LifeLines OnLine—Curriculum and Teaching Strategies for Adult Learners

Integrating Information Technology With Problem-Solving Pedagogies

Ethel D. Stanley and Margaret A. Waterman

Although biology courses introduce the requisite life science concepts to undergraduates, the curriculum and pedagogies often fail to prepare students to use what they have "learned" to solve real problems (Stover 1998). As a result, educators and researchers have called for reform in biology education so students can become familiar with the process of science, not just its products (NSF 1996).

The biology curriculum must provide opportunities for students to access, retrieve, and utilize biological information (Flynn 1998; Stover 1998; Ercegovac 1997; Shotwell 1996; Eaton 1993) so they can connect their knowledge to the biological issues they face every day (White 1988). Inquiry is not just useful in scholarship; asking questions and evaluating information are invaluable skills for daily decision making (Ercegovac and Yamasaki 1998).

The task of addressing the science literacy issue by way of curricular reform rests largely on the shoulders of two-year college faculty members. According to American Association of Community College projections (1998), the typical undergraduate taking biology within five years will be over the age of 25, working, and enrolled in a two-year college. Therefore, these instructors must locate, adapt, and apply curricular resources and teaching strategies that present biology in meaningful contexts and develop problem-solving skills that are pedagogically consistent with adult learning strategies.

A first step toward developing resources that engage the two-year college student is to make more use of pedagogical strategies that recognize and build upon the prior experience, knowledge, and practical learning strengths of adult students. Adult students tend to immerse themselves in tasks that they see as relevant to situations they are likely to face in their own lives (Knowles 1984; Ertmer and Dillon 1998).

Instructors interested in applying appropriate pedagogies for adult learners within the sciences have a choice of science teaching methodologies. For example, collaborative learning is considered a useful addition to the repertoire of teaching methods used in two-year colleges since it "helps prepare students for workplaces that increasingly value self-motivated, self-confident, team-oriented employees" (Cooke 1994). Another example is the use of narratives of realistic problems or case studies. A recent essay in this journal's case study column (Herreid 1999) describes the power of such stories in science learning.

Problem-Based Learning (PBL) is a variation of the case study specifically designed for small collaborative groups. Finkle and Torp (1995) define PBL as:

> a curriculum development and instructional system that simultaneously develops both problem-solving strategies and disciplinary knowledge bases and skills by placing students in the active role of problem solvers confronted with an ill-structured

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problem that mirrors real-world problems.

These "ill-structured problems" or cases have multiple solutions. Resolution of a problem requires students to navigate through a variety of resources, develop supportable problem-solving strategies, and present their conclusions to others. Research by Stepien and Gallagher (1993) shows that PBL enhances self-directed learning and helps students transfer concepts they have learned to new problems.

A second step toward addressing science literacy is to introduce and integrate investigative methodologies into the biology curricula. By linking investigation with PBL case analysis, students will learn biology and scientific practice while exploring realistic and familiar contexts. And if students see these investigative experiences extend their ability to make sense of the science-related problems they face every day, they will be more likely to value and use investigative skills throughout their lives.

CURRICULAR MODULES FOR COMMUNITY COLLEGE BIOLOGY

To address these curricular and pedagogical challenges, we are collaborating with two-year college faculty to further develop and field test problem-based, prototype curriculum materials called *LifeLines OnLine.* These curriculum modules begin with realistically complex situations presented as articles in an electronic newspaper accessible on the Internet.

The teaching strategies for *LifeLines OnLine* are a variant of PBL (Barrows and Tamblyn 1980) called Investigative Case-Based Learning (ICBL) (Waterman 1998; Waterman and Stanley 1998). Like many variants of PBL, this is a method of teaching that gives students opportunities to direct their own learning as they explore the science underlying realistic situations. Students work collaboratively to identify issues, frame questions of interest to them, and identify additional information in answer to their questions.

ICBL strategies encourage students to expand their investigation by developing questions and reasonable investigative approaches, gathering data and information testing their hypotheses, and working to persuade others of their findings. Students use a variety of resources to accomplish these tasks including traditional laboratory and field techniques, software simulations and models, data sets, Internet-based tools and information retrieval methods.

Integrating what students learn in biology with their own interests and concerns enables them to develop an appreciation for the power of science to solve problems.

LifeLines OnLine materials integrate information technology with investigative case-based learning (ICBL) pedagogies. The initial interface students encounter is an electronic newspaper. In *LifeLines OnLine,* resource materials are packaged for students to use as they investigate the science behind the news. As students read the newspaper, several items will have hyperlinks such as a note on plunging corn futures on the stock market page, an editorial cartoon on ineffective corn pesticide use, or a classified ad of a farm for sale. Students click on hyperlinks to get to the resources (e.g., interviews, data, and web sites) related to the corn futures story, the cartoon, and the farm sale.

