

Use of Instructional Technology as an Integral Part of a Non-Major Science Laboratory Course: A New Design

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Abstract

The use of instructional technology to learn and teach science is a natural approach for today's undergraduate. Adding computers to a non-major laboratory to serve as the research laboratory notebook converted the course into a dynamic student-centered classroom. Cooperative teams became very active in doing inquiries and using the tools of technology to gather background information, collect evidence, analysis data, write proposals, submit journal articles to a class electronic journal, and present results at the podium. Student and instructor comments support the design of the new biology non-major laboratory course.

Technology has become a major part of our daily lives. The uses of technology seem to increase at an almost too rapid pace. This science will only become more complex and more useful in the future. We cannot avoid its advances. Clearly there is a need for all citizens to develop an understanding of and basic skills to use technology as a tool "to conduct inquiry and to understand science" (National Research Council, 1996, p. 24). Many universities and colleges, including our own, are beginning to require a basic set of competencies in the area of technology for an undergraduate bachelor's degree. Because of the necessity of understanding technology and our university's requirement in the undergraduate curriculum it became our vision to design a science laboratory which focuses on the use of instructional technology as a tool for teaching and learning. It was to this end that we converted a very traditional non-major undergraduate biology lab course into a dynamic student-center, active learning experience.

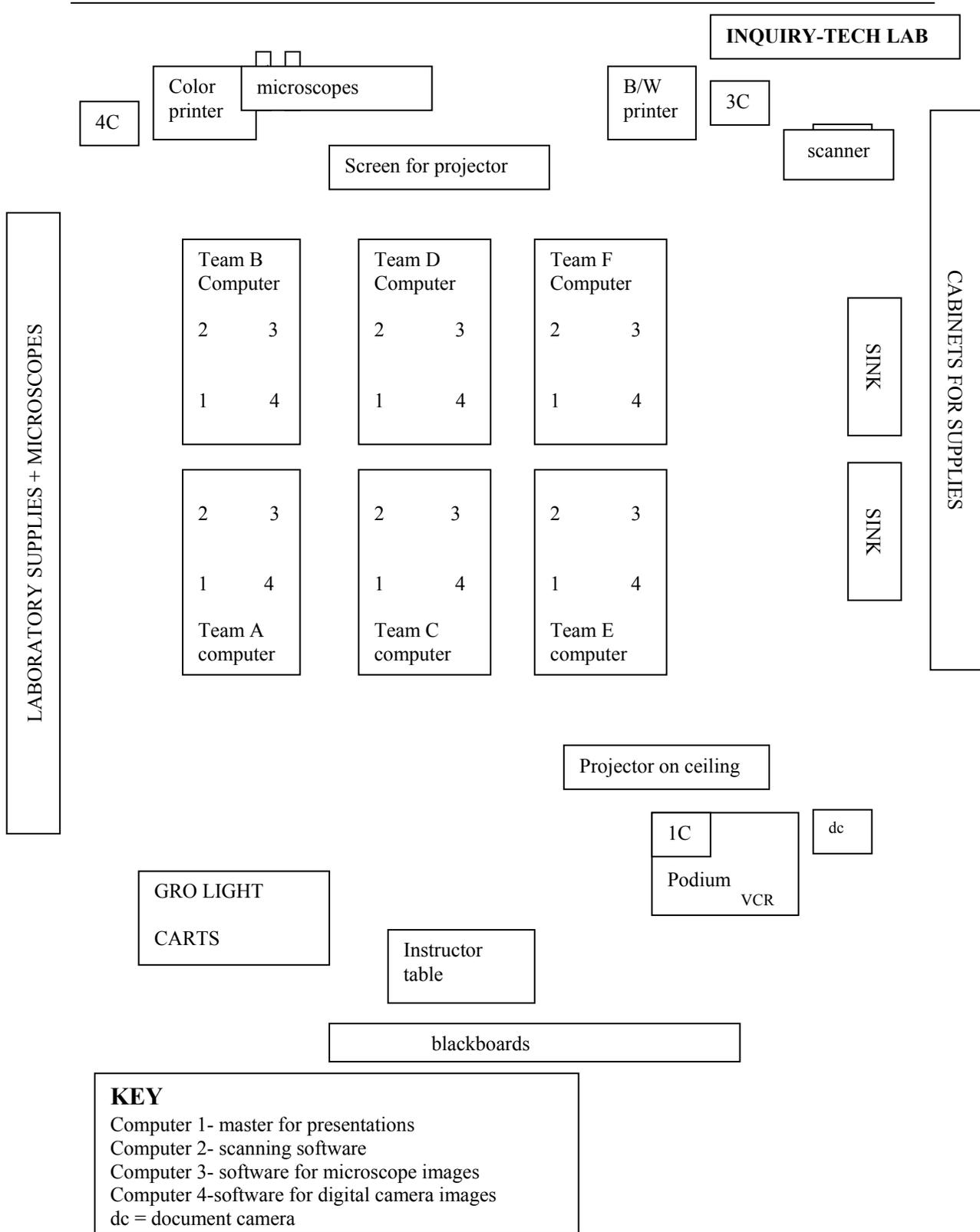
Adding instructional technology into an undergraduate lab course is a natural for today's students who were raised in a technology-driven world. They move easily across the Internet, use e-mail, and listen to as well as record digital music. They require little to no instruction in the use of word processing, e-mail, and Internet searching. For the new lab course we selected Windows 98 as the processing system and Microsoft Office 97 (and now SP-1) as the basic software because they are readily available, inexpensive, and easy to learn for the rare student who might be unfamiliar with them. In addition our campus has a help desk that is available for tech questions and an IT staff that teaches basic courses on how to use the features of the Microsoft Office software. Because the majority of students have experience with the use of computers, the instructor needs to devote little laboratory time to explain the selected science software such as Inspirations 5.0e, DataStudio (PASCO) 1.7, and Winnov Videum 2.7.3, that have been incorporated

into the course. Therefore the technology becomes a tool for learning as envisioned by the National Science Education Standards (National Research Council, 1996, p. 24).

The major change in the dynamics of the laboratory classroom since the implementation of the new design has been that students are always active, busy, and totally engaged in their learning. They enjoy the use of the computers, are able to access their lab notebook from outside the classroom, find writing for the class electronic journal easier, and like learning from their teammates. They are very comfortable in the technology environment.

The Course Design

The first step in this transformation was to change the physical aspects of the laboratory room and adding computers, printers, a podium, digital cameras for the microscopes, a LCD projector, and scanner, and moving the location of the screen. Figure 1 is a diagram of how the room was redesigned. Six computers (A-F) were placed on the three bench tops to serve as the laboratory notebook for “research teams” of three to four undergraduates enrolled in the biology course. A portion of the team laboratory notebook (TLNB) is to be completed during each lab session. The students are placed into cooperative learning groups during the first laboratory session. Each student is assigned a role in his/her team for that lab. The roles include recorder, leader, observer, and material manager (Laine & Heath, 2002). During the next lab the students change roles so there would not be what the students call a “mouse hog”!



KEY
 Computer 1- master for presentations
 Computer 2- scanning software
 Computer 3- software for microscope images
 Computer 4- software for digital camera images
 dc = document camera

Figure 1. Redesign of laboratory room.

As noted previously Windows 98 was chosen as the processing system; Microsoft Office contains sufficient software to accomplish the basic word processing functions needed to complete all the requirements of the course. We used Microsoft Word to write both student instructions and the companion template for each lab. Teams are required to complete a template during each lab and save it to their TLNB in the drop box (see Figure 2). The completion of these 14 templates is part of the team's assessment points

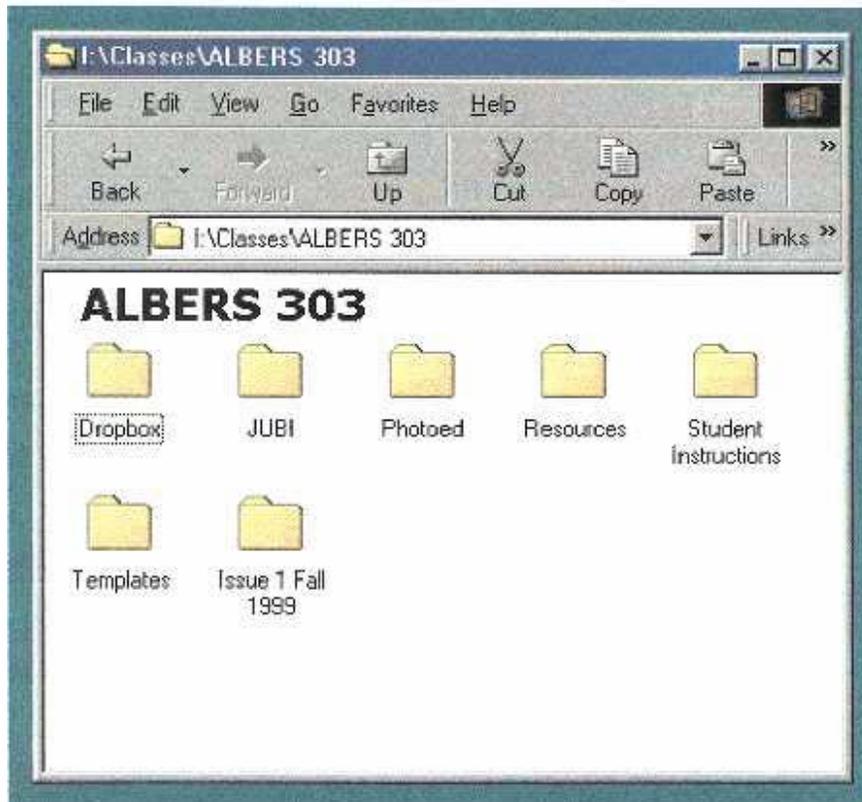


Figure 2. Electronic view of biology laboratory course.

