the symposium. For information on writing a scientific research paper, see the handout entitled 'Lab Report Basics' within the folder called 'Lab Report Paper (Lab Report) Information' to be found on our Blackboard menu under the heading 'Course Documents'. One of our group meetings will include information about writing an effective abstract.
3. **Poster (15% of Course Grade):** A draft must be submitted to your mentor with enough time (about 1 week minimum) for you to print a revised version before the poster session – allow additional 3-5 business days for the printing process. Posters should be polished and complete with legible text, tables and figures including titles, labels and captions that allow the poster to stand on its own (i.e. someone with a strong general science background should be able to read your poster without your assistance and understand what your research was about and what you found). For more information on poster construction see available resources on our Blackboard page. One of our group meetings will be about constructing an effective poster.
4. **Poster presentation (10% of Course Grade):** Professional attire and behavior are expected. You will be evaluated on clarity of presentation, how well you answer questions from seminar visitors, and the reports of other science faculty who observe your work.
5. **Research (45% of Course Grade):** You will be graded on originality, level of difficulty, regular progress, ingenuity, problem solving, creativity, dedication, and timely communication with your faculty advisor.

Notes for the Instructor

Course Development

This course has evolved over the past 8 years and will likely continue to evolve. It began as a one-credit course, with no teaching credit or reimbursement given to faculty for mentoring students. In 2012 we switched to a 2-credit course, with a single course coordinator who received teaching credit for the course (allowing the course coordinator to drop a 3-hr laboratory). [See Appendix A for course structure details] Faculty mentors were still not reimbursed. Arrangements for faculty mentors and lab managers to receive a small amount of reimbursement began in 2015. This has been a key change that has increased buy-in from faculty and laboratory staff. In a semester where there are 13 biology students conducting research in the small biology lab prep room, the two biology lab managers have a significant amount of student oversight. While this student oversight has become a component of the job description, being able to specifically compensate laboratory staff according to the number of students being supervised has been critical. Faculty have also indicated that the small amount of reimbursement has made them feel their mentoring work is recognized and valued by the college.

Project Scope

Although students are given freedom to choose research projects that fit their interest given the college's facilities, equipment, and faculty expertise, we do have several research "systems" or model organisms that students can use to ask unique questions. We do not have a standing IRB or IACUC committee, so human subject or vertebrate animal projects are not permitted. At the beginning of the semester, students are asked to look over abstracts of projects from prior semesters to generate ideas. In addition, students are encouraged to think about laboratory activities they conducted in their introductory science courses and to think of possible extensions to those labs using the same systems.

In biology, for example, students routinely conduct bacteriological studies, using the disk-diffusion method. We have stock cultures of bean beetles (*Callosobruchus maculatus*) and *Daphnia magna* that students use to address behavioral and environmental pollutant questions, respectively. Students also frequently use Wisconsin FastPlants® (*Brassica rapa*) to ask plant physiology and evolutionary questions. Field projects are also low-cost and flexible. Students have sampled macroinvertebrates in both water and leaf litter and have also conducted amphibian surveys on campus, providing much needed local biodiversity information. Students conducting chemistry and geology projects also have a standing set of methods they can use to ask novel questions.

Poster Session

The poster session/symposium is set up in a public space and is open to the college community. Media services publicizes the event, and the college president and upper level administrators always attend, along with faculty, students and staff. For the past year, we have used funds from an NSF LSAMP grant to pay for professional-quality poster printing for all students who submit their poster images on time. However, students have produced high-quality posters on inexpensive tri-fold boards and individual printed sheets of paper.

Student Evaluation

Capacity/Future Directions

At present, we can mentor all A.S. in Science students in the capstone course and keep the number of student mentees at a maximum of three per faculty member per semester. If the program continues to grow, changes in structure will be necessary. We have discussed potential options, including running the course during the summer semester and changing the teaching load so that the course coordinator could mentor additional students beyond three.

Cited References

AAAS (2015). Vision and Change in Undergraduate Biology Education: Chronicling Change, Inspiring the Future. Washington, DC: AAAS http://visionandchange.org/files/2015/07/VISchange2015_webFin.pdf

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About the Author

Joanna Vondrasek is Professor of Biology at Piedmont Virginia Community College, where she teaches introductory biology and genetics and supervises independent research projects.

Appendix A

Organizational Structure of Capstone Course

All A.S. in Science students complete a 2-credit capstone course in their chosen discipline (Biology, Chemistry, Geology, Physics) during their second year (pre-requisites include 2 introductory courses in discipline)

1. Student enrolls in the capstone course by discipline and works with a faculty mentor in discipline (Course designations listed separately as BIO 299, CHM 299, GOL 299, PHY 299)
2. One full-time science faculty coordinates group meetings with all enrolled students that semester and carries teaching credit for the course (this rotates among the full-time science faculty)
3. Science faculty and lab staff receive compensation in the form of one tuition credit per student mentored (currently \$135 / student). Capped at three students per faculty. Lab managers often have more than three students they are supervising in the lab.
4. Timeline of Semester (7 meetings throughout semester – 1 hr/meeting plus Poster Session) over 16-week semester. See specific timeline in student outline. Faculty coordinator leads these in-person meetings, recruits alumni to talk about their experiences, collates and prints abstract booklet, organizes end-of-semester symposium and lunch.
5. Offered every Fall and Spring semester
6. Current faculty: 5 Biology, 2 Chemistry, 1 Geology, 1 Physics (Capacity = 27 students)
7. Current staff: 1 full-time Biology Lab Manager, 1 part-time Biology Lab Manager, 1 full-time Chemistry Lab Manager
8. Physical Space: Biology Lab Prep Room, Chemistry Instrument/Prep room, 2 Biology Lab Classrooms, 1 Chemistry Lab Classroom, 1 Geology Lab Classroom, 1 Physics Lab Classroom.
9. Brief Outcomes:
 - a. Although overall enrollment in the A.S. in Science degree has decreased, reflecting national trends in enrollment at community colleges, we have dramatically increased the graduation success of those students enrolled in the science degree program. In 2012-13, there were 221 students who were enrolled in the A.S. in Science degree, this has declined to 204 students in the Science degree in 2016-17. This is a decrease of 7.7 percent. However, in 2012-2013, PVCC only graduated 15 students with associate degrees in science. In 2016-17, PVCC graduated 33 students with associate degrees in science, effectively doubling the number of graduates while overall student enrollment declined.
 - b. Initial implementation of 2-credit course: From 2012-2015: 73% of A.S. in Science graduates transfer to 4yr school (n=37) within a year.
 - c. Recent transfer success: In the spring semester of 2017: 90% (n=22) students transferring immediately to 4-year schools in the sciences.
10. Future Challenges: Capacity, if the number of degree seeking students increase. Tracking outcomes beyond transfer.

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