

Reform of Introductory Science Courses for Non-Majors

Final Report

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Title of Project: Redesigning Human Biology for Non-Science Majors to Enhance Scientific and Quantitative Literacy

Dates of Project: January 15, 2007 – January 15, 2008, extended to May 10, 2008

Amount Awarded: \$9,500

1. Original Goals and Objectives

The goal of this project is to redesign an existing Human Biology course to provide non-science majors with an active learning environment that (1) increases their appreciation for science and its relevance to their lives, (2) illustrates the interrelatedness of science and math, (3) promotes critical thinking skills.

The specific objectives of the project are to have Human Biology students:

1. Engage in active learning through the use of a wireless classroom response system (“clickers”) to provide immediate responses to questions posed during class and lab.
2. Gain an understanding of scientific inquiry and its importance to their lives by investigating real-life problems presented as case studies.
3. Develop quantitative and analytical skills for interpreting and evaluating scientific information.
4. Apply their newly gained scientific knowledge and analytical skills in their own investigations.

2. Any changes made in goals/objectives

No changes were made in the original goal and objectives of this project.

3. Meeting Project Goals/Objectives

As stated in the project objectives, several methodologies were incorporated into this course to enhance student participation, interest and critical thinking skills.

Wireless Classroom Response System (Clickers)

The "CPS" wireless classroom response (clicker) system was purchased from eInstruction during the summer and used during both the Fall and Spring semesters. The system purchased is a "self-contained" system of 36 numbered keypads with a radio frequency receiver. Each student was assigned a designated keypad to use throughout the semester, which allowed recording of each student's participation and performance. Based on recommendations provided by faculty with experience using clickers, I made the

students' "clicker grade" count toward their final average (~10% of total). This provided incentive to come to class regularly, as well as keep up with reading assignments. Clickers were not used every class day, but were used in the majority of classes.

I found the clicker questions worked best if they were dispersed throughout the class, rather than simply at the beginning to see if an assignment was read or at the end to gauge understanding of material. Interspersing them during the class time kept students engaged and allowed more variety in the types of questions that could be asked. Questions ranged from simple knowledge/concept review to problem-solving/critical thinking. In addition, I employed survey questions where appropriate to ask about student experiences, opinions and attitudes. These types of questions were extremely popular with the students and they would "perk up" in anticipation of the results.

Overall, students responded positively to the use of clickers. In fact, on days when they weren't used students seemed disappointed and asked for them. In course evaluations from fall semester, most students made very positive comments about the clickers. Some comments were:

"I liked using clickers...it was a good test of my knowledge...."

"Clicker questions showed potential test styles."

"Clickers were pretty fun...keeps people active and involved."

"Clickers were a great way to review previous material. I really enjoyed them"

"Clickers were good, alerted me to what I didn't know."

"The clickers were a good way to...make the class more participatory."

"I recommend clickers for the future."

"I thought the clickers were great. They were a good way to keep the class interacting with the material during lecture."

"Clicker questions were very useful and made learning more fun too."

The few negative comments received focused on the stress of having to answer questions, not knowing all the answers to clicker questions (due to inability to prepare or remember information), and the fact that clickers were factored into the final grade.

Case Studies

Case studies were used to provide students with group interaction to examine relevant health issues. Cases required groups to locate and critically evaluate information on each issue. "Should You Take That Pill?" is a case I developed to provide students the opportunity to compare prescription drugs and the FDA approval process with dietary supplements that are not under FDA regulation. The case required students to scientific evidence (and lack thereof) regarding various products on the market. This case led to interesting discussions of advertising gimmicks for both prescription drugs and dietary supplements, of whether FDA approval means a drug is "safe" (Vioxx example), and of the potential dangers in using some dietary supplements. In the Spring, I gave students a case homework assignment that also addresses dietary supplements. This case - entitled "Hormone Boost or Bust?" - prompts students to investigate a young man's desire to build muscles by taking a dietary supplement meant to increase testosterone levels. Each student conducted an investigation of the topic outside of class, groups then convened in class to discuss the results of their findings. The case "Not An Old Person's Disease,"

from the National Center for Case Study Teaching in Science website (<http://ublib.buffalo.edu/libraries/projects/cases>), allowed students to learn about cancer and the risk of melanoma by following a college-age woman with a suspicious mole. Putting the topic of cancer in this context seemed to increase student interest and led to interesting discussions, questions and additional research on the risk of melanoma and the use of tanning beds.