ILLUSTRATING ICBL AND *LIFELINES ONLINE* MODULES

Individuals approach learning with cases in very different ways. Likewise, instructors will use *LifeLines OnLine* in a variety of ways. The following classroom scenario illustrates how an instructor uses ICBL with *LifeLines OnLine* materials as an alternative way to teach ecology in an introductory biology course. The six ICBL strategy boxes for instructors (see page 309) show how the materials are used within the broad framework of ICBL strategies. An instructor might choose to use one or more of these after introducing the newspaper "case."

The instructor asked the students to pay special attention to relationships as they worked through the materials. Four groups of six students at a two-year college in the Midwest were working in a corner of the classroom reading a copy of an interview of two scientists about a corn epidemic. The instructor chose the article from the *LifeLines OnLine* web site. One group focused in on the following part of the article:

Derrick Hernandez explained, "What made me decide to study corn diseases was hearing about when my uncle lost his entire corn crop in 1970 due to southern leaf blight. He just couldn't understand why every field in the county was failing." (See ICBL Box 1.)

Getting Started

In order to organize the group's discussion, the instructor provided a Know/Need to Know chart. The students worked together to construct a list of things they already knew and questions they felt they needed to answer.

What we already know:

▲ Corn is an important agricultural crop.
▲ Corn is planted in the spring and harvested later in the fall and has a long growing season.
▲ Southern leaf blight kills corn.
▲ Weather can influence the spread of corn blight.
▲ Southern leaf blight spreads.

What we need to know:

▲ What can I do to get corn to grow better?
▲ Where does leaf blight come from?
▲ What exactly is southern corn leaf blight?
▲ How is corn blight affected by weather?
▲ How does it cause crop failure?
▲ How does blight spread?

(See ICBL Box 2.)

Table 1. Sample Presentation Strategies by Group.

Group	Sample Strategies
Group 1	Corn crop management—live interview with Mr. Beauchamp, a local corn grower who is also husband of one of the students
Group 2	Role of weather in the spread of blights—research poster featuring screen shots from the Late Blight simulations
Group 3	Spacing impacts on the growth of corn—research poster using lab data
Group 4	Diseases of corn—comparative pathogens poster including images

Next Steps, Same Class Period

To answer their questions, the students agreed to spend 30 minutes searching out resources then meet for a few minutes at the end of the period. Among the resources in the room were web addresses from the reporter's notes, a computer with an Internet connection, folders on corn disease and crop management, and several books as well as their own text. (See ICBL Box 3.)

Continuing in Lab

In the lab, the groups examined the effect of plant spacing on the growth of corn. They set up additional pots to test their hypotheses about temperature, water availability, or light variables. One group chose to look at water availability. The students thoroughly watered both pots, but left one pot sitting in a pan of water and the other sitting in a pan of sand.

The second part of lab was devoted to looking at the effect of weather variables on crop yields of potatoes using the software simulation *Lateblight* (Ticknor and Arneson 1990). Student groups initially compared profits from potato farming during wet, moderate, and dry growing seasons with late blight present. Each group was then asked to explore a variable of their choice such as pesticide applications, protectant sprays, or the use of hybrid potatoes with resistance to blight. (See ICBL Box 4.)

Next Class

In the next lab each of the four groups decided how they were going to present results of their *Lateblight* investigations to the rest of the class. Presentation choices may include designing a group poster that is either research oriented or informational. Round-robin poster sessions, in which each member of the group takes a turn to present the group poster while the nonpresenting members visit other posters, permit students to communicate their work on a personal basis.

Adult learners value face-to-face sessions with "experts" who are approachable. For that reason, interviews are an especially good presentation format. As Table 1 shows, Group 1 has invited a corn grower, who is the spouse of a student in the class, to be interviewed. The group prepared a list of questions beforehand to make the best use of the interview time. (See ICBL Box 5.)

Exam Questions

The instructor used the posters and lab work to evaluate student knowledge of relationships between organisms and environments. Students also submitted a one- page summary of the relationships they have been studying in the corn field ecosystem and related them to larger concepts of ecology they learned in lectures and from their text. To further evaluate the students' processes of investigation and values about science, we used the following exam questions:

Consider the following scenario. A previously thriving clump of oaks is in trouble. A year ago, moths came in and laid eggs, which produced caterpillars that eat oak leaves. This fall, there are few acorns and many hungry squirrels.

▲ Identify three questions you have about this ecosystem.
▲ Choose one and describe the procedures you might use to answer this question. Be specific. List five types of resources.
▲ Which one of the above resources would you use first? Why?

Scientists living in the Biosphere II project (described in class) were surprised that the oxygen level was dropping more rapidly than anticipated. They added more oxygen to the dome, but wanted to look into other solutions. Which one of the following approaches to this problem would you recommend and why?

