Integration of a Discovery-Based Project into a Biology Course

(Final Report)

By

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Abstract

One way to motivate students' interest in learning science is to enable them to feel the self-satisfaction of being able to *apply and communicate* what they learn. The monograph here reports progress of the QEP project we developed in the Genetics course that provides students such a platform. In this project we ask students to develop a proposal to enhance an aspect of human health that is centered on a genetic disease. Paper writing and poster presentation assignments enabled students to integrate their textbook knowledge with a simulation of real life experience while improving their communication and project management skills.

Introduction

Science is a way of acquiring knowledge. By learning science, we are better able to explain how the natural world functions, and we equip ourselves with abilities of problem solving and judgment making. Conventionally, science education for undergraduates focuses on preparing students for advanced-level learning by providing background information. While building their vocabulary of science, the spark and pleasure of finding things out often are lost among students in traditional science curricula. The number of students who have careers in science and technology has been declining (Rosenberg, 1999): our society faces a challenge to awaken students' interest in learning science.

One way to motivate students' learning in science is to enable them to feel the self-satisfaction of being able to *apply and communicate* what they learn. Because students in a genetics class can easily correlate textbook knowledge to problems of daily life, the Genetics course could provide such a platform. To enhance students' learning of biology in this project, we ask students to develop a proposed activity, apply their knowledge of modern genetics, and share their ideas with their peers.

Project Overview

Genetics is a core course in the Biology and Clinical Laboratory Sciences curriculum at the University of West Florida. Genetics is taken in the second or third year of the degree. The content learned in Genetics is applicable to all scientists. Other skills that are necessary to both students and professional scientists are skills in project management and communication. This project integrates content, communication and project management in an environment of active learning.

Rationale

Students gain a level of expertise and personal satisfaction in being able to apply and communicate what they learn in science. We defined four activities in formatting this project, elements 1 and 2 emphasize content and elements 3 and 4 emphasize communication and project management. In the course of this project, the successful students will:

1) Solve computational biology problems to acquire science knowledge and enhance problem-solving and hypothesis-testing skills.
2) Write reports to sharpen critical thinking and communication skills.
3) Design and present a scientific poster to enhance verbal communication and project management skills.
4) Participate in the evaluation process of poster presentation done by other students to enhance their ability to provide constructive criticism.

Original Project Description

The project utilizes an active learning approach for students to investigate a genetic disease, report on it, and become involved in it by developing a proposal that will enhance an aspect of human health relative to the disease.

Three to four students work as a group to manage the project. Each group is given an unknown human DNA sequence by the instructor and asked to resolve the nature of the unknown DNA sequence through genomic data mining, and then use the information, through science literature search and experimental operation, to find out the significant biological property of the DNA in humans and in other species of the global animal kingdom. For example, after genomic data mining, the unknown human DNA may be found to have originated from a gene called CF1 (what this gene is), which later produces a protein that is an important gate keeper of the cell (what the function of the gene product is). If the gene is mutated, it may cause a disease called cystic fibrosis. The CF1 gene not only exists in humans, it also has counterparts in other species (e.g., the fruit fly). The student group can then use molecular methods such as Polymerase Chain Reaction (PCR) to prove the existence of the CF1 gene in the fruit fly. Lastly, each group will present a poster to explain their discovery, the significance of this particular gene to human health, and to propose what they intend to do with this knowledge (e.g., propose a survey in the local community to determine how many suffer from cystic fibrosis or propose a public presentation on how to do the genetic diagnosis of cystic fibrosis).

In summary, during the course of this project, the successful student will be able to:

- Utilize genomic data mining to identify the unknown gene.
- Experiment with the DNA sequence to determine the biological function of the gene.
- Determine genetic disease(s) associated with the gene.
- Investigate resources available to individuals with that disease.
- Develop a proposal to improve the health of those individuals.
- Communicate all of the information in a professional manner to an informed audience.
- Assess the work of other student groups and provide constructive criticism.

Project Assessment

Students report their findings in a written report with an individual grade followed by a poster designed and presented by the group for a group grade.

- The written paper is considered a first draft, and is reviewed and returned by the instructor with notes for revision. The second draft is peer viewed by two other students who use a rubric to score it (Appendix A). Only the final draft is graded.
- The poster exhibition is scored by all other students in the class and guest faculty, using a rubric (Appendix B). The student scores count for 40 % of the grade.

