

Provost's Initiative on Teaching Advancement (PITA) Project
Final Report
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Title: Redesigning the Learning Objectives for Use of Web-based Learning Modules in Plants, Pathogens, and People (PLPA 200)

Investigators: Darin M. Eastburn, Crop Sciences, eastburn@uiuc.edu, 244-9632
Cleora J. D'Arcy, Crop Sciences
Bertram Bruce, Library and Information Sciences

Abstract:

A study was undertaken to evaluate the use of web-based laboratory activities on student comprehension of the scientific method in Plants, Pathogens, and People (PLPA 200), a general education course that fulfills requirements for advanced composition and natural science. At the beginning of the Fall 2006 and Spring 2007 semesters students in PLPA 200 were given a pre-test to determine their level of competence in describing and applying the scientific method. They were then assigned a series of virtual lab experiments, asked to reflect on those experiments, and given a post-test to ascertain if their competence had improved. Comparing pre- and post-test results, overall student scores on post-tests were significantly higher than their pre-test scores. For individual questions, scores for 10 of the 13 questions were significantly higher on the post-test. Improvement was seen on 6 of 7 questions asking for general descriptions, such as "What is a scientific observation?" Scores improved on 4 of 6 questions that asked for specific information, such as "Write a specific hypothesis for this experiment." Pre- and post-test scores were not found to be associated with the students' gender or major (science vs. non-science, or agriculture vs. non-agriculture). These findings indicate that students' use of the PPP web site did result in an increase in both their ability to describe the general concepts of the scientific method and their ability to apply that knowledge to specific situations.

Project overview:

Plants, Pathogens, and People, PLPA 200, is an undergraduate course that fulfills general education requirements for advanced composition and natural science. During the course of a semester, students learn about the biology and impact of approximately fifteen important plant disease epidemics. To provide for the needs of diverse learning styles and to incorporate the concept of active learning into PLPA 200, the instructors, Drs. D'Arcy and Eastburn, developed the Plants, Pathogens and People (PPP) website (<http://www.ppp.uiuc.edu>). The site offers in-depth information and on-line activities related to some of the important plant diseases that are covered in class lectures.

From 2004 to 2006 we conducted a study to determine whether completion of class assignments that require the use of the website, as a supplement to lectures, results in greater student understanding of the subject matter than when the information is delivered through lectures alone. We found that while use of the web site increased learning about specific diseases

in some instances, the improvements were not as consistent or as dramatic as we would have hoped.

In the current study we evaluated an aspect of learning that is addressed on the web site, but not in lecture: use of the scientific method to answer questions of interest. The current study was carried out in the Fall 2006 and Spring 2007 semesters. At the beginning of each semester the students were given a pre-test to assess their level of competence in applying the scientific method. Students were asked to explain the concepts involved in the scientific process, including observation, hypothesis, variables, use of control treatments, conclusion, and replication/ repetition. They also were asked to identify these elements in a specific experiment. Over the course of the semester, students completed a series of virtual lab experiments on the PPP site. For each experiment they submitted a lab notebook, including a statement of purpose, an hypothesis, an analysis of results, and a conclusion. They also completed an online web assignment that asked them to explain the experiment, including identifying the variable being studied, the controls used, whether the experiment was replicated or repeated, and whether or not their hypothesis was supported. Students received feedback on their submitted notebooks and assignments before the next assignment was due, thus they had the chance to learn to use the scientific method more effectively over the course of the semester. At the end of the semester each student was given a post-test to reassess their competence in applying the scientific method. The questions on the pre- and post-tests were parallel, but the experiments described were different, thus facilitating pair-wise comparisons of student responses.

Results:

The material on the scientific method on the PPP site was expanded and is now presented in such a way as to highlight its importance and to lead the students more carefully through the steps of the process. Information on the development of research questions and generation of testable hypotheses was enhanced.

A total of 63 students in Fall 2006 and 55 students in Spring 2007 completed both the pre- and post-tests, as well as the three web site assignments. Results from the two semesters were combined, and total and individual question scores on the pre- and post-tests were compared using pair-wise comparison T tests, calculated using the Proc GLM procedure of SAS. Comparing the total scores of pre- and post-tests, students, on average, showed significantly higher scores on the post-test (Table 1). Looking at the scores of individual questions (parallel questions on pre- and post-tests), students scored significantly higher ($\alpha = 0.5$), on 10 of the 13 questions. There were no significant differences between pre- and post-test scores on the other three questions. The improvement on the post-test was seen on both the questions asking for general descriptions, such as "What is a scientific observation?" and on questions that asked for specific information, such as "Write a specific hypothesis for this experiment". The data show that following the completion of web based assignments involving virtual experiments, and the completion of three lab notebooks and online assignments on these experiments, students in PLPA 200 significantly improved their ability to describe the general concepts associated with the scientific method, as well as their ability to apply that knowledge to specific situations.

Pre- and post-test results also were analyzed to evaluate the effect of the students' gender and major (science vs. non-science, or agriculture vs. non-agriculture). There were no significant

associations of gender and performance on pre- or post-tests, or with pre-/post-test differences, indicating that both men and women started the semester with the same level of understanding of the scientific method and showed an equal level of improvement resulting from use of the PPP site. Interestingly, students in science or agriculture-related majors did not demonstrate a higher level of competence with the scientific method on either pre- or post-tests. This makes us wonder how much exposure science majors are getting to the scientific method in their science courses.

Table 1. Scientific Methods Pre- and Post-Test Score Differences

Pre-test/Post-test Question	Point Value	Post-Pre Test Difference^a
In general, what is a scientific observation?	2	0.30***
What specific observation did Darwin/Millardet make?	2	-0.03ns
In general, what is a scientific hypothesis?	2	0.26***
Write a specific hypothesis for Darwin/Millardet's experiment.	2	0.00ns
In general, what is a variable in a scientific experiment?	2	0.03ns
List 4 variables that need to be considered in Darwin/Millardet's experiment.	2	0.42***
In general, what is a control treatment? Why is it important?	2	0.40***
Which group(s) was(were) the control treatment in Darwin/Millardet's experiment?	2	0.31***
Was your hypothesis supported or not supported?	2	0.43***
In general, what is a conclusion in a scientific experiment?	2	0.20**
What conclusion can you draw from Darwin/Millardet's results?	2	0.26***
In scientific experiments, what are replication and repetition?	2	0.36***
Why should an experiment be replicated and/or repeated?	2	0.34**
Total pre-test/post-test scores	26	3.03***

^a Paired T-Test analysis using combined data from Fall 06 and Spring 07 semesters, n = 118
 ** significant the 5% level, *** significant at the 1% level

Comparing the results of this study to those of the previous study, which looked at the effect of the PPP on student learning when used as a supplement for course material provided in lecture, we see a much more significant and consistent increase in student learning for material not presented in the lecture (i.e. the scientific method). This is most likely due, in part, to a change in the format of the web based assignment. In the previous study, students were given credit for completing the web assignments, without much evaluation of the students' work. In the current study, not only were the notebooks critically evaluated, but the students received feedback on one assignment that could help them do better on the next assignment. Overall, we feel that having students in PLPA 200 use the PPP web site does increase their understanding of course material and improve student learning in the area of plant pathology and basic biology. However, we need to carefully consider how we design the assignments to encourage the

students to spend an appropriate amount of time using the site and putting some effort into thinking about the assignments.