▲ Add more plants to the Biosphere II.
▲ Analyze samples of soil, water and air for the rate of oxygen consumption

and compare to expected rates.

▲ Put on "moon suits" and oxygen tanks.

Examine the following news sources about a chemical spill into the watershed for the town's drinking water supply. Which would you choose to identify the dangers? Why?

▲ An article on the web written anonymously and posted on a public bulletin board.

▲ A newscaster's notes and videotape of interviews with two residents.

▲ An interview on the radio with a team of scientists from the chemical company.

SUMMARY

Integrating what students learn in biology with their own interests and concerns enables them to develop an appreciation for the power of science to solve problems. Although there are multiple ways to accomplish this (see, e.g., Tolman 1999), the *LifeLines OnLine* materials and ICBL strategies described here provide a wealth of resources to these ends.

LifeLines OnLine modules and methods offer a reasonable approach to needed reforms to the traditional biology curriculum because students not only identify issues and frame questions of interest to them, but they also learn to locate and manage information, develop reasonable answers to the questions, provide support for their conclusions, and work on decision-making abilities.

Some web sites related to *LifeLines OnLine* materials and strategies include the prototype *LifeLines OnLine* web site (http://bioquest.org/llacube), possible initial steps in ICBL (http://cstl.semo.edu/waterman/LifeLines/zeaimplement.htm), ways in which simulation software might link to a case (http://bioquest.org/case.html), and excerpts from our paper describing the Investigative Case Study Approach for Biology Learning (http://bioquest.org/case99.html).

ICBL Strategy Box 1 *Recognize potential issues.* Read the case noting words or phrases that seem to be important to understanding what the case is about. Students are looking for learning issues that they might explore further. If students have a hard copy, they might underline these phrases and jot down ideas and questions about these phrases. If students are working in a group, this approach might be led as a group discussion, with one person keeping a list of issues as they are raised.

ICBL Strategy Box 2 *Brainstorm for connections.* The specifics of the case should be reviewed to identify potential learning issues or biology problems to investigate. It may be helpful to think about the case as a whole and pinpoint underlying themes. Ask the question: "What is this case about?" Pose specific questions. Another way to generate ideas and connections is to be clear about what is known so far and then see what questions arise. Students might use a chart like the popular "Know/Need to Know" format. See example in text. Define problems further by sharing views and concerns. As learners define problems and frame specific questions to investigate, they must consult with others from their group or their classmates. Talking about ideas and plans with others helps to refine problems and can lead to different perspectives that might shape good research problems. Such discussion and collaboration is a hallmark of the work of scientists.

ICBL Strategy Box 3 *Obtain additional references/resources.* No matter what type of question learners pose, it is likely they will seek and use additional resources to help them support and formulate a reasonable answer. Resources may include textbooks, other library materials, results of computer simulations, results of lab or field research, articles from professional journals or popular press, data sets, maps, e-mails, web sites or other electronically based resources, pamphlets from organizations, interviews with experts, or information from museum exhibits.

ICBL Strategy Box 4 *Design and conduct scientific investigations.* Students are encouraged to use available laboratory, field, or computer tools and resources. Students, like scientists, begin by synthesizing pieces of existing information into a new theoretical framework (work that may be accompanied by modeling, as was done by Watson and Crick). They locate datasets, conduct interviews, and gather ideas from their reading and library research as well as from laboratory activities.

ICBL Strategy Box 5 *Produce materials that support understanding of the conclusions.* When students are ready to present their own conclusions, ask them to identify ways for others to view and review their work. Traditionally, we ask for term papers or lab reports, but the possibilities for other supporting materials are vast, for example, posters, poetry, plays, videos, booklets, pamphlets, consulting reports, artwork, designs for new technology, scientific publications, newspaper stories, editorials, or new case studies. When students review each others' products, they discuss differing methods and results, as is common in scientific discourse.

ICBL Strategy Box 6 *Be sure to assess all that you want students to learn.* It is well understood that the way students are tested is the most significant factor in how they will approach learning in a course. Be sure to include assessments of the students' skills in identifying questions, resources, investigative methodologies, and values as well as their knowledge of the science concepts. Assessments of process and values can be formal, as illustrated above, or they can include observations of students at work, summaries written by students of the strategies employed by their group, and so forth.

We believe that biology learning should result in applicable, flexible knowledge of the living world as well as the ability to investigate biological problems. In order to value a scientific approach to problem-solving in their own lives, students should use scientific reasoning to identify, explore, and resolve meaningful concerns in the classroom, laboratory, or field.

Case-based learning emphasizes the role of the students in defining not only the problems to be studied, but also in the development of strategies by which to approach these problems. Group work further enhances problem-solving skills by letting students collaborate with their peers and use multiple resources. Lastly, this approach allows students to practice their newly acquired scientific literacy as they support their own conclusions and evaluate those of others. ■

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