for the semester. In addition the research teams write three journal articles from their laboratory experiments and submit these to the class electronic journal *JUBI, Journal of Undergraduate Biology Inquiry*. The journal articles are due following completion of three phases of the course: (1) *introduction* to learn the basic process skills needed to do science, solve problems, or answer questions (National Research Council, 1996, p. 23); (2) *practice* to improve their skills; and finally (3) *performance* to do their best. The third journal article has to be communicated orally as a poster or Microsoft PowerPoint (versions 97 and SP-1) presentation.

The class folder shown in Figure 2 is located on a local area network at the university. In addition to the student instructions, template, *JUBI*, and drop box folders, the course folder contains a resource folder. The resource folder holds information for the instructors teaching the course as well as documents to which students have access for gathering background information, images, and data needed to complete a laboratory on

“dissection” and presentation of a science journal article. Eight articles were chosen from journals applicable for the undergraduate level. These were real journal articles selected from either electronic journals or magazine journals appropriate for the non-major student. Two examples are *JYI, Journal of Young Investigators* (<http://www.jyi.org>) and *JUS, Journal of Undergraduate Science* (<http://hcs.harvard.edu/~jus/home.html>). We use this “dissection” laboratory to teach the teams how to write a science journal article prior to writing their first article.

Tools needed for the research teams to gather background information to conduct their inquiries include Internet access and a flatbed scanner. Both Netscape 4.6 and Explorer 6.0 are available as browsers. Students are provided with a list of URLs that have been checked for their science content and are required to use other resources beyond the Internet. In addition the Internet can be used for students to locate and then contact other scientists to obtain information. The laboratory room contains a “lab library.” This library contains many non-major biology texts, specific books for the inquiries the teams are asked to complete, pertinent journal articles, and lab method books. Students can use the to enter text, images, or diagrams into the TLNB; those who prefer can add their own drawings of organisms or data charts.

Teams use Inspiration software (<http://www.inspiration.com>) to produce concept maps to summarize and present an overview of the information they have gathered. This software and all the other tech tools are introduced during the first phase of the course so students feel confident to use them during the practice and performance phases. Concept mapping can be used in assessments, classroom discussions, or as peer evaluations (Novak, 1990). An excellent web site to provide more information on concept maps is <http://www.graphic.org/concept.html>.

To collect data from experiments teams, have available PASCO digital probes with DataStudio software. Typical non-major biology probes include the amount of dissolved oxygen, pH, temperature, humidity, and light intensity. The software is a data acquisition, display, and analysis program. It also allows one to enter data manually. The analysis function is quite extensive (<http://www.pasco.com>). As an alternative, students can use the Microsoft Excel program (97 and SP-1) with spreadsheets and chart wizard functions to analyze and produce data.

The non-major biology lab has two ways for students to document visual evidence of either methods or results from experiments. Winnov Videum is a multimedia capture board (<http://www.winnov.com>). The teams use its software and hardware to capture still images under the microscope. They can then paste the image into the TLNB and include it their *JUBI* articles, PowerPoint or poster presentations. The second method for students to document visual evidence in the lab is the use of the hand-held digital camera. Teams can take a picture of either the experimental set-up or the experimental results. Kodak Picture Easy 3.1 software is used to download and edit the images. The evidence is then pasted into the TLNB.

A very important part of the new biology lab course is communication. Communication is an essential part of the process of science (National Research Council, 1996, p. 23). The research teams participate in the following types of oral presentations: research proposals prior to beginning an experiment, evidence from their inquiries, sharing information from their TLNB, explaining their concept maps, background information on assigned organisms, and presenting the evidence from a published science

journal article. Teams are required to communicate orally during most of the 14 laboratory sessions (see Figure 3). As Figure 1 shows, the laboratory room is equipped with a podium and LCD projector as well as a document camera. The document camera can be used to view larger animals and plants. It is an extremely valuable piece of



Figure 3. A research team presenting their findings at the podium.

equipment for oral presentations if the computers lose function. In such times the teams can always rely on the paper/pencil approach.

The LCD projector is connected to video cameras mounted on two microscopes. The video cameras are perfect for presenting visual evidence resulting from a class inquiry in which the research teams are asked to find out which of five organisms are able to use *Saccharomyces cerevisiae* as a food source. The teams must defend their answers and this erupts into a real class debate. Both students and instructors use the LCD projector, podium, and video cameras for oral and visual communication.

Students' Reactions to the New Course

Below is a student e-mail assignment following the first lab session. Students are asked to reflect on their first experience in the new laboratory course.

Hello Dr. Laine!

I am very excited to be a part of your class. I think that it should be a wonderful experience. I feel as though it will create a great opportunity for me to learn biology in a new and fun way. Our world has become very computer centered and I think that this lab is a great way to incorporate computers into the classroom.

I think that today's lab was a lot of fun and I learned a lot from being able to think on my own inside my group. I also learned a lot from hearing what my classmates did in their own experiments. Everything was explained very clearly today, and I think that we all have a wonderful foundation to build on for the remainder of the semester.

I hope that you have a wonderful weekend and I will see you in class on Thursday!

At the end of the course students were asked to respond to the question: What did you like best in this course?

- I liked having the freedom to plan our own inquiries.
- It was fun doing hands on stuff as opposed to my usual boring lectures.
- I liked using computers, digital camera, adding technology to research - ability to research how your group wanted.
- I liked working in groups along w/learning about things that I normally wouldn't even think about.
- I liked being able to think of & conduct our own experiments. I think it allowed groups to be more creative & really get to know what they were studying.
- I liked the presentations.

Instructors' Reactions to the New Course

A total of ten different instructors have taught the new technology-intensive biology laboratory course for the non-major student. The prior teaching experience of the instructors has been very diverse from a few who have taught for over 35 to 40 years to those who were just completing their doctoral degrees. It became very clear that those instructors who were not comfortable with the addition of the "tools of technology" struggled with the fact that the students were more knowledgeable. Isn't the instructor to be the expert in the classroom? The learning curve was very steep and demanding for most of the older faculty. The easiest remedy to this situation is to allow the students to become the teachers and then everyone in the classroom learns together. A comment from a senior instructor after his first semester teaching the new laboratory:

My initial impression of this course was to teach students to think like scientists, and that the course did not need to focus on science content. In other words the process was most important. The little experiments, I feel, did teach the process, and they involved the students and created enthusiasm as I have never seen in this type of student.

However their understanding of biological concepts was not expanded appreciably in this semester as far as I can see. The logistics of the course, the technology that was new to me, and the time factor were hindrances to my spending time with the individual teams and encouraging them to expand their knowledge of science.

Next time around I will certainly spend more time and effort drawing out of the students their ideas, reasons for their findings, and their conclusions, based on biological/scientific understanding.

I must say that some of them were very good at finding information related to their experiments on the Internet. I need time to discuss this information with them.

Overall the instructors enjoyed the ability to grade the three journal articles online from their own office computer. The team laboratory notebooks were graded each week for completion. These team notebooks became an excellent source to detect student misconceptions that serve as points of discussion during the introduction of the next lab. The instructor can copy/paste sections from a team notebook with no student names attached and share this electronically to initiate the class discussion.

Summary of Development Process

Adding instructional technology to a traditional biology laboratory for non-major undergraduates has been a very rewarding adventure. After teaching the non-major student for many years it was a delight to see them totally engaged in doing science and taking ownership for the journal articles they submitted to *JUBI*. Examples of student work can be seen at <http://www.jubi.org> or <http://www.xavier.edu/biology.dept>.

The course was developed over a two-year period and required the help of many different people from the campus community. During the first year, two different instructors taught three pilot sections. In the original pilot section of 24 students both instructors were in the classroom together so observations and notes could be recorded and improvements made. During the second and third pilot sections each instructor tried slightly different activities, approaches and assessments.

Enrollment the second year required that the department offer 13 sections of the course. The developing instructors taught a weeklong professional development workshop during the summer prior to the fall semester to prepare for this many sections. All eight of the instructors needed to become comfortable with the pedagogical approach of a student-centered classroom, their new role as facilitator, and all the technology tools that had become an integral part of the new course. Weekly meetings were held during this scale-up semester to discuss what worked and what needed improvement. A total of 315 students successfully completed the course that semester. The course is now a permanent part of the biology curriculum offered by our university for the non-major student. The process used to develop this new course, that is, “how to integrate instructional technology and inquiry into science laboratories for the non-major undergraduate,” has been taught as a National Science Foundation Chautauqua short course for biology and science education faculty during the summers of 2001 and 2002.

The course is called *Discovering Life Science*. A laboratory manual with the same title has been written and is available through the Symbiosis product line of Pearson Custom Publishing Company (www.pearsoncustom.com).

Note

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