Project Results and Interpretation

The QEP project was proposed in the summer of 2005, before Hurricane Dennis. Funding was not available until October. The project was therefore implemented in the Spring Semester of 2006. Soon after the semester started, the authors realized that the students would not have the skills necessary to begin the project until most of the semester was complete. Beginning the project so late in the semester would have compressed all of the activities so as to be unmanageable for both students and faculty, what with exams, quizzes, labs and the like. The authors reevaluated the project, and decided to focus on the latter components of the project, emphasizing the student learning outcomes that stress project management and communication, which are:

- investigate resources of a disease of the student's choice
- develop a proposal to improve the health of those affected with the disease
- communicate that information to an informed audience

These are the components involved in applying and communicating knowledge, and gaining the satisfaction of active learning. The final outcome was evaluated in the Spring 2006 semester by an individual report, and is summarized below. The final outcome in the Fall 2006 semester was a poster presentation, also summarized below. The analysis of both projects follows those summaries.

Spring Semester – Written Report

The students were already familiar and comfortable with the process of writing a research paper, *after all, they are college students*. They were instructed to propose an activity that is centered upon a human genetic disease of their choice. The activity was not restricted to scientific research carried out in a lab, it could be public awareness and education related. The student had to provide background information of the disease and illustrate the rationale and detail of the proposed activity. Before submitting the final paper, the student received instructor comments on how to improve the paper, and two other students' anonymous comments, derived using the rubric in Appendix A. Students were expected to revise their papers to accommodate suggestions. In total, 43 proposals were evaluated. A summary of the results is shown in Table 1.

Table 1. Results of Written Report, Spring semester

Issue	Result
Focus of proposal	93% related to public education and awareness 7% related to testing a scientific hypothesis
Revision of manuscripts	90% of student made improvements in giving concrete details on their proposed activity in the final draft of the proposal.
Student perception of peer review as author	Students in general appreciated the peer review process.
Student perception of peer review as reviewer	Students in general enjoyed being a reviewer and offering a critique of other students' work. About 50% gave constructive comments when reviewing proposals. Comments from students included: a) one complaint was that not all of the first drafts had been completed by the time of the peer review b) The realization that the peer review process increased a student's ability to rank themselves against other students, to assess the quality of their work.
Instructor perception	The process of iterative review improves the student's writing, but it is very time consuming to the teacher.
Common problems	A lack of specifics about the proposed activity was often observed in the first draft: students often described their proposed activity vaguely, giving little illustration of the plan. For instance, a proposed activity on bringing awareness to breast cancer was described, but without telling *how*, *why* and *where*.

Fall Semester –Poster Presentation

Originally most of the students were not familiar with the concept or the presentation of a scientific poster and some were not comfortable with the idea. Assigning this task as a group project added the dimension of group dynamics and is an excellent format to develop project management skills. As in the Spring Semester, the project entailed proposing an activity that is centered upon a human genetic disease. Students worked in groups to propose an activity that was either scientific research or public education and awareness. They had to develop an aesthetically pleasing poster to display their work and discuss it with their peers. They submitted an outline to the instructor prior to the event and were given some guidance for improvement. All students evaluated all posters, as did the instructor and guest faculty, using the rubric presented in Appendix B. Students were asked to vote for their favorite poster and the faculty voted for the poster that was the most scientifically intriguing. In total, 14 group projects were presented, as students worked in groups of 2, 3 or 4. Table 2 shows the summary of the results from this approach. Two examples of the posters are shown in Figure 1.

Table 2. Results of Poster Presentation, Fall Semester

Issues	Result
Focus of proposal	79% related to public education and awareness 21% related to testing a scientific hypothesis
Student perception of peer review as author	Students in general appreciated the peer review process. Students overall enjoyed explaining their proposal to the audience and welcomed their challenge during the poster exhibition. Comments from students included: a) Some students expressed concern that while the peer review is anonymous, the author is not, and may be a friend. Bias may be an issue in the review process. b) No previous expertise, and no model to follow makes the task outside of the zone of comfort. c) There was a more commitment to the success of the project due to the group investment.
Student perception of peer review as reviewer	Students in general enjoyed being a reviewer and offering a critique of other students' work. 99% of the students favored doing a poster group project over doing a written proposal. The three posters with the highest peer earned points were also voted as the three most favorite posters by the students.
Instructor perception	The overall quality of products was good. Students enjoyed the experience, especially in the final stage of presenting and evaluating. The workload of the instructor was less than with the research paper.
Common problems	On rare occasion, a group asked the instructor for help in resolving a conflict over the coordination of teamwork.
Written report versus poster presentation	In general, posters gave a detailed account of the type of activity proposed. Aesthetics were important in the poster, not in the paper. Overall, posters presented had a good balance between information and visual display. Students who did not present in the first session (there were two in the same week) have a self-motivated opportunity to improve their product. This may be perceived as an unfair advantage. There is a cost involved for materials in the poster presentations but not in the written paper.

Figure 1. Students present poster information to faculty and peers.