Inquiry Labs

Inquiry labs were included throughout the semester to provide students with opportunities to develop quantitative and analytical skills. Labs included both guided inquiry (to provide a framework for investigation and building skills) and opportunities for students to conduct their own investigations (so they could practice the skills they had gained). Students jumped into conducting their own investigations during the first lab of the semester when they designed and conducted an experiment to investigate factors that may affect human reaction time. In this lab, students learned how difficult it is to conduct a controlled experiment, as well as the limitations of small sample size. A later lab on human morphology had students go a step further by using descriptive statistics to summarize and examine the data they gathered regarding body measurements. This type of investigation and analysis was used again in the cardiopulmonary lab to examine aspects of cardiovascular and respiratory functioning for the entire class. My original intent was to incorporate formal statistical tests (t-test or chi-square) in data analysis, however this proved to be too time consuming and labor intensive given the extremely wide range of student abilities in the class. I have not abandoned the idea but will need to come up with a new strategy for introducing this type of analysis to my students.

4. Evaluation/Assessment

To assess student attitudes toward science, students were given the Science Values Inventory developed by researchers at Drury University in both Fall and Spring. These pre- and post-course surveys have been sent to Bruce Callen of Drury for analysis. Unfortunately, results are still pending due to a malfunction in their scanner equipment. I hope to receive these results in the near future.

Student attitudes toward math were assessed using a pre-course survey I developed. The results of this survey over both semesters showed that most of my students feel comfortable with math and realize a need for math/statistics skills in their lives. However, approximately 20% of my students feel they are not good at math, find it difficult and become nervous when faced with math problems. A higher proportion (approximately 30%) reported they are comfortable with simple math but panic when faced with more complex problems. Furthermore, 30% reported that they avoid math when possible.

I also conducted a pre- and post-course knowledge survey to help identify existing knowledge and misconceptions, as well as knowledge gains over the semester. The result of these surveys was encouraging in that a much larger percentage of students answered correctly at the end of the semester. This was even more encouraging since the survey

was given without warning and prior to the start of exams, when students were not likely to have studied the material. The pre-surveys shows the greatest misconceptions in the areas of heart function, blood pressure, digestion, fertilization, and DNA function. For example, less than 30% of students knew the function of DNA entering the course, while 84% answered this correctly in the post-survey. And while only 8% of students were able to indicate the "double-pump" action of the heart upon entering the course, over 80% knew this answer at the end of the semester. Similar results occurred for the other areas indicated and, though less drastic, gains in the number of correct responses were seen for all questions with one exception. The surprising drop in knowledge occurred on the question of which molecule is most abundant in the body. While 87% of students correctly responded at the beginning of the semester, that number was reduced to 65% at the end of fall semester and 80% at the end of spring. I believe the reason for the change was the focus we placed on proteins throughout the semester – as this was the answer chosen by those answering incorrectly. This result made me realize how easily students can form misconceptions.

Finally, student evaluations and comments were used to assess student response to the course format. Evaluations received during the Fall semester were positive overall and students commented repeatedly on how helpful they found the knowledge gained from the course. While Spring course evaluations have not yet been received, several students commented that they felt this course gave them a better understanding of science and made them more interested in hearing scientific information. In addition, several students have noted the relevance of the material they learned to their lives, citing personal experiences and/or news items they have encountered. Overall, the feedback I have received from students has been extremely positive with regard to increased interest, appreciation, and understanding of science.

5. "Lessons Learned"/Project Redesign

Perhaps the major lesson I learned involved the scope and timing of the project itself. My proposal involved many major course revisions, as well as the use of a completely new technology (clickers) into the class. I chose to implement these changes during the Fall semester, when I have my heaviest teaching load. At that time, an unexpected health issue occurred that further complicated the situation by limiting my time and mobility. Thus, while I was able to accomplish many of my objectives, I requested and received an extension for the completion of the project to May so I could better implement the changes I had planned. In the end, I was able to successfully accomplish my proposed changes. However, in hindsight, the project would have progressed more smoothly had I made alterations on a smaller scale and chose the "lighter" of my semesters for implementing them.

Another lesson I quickly learned was that the clicker technology requires a lot of time to implement – especially in the beginning. Coming up with challenging and meaningful questions, entering those questions into the system and later evaluating student performance took more time and energy than expected. In addition, using the clickers in class shortens class time for other activities. While I think that the clickers are well

worth the effort, I found it is important to limit how many questions are used in any given class period and to allow ample time to prepare these questions prior to class.

Students gained valuable knowledge from the case studies used and seemed to enjoy the group investigations and discussions they had; however, I saw a mixed response to using the case method in the class as a whole. Some groups were very good at jumping into the case and working together, others fell into the pattern of answering questions individually without discussion with group members. I had to prod them to discuss and work together. I also found that cases that went on too long resulted in a loss of interest for some students. Another problem involved differences in the speed at which groups handled sections of the case – it was difficult to keep everyone on track. In hindsight, I would approach the case studies differently – perhaps presenting more questions that require students to discuss or debate an issue. In addition, due to the amount of time it takes to conduct some case studies, I would require students do more outside reading and investigation beforehand.

Finally, I found many students were lacking in the math/computer skills needed for meaningful manipulation and analysis of data. Requiring students to do more outside assignments and practice exercises to build skills these skills would allow more in-depth work in the laboratory.

6. Dissemination

A poster outlining this project was presented at the National Association of Biology Teachers (NABT) 2007 Professional Development Conference in Atlanta, Georgia in November 2007. An additional presentation was made at the National Science Teachers Association (NSTA) conference in Boston, Massachusetts in March 2008 during a poster session sponsored by the Society of College Science Teachers (SCST). In addition, informal discussions of this project and its results have also occurred with colleagues on and off campus. I have also made information regarding the project available through a course Blackboard website and will incorporate this information onto the course homepage. Future plans are to submit an article summarizing the results of this project to the *American Biology Teacher*.

7. Next steps/Follow-up

I believe the redesign of the course was successful in providing an active learning environment that increased student appreciation and knowledge of science. I plan to teach the course again in the Fall and will make some modifications based on my experiences. I plan to re-examine the case study approach with regard to the format used, as well as content. Choosing cases that require debate or presenting different sides of an issue could encourage more student discussion and allow further critical thinking opportunities. I also plan to continue to modify the laboratory portion of the course to further incorporate inquiry and data analysis. For example, with the purchase equipment from this grant, I can revise the cardiopulmonary investigation for more extensive and accurate data collection. This summer I also plan to develop homework exercises that

will allow students to build a foundation on which to further sharpen their analytical and quantitative skills.

8. Financial Accounting

Approved budget

Faculty Stipend	\$5,000.00
Travel	\$1,300.00
Classroom Response System	\$3,000.00
Books	\$ 200.00

Total Approved	\$9,500 .00
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Actual Expenditures

Faculty Stipend	\$4,994.83
Travel	
NABT Conference	\$1,055.76
NSTA Conference	\$ 153.78 *
Equipment	
Classroom Response System	\$2,401.00
Blood Pressure Monitors, Stethoscopes & Spirometer	\$ 662.63 **
Books	\$ 226.23

Total Expenditures	\$9,494.23
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Remaining Funds	\$ 5.77
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* Davidson College covered \$1,500 in expenses for attending this conference.

** Part of the \$572.77 remaining from the purchase of the clicker system and \$90.46 unused from travel funds was used to purchase equipment for use in the cardiopulmonary inquiry lab module.

9. Permission Statement:

I give the Associated Colleges of the South permission to post my original proposal and the results of my project work on the ACS Science Reform website.