Redesigning Introductory Biology: Does an Active Learning Environment Facilitate Scientific Literacy

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Introduction

The underlying importance of a scientifically literate society has never been more critical. With increases in technology, our understandings of how genetics and environment impact human health, and the impact of global climate change on resources such as water and fossil fuels, the development of a scientifically literate populous is of tantamount importance.

While biology and other science majors are required to take a plethora of science courses, students not interested in pursuing careers in science are required to take only one lab-based science course. Frequently, this course is the Introductory Biology for Non-Majors (BIO 103) course.

This project proposed to completely redesign BIO 103 to be more appropriate for the population being served by this course. More and more research advocates the institution of active learning strategies into lecture (Freeman et al., 2007), and a more inquiry approach to labs (Wood, 2009) regardless of the discipline studied. Traditionally, BIO 103 at UW-La Crosse has been taught in a format similar to BIO 105 and with similar content and curriculum. The lectures have been didactic in nature and encourage more passive learning on the part of the student. Our overhaul uses current educational strategies, such as Process Oriented Guided Inquiry Learning (POGIL; Eberlein et al., 2008), Problem Based Learning (PBL; Dochy et al., 2003) and Peer Instruction (Freeman et al., 2007). These strategies are employed to engage this group of learners and create a more relevant curriculum as we incorporate examples from current events (global climate change, human health and disease, nutrition, etc…).

Ultimately our goal is to produce scientifically literate students who are able to think critically about scientific information, and understand the role science plays in society (AAAS, 1990).

Active Learning Strategies

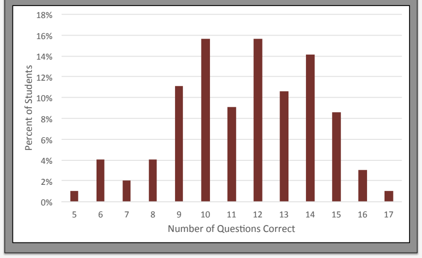
Active Learning Strategies have been shown to benefit students from all educational backgrounds, but can have a more profound effect on students with limited science background (Ernst & Colthorpe, 2007).

1. ***Process Oriented Guided Inquiry Learning (POGIL):*** POGIL is a technique that has been extensively used in Chemistry, but has been show to have positive impacts on Biology and Anatomy & Physiology students as well (Brown, 2010). POGIL is used to guide students as they complete readings and activities designed to allow them to construct their own ideas about the subject. In addition, POGIL activities can make a large class seem smaller by engaging students in "learning teams" and activities facilitated by Faculty and/or Teaching Assistants (Eberlein et al., 2008). POGIL activities are easily paired with personal response systems (e.g., iClickers) to gauge student learning.
2. ***Problem Based Learning/Case Studies:*** PBL presents the learner with a problem or "case study"(Dochy et al., 2003) that students need to address. Students utilize a variety of resources, including their textbook, journal articles or other sources identified by the learners, to answer the question being asked. Regardless of the format for result presentation, PBL has been shown to increase students' problem solving and critical thinking abilities (Dochy et al., 2003)--one of the main goals of our project.
3. ***Peer Instruction:*** Peer Instruction is a technique brought to the forefront by Eric Mazur (Crouch & Mazur, 2001)and has positive effects on student engagement and learning (Freeman et al., 2007). Peer Instruction uses personal response systems (e.g., iClickers) and concept inventories/diagnostic question clusters to diagnose areas where students are struggling and incorporates "mini-lectures" and demonstrations to aid students in discussions with their peers about complex or difficult concepts. Students are then re-questioned to see if they have grasped the topic.

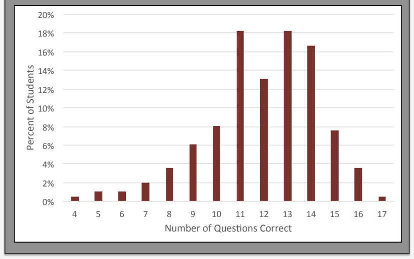
Results

Spring 2014: Before Redesign

Pre-Instruction Scores

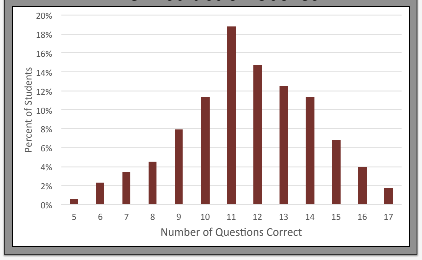


Post-Instruction Scores

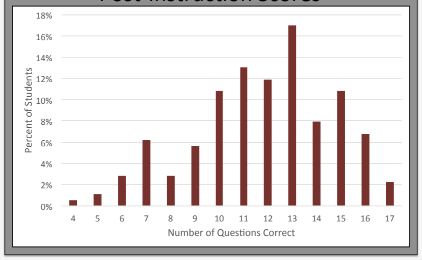


Spring 2015: After Redesign

Pre-Instruction Scores



Post-Instruction Scores



Conclusions & Future Directions

During the Spring 2015 semester, we implemented major course change with the increase in active learning strategies. We were interested in how student critical thinking changed as a result of instituting these strategies. We compared students' conceptions from before instruction to after instruction to determine what impact, if any, our change of instruction had on their scientific literacy. Looking at the overall averages, there appears to be little to no change as determined by instructional strategy employed (lecture vs. active learning). However, if we look at the number of students score 70% or higher on the pre-test and compare that to the number of students scoring 70% or higher on the post-test, we do see an average increase both before the redesign and after the redesign. There may be several factors that could impact the seemingly no result; 1. student buy in. Students received credit for taking the survey, but were not graded on how well they did. As a consequence of this, some students just filled in all A or all E etc… not really putting in any effort. 2. This is the first iteration of the new course design, and is still undergoing an evolution in how best to meet students needs. We are hopeful that in the future we will see continued improvement in students' scientific literacy.

While not the result we were expecting, we are encouraged that there was some improvement in scientific literacy, and we will continue to explore ways in which to increase student literacy.

Methods

To investigate students critical thinking skills we utilized a modified version of a scientific literacy survey developed by Gormally et al. (2012). The Test of Scientific Literacy Skills (TOSLS) was developed to "investigate students' skills with regard to identified areas of scientific literacy: recognizing and analyzing the use of methods of inquiry that lead to scientific knowledge and the ability to organize, analyze, and interpret quantitative data and scientific information." (Gormally et al., 2012).

Students were asked to complete the modified TOSLS during the first 2 weeks of lab to obtain a baseline score. The students then took the modified TOSLS during the last day of lab to obtain their literacy score at the end of the course. We then compared students pre-instruction scores to their post-instruction scores by matching each student's pre-test and post test score and then taking an overall average.

Student Learning Outcomes

When designing the course, we started with the idea of what we wanted all students to know when they were done with our course. We designed the following learning outcomes/ performance expectations for our students. Upon completion of this course students should know and be able to:

1. Identify valid scientific arguments
2. Read and design accurate and effective graphs designed to convey scientific data.
3. Solve problems using quantitative skills.
4. Use data to develop and express logical arguments.
5. Evaluate the use and misuse of scientific information.

Resources

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