Summary and Discussion of Outcomes, Methods for Quality Improvement

Our project to enhance students' learning of science revolved around gathering information about a certain disease and developing a proposal to enhance human health. We tried two different formats for the synthesis and communication of the results, in two different semesters. One of the methods depended entirely upon one student to coordinate the project, which entailed investigating scientific information, applying knowledge to develop a proposal, and communicating ideas. The other method inserted group dynamics and face-to-face communication. Both methods were found to improve students' ability to own a problem and to suggest and communicate a solution. Both methods introduced the students to peer review.

Students benefited from the peer review process in improving their writing skills during the Spring Semester of 2006. They also experienced the flavor of being the critic while they evaluated each other's proposals. They experienced the joy of communicating their findings, but the sharing of the findings was limited to four people – the student, the instructor, and two peers. The format of the poster presentation provided increased opportunity for interaction with peers within a group in the preparation, and with peer reviewers during discussion at each of the posters. Furthermore, the audience themselves were able to evaluate and appreciate the level of the work of their peers, and learn more about the diseases and alternate approaches that they may not have considered.

The authors favor the poster presentation format over the research paper as the learning strategy for the discovery based project in Genetics. This is the format that we will continue for the upcoming semester. During the next round we will gather more data about the opportunities and threats provided by such a presentation. Specifically, we will generate a survey of the student perceptions of active learning by poster, both at the level of the designer and presenter, and at the level of the audience. Furthermore, we will evaluate the reliability of the students' peer review, by comparing the overall numerical grade of each poster to the grade given by the faculty.

Dissemination and Institutionalization

The authors take great pride in the success of this project at the stage it is in, but we do not feel that it is complete or ready for institutionalization. The Genetics course is a core course within the Biology curriculum, and is offered every semester. Two out of three semesters a year it is taught by Chung. During the Spring 2007 semester, the project will be repeated and tweaked. The results will be shared with the faculty teaching the Summer session, and if time permits, will be institutionalized into the year round Genetics curriculum.

Genetics is a prerequisite for more advanced courses such as Molecular Genetics and Genetic Engineering taught by Chung and Clinical Chemistry and Molecular Diagnostics taught by Behan. The skills in project management and communication that students learned in the 2006 Genetics project are expected to improve their performance in the upper division classes in 2007. The PIs are in the process of developing an assessment tool to determine whether this occurs. It will take more than one year to gather data and make an interpretation. We feel that it is premature to disseminate our findings outside of these courses at this point, but we will continue to meet to discuss and refine the project. Students in the past classes gained new insight into peer review, and were able to rank themselves and their own effort against other students. For the future classes, selected posters will be made available to serve as examples, setting a benchmark for quality improvement.

Conclusion

A discovery based project in Genetics was initiated and refined during 2006, building project management and communication skills. Two methods of communication were evaluated, writing an individual research paper and collaborating and presenting a poster. Each method was subject to peer and instructor scrutiny. The PIs favor the poster presentation as it offers all students the chance to participate in and review all other students' work. It is a collaborative project which gives students experience in group dynamics. The format allows an opportunity for other faculty to participate in a manner that is not time consuming. Although the PIs do not feel that the project is ready for institutionalization, it remains on the front burner, and has tremendous potential.

Acknowledgement

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Citations

Leon E. Rosenberg *"Physician-Scientists--Endangered and Essential,"* Science, *283* (1999), pp. 331 - 332

Appendix A*: Criteria for evaluation on peer review of report writing

Title of the reviewed paper:

Number of the assigned author:

Reviewer's name:

Score (0-3)	Element	Comment
	1. Information about the disease	
	2. Logic and organization of the introduction	
	3. Completeness & breadth of the literature reviewed	
	4. Clear statement of the research proposed activity	
	5. Method of the proposed activity	
	6. Predicted results	
	7. Discussion	
	8. Quality of writing: Is the paper understandable?	
	9. Quality of writing: Are there lots of typo and grammar mistakes?	
	10. References	
	11. Overall impression of the paper	
	12. Other comments	

* This rubric is a modification based on the template provided by Dr. Claudia Stanny

Appendix B: Criteria for poster grading

All students are to score all groups excluding themselves

Exhibition Group	**Group 1**	**Group 2**	**Group 3**	**Group 4**	**Group 5**	**Group 6**	**Group 7**
Is the background information sufficient and logically displayed? (0-20 points)							
Are the purpose and method of proposed activity clearly stated? (0-20 points)							
Is the predicted result carefully discussed? (0-15 points)							
Is the project interesting and with significance? (0-15 points)							
Is the poster display visually clear and expressive? (0-15 points)							
Is the information complete and easy to follow? (0-15 points)							
Total points							

Your favorite poster (not including your own) today, and why: