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Linking Art and Science with a Drawing Class

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Linking Art and Science with a Drawing Class

Description
Strong observational skills are important to students and professionals of both the arts and the sciences. In order to help science students improve their observational skills and show them the interconnectedness of the arts and the sciences, we designed a drawing class for students who were concurrently enrolled in the first semester of a two semester General Biology sequence. Drawing assignments required students to observe and draw specimens that would subsequently be studied in the biology course thus causing students to examine them closely and potentially enabling them to have a deeper appreciation for the similarities and differences between organisms. Surprisingly, students who were enrolled in the drawing course performed significantly worse on biology assignments than students who were not enrolled in the drawing class. We believe that relatively weak students who expected to have difficulty in biology chose to enroll in the drawing course hoping that it would serve as a tutorial for the biology class. Students in the drawing course clearly improved their drawing skills as evidenced by student comments and pre- and post-instructional drawings. Importantly, student comments indicate that the drawing class helped them make better observations in the biology course.

Disciplines
Arts and Humanities | Biology

Comments
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Abstract: Strong observational skills are important to students and professionals of both the arts and the sciences. In order to help science students improve their observational skills and show them the interconnectedness of the arts and the sciences, we designed a drawing class for students who were concurrently enrolled in the first semester of a two semester General Biology sequence. Drawing assignments required students to observe and draw specimens that would subsequently be studied in the biology course thus causing students to examine them closely and potentially enabling them to have a deeper appreciation for the similarities and differences between organisms. Surprisingly, students who were enrolled in the drawing course performed significantly worse on biology assignments than students who were not enrolled in the drawing class. We believe that relatively weak students who expected to have difficulty in biology chose to enroll in the drawing course hoping that it would serve as a tutorial for the biology class. Students in the drawing course clearly improved their drawing skills as evidenced by student comments and pre- and post-instructional drawings. Importantly, student comments indicate that the drawing class helped them make better observations in the biology course.

Keywords: observational skills, drawing, biology, interdisciplinary connections

INTRODUCTION

In 1959, C.P. Snow described practitioners of the arts and of the sciences as belonging to two very different cultures (Snow, 1959). Artists were described as having little understanding of science while scientists were ignorant of history and literature. Members of the two groups were described as being unable to comprehend each other’s fields of endeavor (Snow, 1959).

The arts and the sciences are often seen as separate and independent spheres of human activity. However, this incomplete and widely held perception is undergoing revision. For example, students studying art may think of themselves as working in a subjective field that is unconnected to the world of science. But a strong case can be made that the process of creating a piece of art requires objectivity and cognitive skills that are typically associated with scientific work (Hanrahan, 2000). Students majoring in the sciences may just as easily believe that their work has little to do with the humanities. However Snow himself wanted to bring the two cultures closer together (Ruprecht, 1999) and many educators now recognize that the two cultures continuously interact with each other in productive ways (Hallett and Kalman, 1975).

How can we as educators more effectively communicate to our students the interdisciplinary nature of all knowledge? There has been a concerted effort to connect the natural sciences with mathematics (see Czerniak et al., 1999 for a review of this literature). More relevant to Snow’s dichotomy, innovative curricula have been developed that attempt to bridge the perceived gap between the humanities and the sciences. There are many published examples of courses that integrate biology, chemistry or physics with literature, art or history (Allchin et al., 1999; Flannery and Hendrick, 1999; Carstens-Wickham, 2001). It seems clear that knowledge that is typically associated with one discipline can be easily connected to other disciplines.

Perhaps less widely appreciated is the fact that skills can be interdisciplinary as well. The ability to make careful observations is an example of a discipline-independent skill that benefits all students and professionals regardless of with which of the two cultures they identify. A common model of the scientific process describes it as beginning with observations that lead to questions, hypotheses, predictions, data collection and interpretation, and then conclusions (Purves et al., 1998; Solomon et al., 1999).
A fundamental act of science, then, is making observations; developing observational skills is therefore a crucial element in science education. Students in our first semester General Biology course have been asked for several years to draw and label specimens in lab with the intent that this task would help students to observe specimens more carefully than they might otherwise. Other biology instructors have required students to make labeled drawings in lab for similar purposes, and they have reported success (Matern and Feliciano, 2000). Although observational skills are important, our experience with students has led us to believe that freshmen often have weak observational skills.

Making careful observations is clearly the foundation for the scientific process but it is crucial for other endeavors as well. It is difficult for us to imagine how meaningful work in the fields of music, history, or creative writing can be conducted in the absence of sound observations. In fact, work in the humanities requires some of the same skills as does work in the sciences (Adams and Fuchs, 1985). Here, then, is a fundamental attribute held in common by both the arts and sciences: work of good quality in both spheres of endeavor depends on the practitioner’s ability to make careful observations.

One possible way to help students recognize and benefit from the shared skills required by the two disciplines is to have them study a single body of material in the context of both an art course and a science course simultaneously. We developed a drawing course for students who were concurrently enrolled in an introductory biology course. The primary goal of the drawing course was the improvement of students’ ability to draw. However, we had an additional goal; we wanted to use the teaching of observational skills as a platform from which students could clearly see and benefit from the connections between the arts and the sciences.

METHODS

Biology 202 is the first biology course taken by freshmen at Pacific University. It has no prerequisites and is offered in the second semester of the academic year so the majority of students enrolled in the course are second semester freshmen. It is taken by non-science majors as well as by students majoring or minoring in Biology, Chemistry, Environmental Science or Exercise Science; many of these students intend to become health care professionals.

The course covers evolution, the diversity, structure and function of organisms, and ecology. The course requires students to learn what they commonly perceive as a large volume of detailed material. Lecture and lab activities are synchronized so that students are exposed to topics in a lecture setting several days before they explore those same topics in a lab setting. For example students may be exposed to the idea of transpiration via stomata in lecture and then in lab they will actually make measurements of transpiration rates and prepare epidermal peels to observe stomata under the microscope. While each lab activity is different, almost every lab meeting requires students to look carefully at organisms, make labeled sketches, ask questions and use the scientific method to reach conclusions.

The authors met weekly for one semester prior to the drawing course to discuss the goals of the course and the methods by which they might best achieve those goals. We decided that students should be exposed to biological specimens in the drawing class before they acquired any knowledge of them from the biology class. Hopefully this would ensure that the students would make observations and drawings based upon skills and techniques learned in the art class without being influenced by the knowledge of structures and functions that should be drawn and labeled in a biology class.

We also decided that assignments made in the art class would not require the students to actually learn any biological content. We wanted to make sure that the drawing course did not become a “help session” for the biology course. This was important to us for two reasons: 1) We wanted to see what influence (if any) learning how to draw might have on students’ performance or attitudes in the biology course without the confounding variable of making drawings assignments that amounted to studying biology. For example, we agreed that asking students to include labels on their drawings of biological specimens before the material had been studied in the biology course was tantamount to asking them to study and learn biology. We therefore made every effort to avoid creating drawing assignments that resembled biology homework. 2) Biology 202 had an enrollment of 143 students, only 18 of whom were enrolled in the drawing class. We did not want the vast majority of biology students who were not enrolled in the drawing class to feel that the students in the drawing class had an unfair advantage as a result of “studying biology” in the drawing course.

The drawing course used the approach described in the text entitled *The New Drawing on the Right Side of the Brain* (Edwards, 1999). This approach requires students to learn to ignore messages from the left hemisphere of the cerebrum that tell them to think about and draw objects logically and analytically. Edwards encourages students to draw in a more intuitive mode. Students who avoid affixing biasing labels to their subjects and who are not concerned about whether the final drawing is “stupid” or “horrible” are more likely to explore different ways of thinking and drawing, and so are more likely to make good progress with their drawing skills.

Students in the drawing class spent the first several weeks learning basic drawing skills designed
primarily to engage students in new modes of thinking. Exercises included making drawings of upside down subjects, drawing the missing half of an object and doing drawings without looking at their paper (“blind contour drawings”). Subsequent drawing assignments were correlated with Biology 202 (Table 1). One or two weeks before a given Biology 202 topic was to be covered, drawing students were given an assignment related to that material. Students were not expected to know the biological names or functions of any of the parts of these specimens. Students were simply asked to make the best drawing they could. They then studied the subjects of their drawings in biology lecture and the following week they observed specimens in biology lab.

**Table 1.** A partial outline of the weekly assignments in the drawing class and their relationship to material under study in the biology class. Note that specimens are drawn in the drawing class before they are studied in the biology class.

<table>
<thead>
<tr>
<th>Week</th>
<th>Drawing assignments</th>
<th>Biology topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre-instructional drawing: tree</td>
<td>Evolution</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Evolution</td>
</tr>
<tr>
<td>3</td>
<td>Note-taking graphics: Protists (from text)</td>
<td>Taxonomy; cells</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Bacteria; Protists</td>
</tr>
<tr>
<td>5</td>
<td>Negative space drawings: plants</td>
<td>Fungi; plants</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Plants</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Plants</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Plants</td>
</tr>
<tr>
<td>9</td>
<td>Scratchboard: biological subject chosen by student</td>
<td>Animals</td>
</tr>
<tr>
<td>10</td>
<td>Final project: three-part drawing of an organism, its</td>
<td>Animals</td>
</tr>
<tr>
<td></td>
<td>environment, and detail of its anatomical structure</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>Animals</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>Ecology</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>Ecology</td>
</tr>
<tr>
<td>14</td>
<td>Post-instructional drawing: tree</td>
<td>Ecology</td>
</tr>
</tbody>
</table>

We created five assignments that were connected to the biology course. The first was a pre-instructional drawing of a tree, completed during the first week of the semester (Fig. 1), that could be compared to their post-instructional drawing of a tree, completed at the end of the semester (Fig. 2), as an indicator of their progress. The second was to draw several groups of protists and/or fungi from their biology textbook (Fig. 3). This activity served both as an exercise in contour drawing and as an introduction to the concept of “note-taking graphics”, which is an alternative way for students to study and record information. The third was to make “negative space” (Edwards, 1999) drawings of plants (Fig. 4). Negative space drawings required students to ignore the focal object and instead draw the space surrounding the object. The space around an object is unlikely to resemble any shape or icon (for example, “chair” or “face”) that already exists in the students’ mind. Because they had no pre-existing mental model from which to work negative space drawings forced them to make unprejudiced observations. The fourth assignment was to bring in a small biological specimen that could be magnified and represented on a scratchboard. Students used a very finely pointed metal tool to precisely scratch off some of the black coating of the scratchboard and reveal the underlying white material. This is a technique that allows for expression of value and fine detail. Students selected subjects such as grasshoppers, dandelion fruits, and flowers (Fig. 5). The fifth assignment was the last of the semester and students were given approximately three weeks to work on it because of its complexity. Students were asked to design a three-part drawing that showed an organism, its environment, and some detail of the anatomy of the organism. This assignment required students to select from a wide variety of options and compose and execute the final product using the skills they had acquired throughout the semester. Examples of these final projects include: ants on a hill, an ant, and a close-up of the ant’s head (Fig. 6); a robin pulling an earthworm out of the ground and a close-up of a feather; a fish in a reef environment and a diagram of counter-current gas exchange in the gills; an anemone eating a fish with a close-up of the anemone’s mouth. (Additional examples of all drawing assignments can be seen at http://cas.pacificu.edu/art/Hewlett.html.)
Figure 1. A sample pre-instructional drawing of a tree by a student who was concurrently enrolled in both drawing and biology courses.

Figure 2. A post-instructional drawing of a tree by the same student whose pre-instructional drawing is seen in Figure 1.

Figure 3. A student drawing exemplifying the technique of graphic note-taking.

Figure 4. One student’s drawing using the technique of negative space.
In addition, students were asked to keep a sketchbook containing a variety of their drawings from the second half of the semester. Students created several drawings each week, both in and out of the drawing class, and at least one of these each week was to relate to their biology class. Students were free to draw images from their biology textbook and from live or preserved specimens. Drawings included note-taking graphics and detailed drawings of anatomical structures or biological processes (Fig. 7). Students often chose to label these drawings although they were not asked to do so.

Funding from the Hewlett Foundation made it possible for us to provide students with a set of materials including pencils, paper, a viewfinder, and magnifiers. In addition, Hewlett funding allowed us to purchase biological charts, models and books (e.g., field guides) to serve as both resources and stimuli for students enrolled in the drawing class.

We wanted to ensure that any subsequent differences in student performance in the biology class between biology students who were enrolled in the drawing class and those who were not would not be attributable to initial differences in their academic abilities. As indicators of academic ability we collected the following background information about each student: high school GPA, first semester GPA at Pacific University (Biology 202 is almost exclusively enrolled by second-semester freshmen), and SAT scores (verbal, analytical, and total). Z-score histograms showed that these variables were not distributed normally. The distributions of these variables were compared using Mann-Whitney U tests.

We compared the scores in biology of students who were enrolled in the drawing course to the scores of students who were not. We compared the final course grades and grades for all lab assignments and lecture exams. Assignments with grades that were not distributed normally were analyzed using Mann-Whitney U tests; t tests were used to compare the means of assignments with grades that were normally distributed. All data were analyzed using Statview© version 5.0.1.

Students enrolled in both courses were also asked to write an evaluation of their drawing skills and to comment on the relationship between the two courses.
Table 2. A comparison of the academic profile of 18 students who were enrolled in both the biology and drawing classes to that of 125 students who were enrolled only in the biology class. Values are means and are indicated as + or – values for the percent difference between students who enrolled in both biology and drawing classes and those who enrolled in only the biology class. With the exception of values for College GPA, all measurements indicate lower values for the students enrolled in both classes. Some pieces of information were not available for every student thus the ranges of “n”.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Students enrolled in Biology and Drawing (n = 16-17)</th>
<th>Students enrolled in Biology only (n = 97-119)</th>
<th>% difference between B&amp;D and B (n=16-17)</th>
</tr>
</thead>
<tbody>
<tr>
<td>College GPA</td>
<td>2.806</td>
<td>2.677</td>
<td>+4.60</td>
</tr>
<tr>
<td>Verbal SAT</td>
<td>517.5</td>
<td>544.0</td>
<td>-5.12</td>
</tr>
<tr>
<td>Total SAT</td>
<td>1069.4</td>
<td>1106.0</td>
<td>-3.42</td>
</tr>
<tr>
<td>High school GPA</td>
<td>3.493</td>
<td>3.567</td>
<td>-2.12</td>
</tr>
<tr>
<td>Analytical SAT</td>
<td>551.9</td>
<td>559.7</td>
<td>-1.41</td>
</tr>
</tbody>
</table>

RESULTS
Eighteen students enrolled concurrently in the drawing class and the biology class. An additional 125 were enrolled only in biology and two were enrolled only in the drawing class.

There were no statistically significant differences between the high school GPA’s, college GPA’s, verbal SAT scores, analytical SAT scores or total SAT scores of students who were enrolled only in the biology course and those who were enrolled in both courses (Table 2). However the means of four of these five attributes were lower in the students enrolled in both courses.

In 14 of 17 biology assignments (five exams and 12 labs), the mean scores of students enrolled in the drawing class were lower than those of students who were not enrolled in the drawing class. Although their mean scores were significantly lower on only two assignments (lab exercises)(t test, p < 0.0274), the fact that these students enrolled in the drawing class had lower mean scores in 14 of 17 assignments was a statistically significant finding (Chi-squared test, d.f. = 1, p < 0.01). In addition, the overall mean score for all lab assignments was significantly lower for students enrolled in the drawing course (t test, p = 0.0447).

Post-instructional student comments about their ability to draw can be seen in Table 3. Many indicated that the drawing class improved their ability to “pay attention to detail.” Student comments about the drawing class and its relationship to the biology class indicated that they expected the drawing class to have a more direct connection to the biology class, and that the drawing class helped them make better observations in their biology class (Table 4).

Table 3. Some post-instructional comments by students on their drawing ability, written at the end of the semester by students enrolled in both drawing and biology classes.

“My ambitions for being a much better artist have increased.”
“I did learn some very useful skills in the art class, and I am glad that I decided to take the class.”
“I hope that the class is offered again so others can learn how to draw the world around them just a little bit better and know that they can draw just fine. It was a good confidence booster for people not so artistically inclined in the drawing department.”
“…I think I have become a better artist by taking this course. I came into the course as one of the few students who thought they had any idea how to draw, however, I found that I didn’t know how to draw quite as well as I thought.”
“I like being able to look through my sketchbook and seeing my improvement….I thought I could never learn to draw but I proved to myself that I could.”
“…I have learned to draw what I actually see instead of what I think I should see….I did learn to pay attention to details…..”
“I felt that this drawing class really helped me improve my drawing ability. (The instructor) helped us realize the importance of truly examining the object that we are drawing, rather than using our imagination and draw what we thought we were seeing.”
“I became an all around better artist by merely using something that I had taken for granted, the ability to see and pay attention to detail.”
“The class taught me to pay attention to detail.”
Table 4. A sampling of post-instructional comments on the relationship between drawing and biology, written at the end of the semester by students enrolled in both courses.

<table>
<thead>
<tr>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;I think it is great to know how to draw for biology. Becoming a better artist will help me be able to study better and fully understand the material.&quot;</td>
</tr>
<tr>
<td>&quot;I didn’t think that there was a relationship but after taking the class I payed more attention to details.&quot;</td>
</tr>
<tr>
<td>&quot;I don’t really know, I just know that it is much easier to study biology, if you can draw. And vice versa.”</td>
</tr>
<tr>
<td>&quot;It helped me not only learn how to draw but also with my studying for biology….In labs we did a great amount of sketching and knowing the organism helped me to observe the organism helped me draw a more accurate picture of the organisms we studied.”</td>
</tr>
<tr>
<td>&quot;I have realized, during my labs, how much more attention I pay to what I am trying to draw. Before I took this drawing class, I would’ve drawn a worm like a long skinny line and not given it its true justice of what it is really composed of:”</td>
</tr>
<tr>
<td>&quot;Our (biology) tests asked us specifically for features of certain organisms. The drawings helped me remember what the organism that we were studying looked like.”</td>
</tr>
</tbody>
</table>

DISCUSSION

The primary goal of a drawing course must be improvement in the ability of students to draw. The student comments (Table 3) and pre- and post-instructional drawings (Figs. 1 & 2) are strong evidence that this goal was achieved. These findings are consistent with those of Edwards (1999) who describes tremendous gains made by novice drawing students during a five-day course. Edwards’s text includes sample pre- and post instructional drawings as evidence of improvement. Because similar methods were used by the drawing instructor (O’Day), similar results are not surprising.

Although students have long been asked to make sketches in biology labs as a means of carefully observing the features of different specimens, drawings have not been graded for their accuracy or artistry but rather on whether all structures were recognizable and properly labeled. Other biology instructors have asked students to draw and label specimens as an aid to learning morphology and reported that this technique is both effective and well received by students (Matern and Feliciano, 2000).

Differences in performance in the biology course between students who were also enrolled in the drawing course and those who were not cannot be attributed to statistically significant differences in their academic histories (Table 2). However it is interesting to note that all indicators of previous academic performance except for “College GPA” were lower in the students who chose to enroll in both courses. Furthermore, internal studies by the Biology Department at Pacific University have shown that verbal SAT score has historically been the strongest predictor of performance in our introductory biology course. The mean verbal SAT score differed between the two groups of students by a greater percentage than did any other attribute measured before the course started (Table 2); this suggests that students who were statistically less likely to perform well in Biology 202 were more likely to enroll in the drawing class than were other students. It is possible that the drawing class was perceived as a “tutorial” for biology. Students in biology were told about this course during the first day of the semester and although the two courses ran in parallel we tried to avoid describing the course as a tutorial for biology. For whatever reason, it appears that students who chose to enroll in the drawing course were relatively, although not statistically, weaker academically.

The apparent non-random enrollment of students in the drawing course may explain why students enrolled in the drawing class tended to perform worse in Biology 202 than their peers. (It is possible that the drawing course itself caused students to perform worse in biology by giving them a false sense of biological knowledge as a result of their frequent observations of specimens, but this possibility strikes us as unlikely.) Perhaps these students anticipated correctly that the biology course would be difficult for them and hoped that the drawing class would help them perform better. Clearly a challenge for future versions of this course will be to make clear to students and academic advisors that while the drawing and biology courses “go together”, neither should be regarded as a tutorial for the other.

Student comments about the relationship between the two courses tended to center around two themes (Table 4). The first was that some students expected that there would be a greater number of assignments that were directly relevant to the biology course. This first iteration of the course had five assignments that were connected to the biology course (in addition to the weekly sketchbook entries as selected by each student) but the potential for many more exists. Since we know before the semester starts what organisms will be under study in biology each week we can design drawing assignments that mesh more frequently and directly with the biology course. For example, mosses and ferns, cone-bearing trees, and flowers and fruits could
each be drawn for one week before the weeks during which those groups are studied in Biology 202.

The second theme in student comments was that the course helped some of them pay attention to details better and that this helped them study for biology. We interpret this as an indication that the observational skills of some students improved and that they were cognizant of the fact that this skill was helpful in studying science. This indicates that our secondary goal for the drawing course (that students recognize the significance of observational skills to both artistic and scientific endeavors) was met for some students. We expect that by incorporating more assignments that connect directly with Biology 202 into future versions of the drawing course, we will meet that goal for a greater percentage of students.

ACKNOWLEDGEMENTS

A grant from the Hewlett Foundation made it possible for us to design, offer and supply students with materials for this course. Data analysis and writing took place during E.A.’s sabbatical leave funded by Pacific University. The manuscript benefited from the comments of two anonymous reviewers.

LITERATURE CITED


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