A Thematic Approach: Making a Biology Course Relevant & Process-Oriented
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A Thematic Approach

Making a Biology Course Relevant & Process-Oriented

Mark Lung

THE following is a thematic program designed for use in introductory biology courses. Its main objectives are to 1) provide relevancy of biological concepts to the world outside of the classroom, 2) be process-oriented, 3) integrate units within a biology course, 4) teach for higher-order thinking, and 5) expand the use of resources beyond the textbook. It was the author's intent to create a program to encompass an entire semester, not just a unit or a lesson. It is not a curriculum as the term is generally used, but a framework in which existing curricula can be organized. It uses an interactive, cooperative, problem-solving format centered around a science and technologically related societal problem. The theme used as an example is an outbreak of malaria due to new irrigation in a hypothetical village in East Africa, but the program is specifically designed for flexibility in choice of theme and in particular objectives in order to make it relevant and meaningful to different groups of students at different times.

The auditorium is dark. A large table, draped in colorful fabrics, sits on the edge of the stage. A dozen candles flicker along the front edge of the table bouncing light off two woven baskets that border its sides and an assortment of horns, gourds and skins that adorn its top. A high-backed chair rests behind it. Larger than life photos of an African village project on the backdrop of the stage. Drums echo in the distance. Students enter by a door at the back of the auditorium. A hushed anticipation follows them. They sit in a semi-circle of chairs in front of the table. It's the last day of the semester and presentations of final projects are due. Drama class? No. Biology.

The drums soften and from the side of the stage a man dressed in African clothes enters and stands, center stage, before the assembly. Like those seated before him he is anxious and curious. He sits and greets the group before him:

Salamia wrafriki. Asante kwa kuja hapa kusidia watu mimi. Kuende. (Greetings friends. Thank you for coming here to help my people. Let us begin.)

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He nods and the meeting begins. The first group of students, S.A.M.—Students Against Malaria, approaches the table. A boy from the back presents the dressed man with a package of M&Ms, a small but customary offering before addressing a chief.

Salamia mzee (Greetings wise one), says the spokesperson of the group.

Salamia rafiki (Greetings friend), replies the chief.

> *We have come to you with a solution to the problem your village faces. The disease, which causes the fever and chills you spoke of and has caused the death of many of your children, we call malaria. The disease comes from the bite of a mosquito, which is breeding in the irrigation water that was brought here a few years back. The mosquito, when biting, injects a tiny "bug" into the body . . .*

And so goes the day as students, in small groups, present the culmination of a semester's study of introductory biology. For the last 16 weeks they've researched books and journals on topics such as human and insect ecology, parasitology, and immunology; they've interviewed professors on concepts such as sickle-cell anemia, genetic engineering, and protozoan life cycles; they've designed and conducted experiments on topics of mosquito egg laying and the effects of pesticides; they've talked to hospital staff concerning vaccines and prophylaxes. They were lectured on evolution and natural selection and discussed the relationship of this to the emergence of parasitic diseases and the resistance of the protozoan to preventative drugs and the mosquito to various pesticides. They listened and interacted with guest speakers on topics of local pest control and the role of predators in a community. They watched videos on parasitism and the anatomy and physiology of human blood and the immune system. They used the Internet, finding information on numerous topics and opening dialogue with other interested parties. They've worked in and out of class, both independently and in groups, sharing knowledge and teaching each other. They were expected to be thorough and organized in their research, and clear and thoughtful in the preparation of the final report. They worked hard and they had fun. They felt they were involved, doing something important and interesting to them, studying something that had meaning outside of the classroom. They were actively involved in the process of science in a way that was relevant, practical and useful to them. I hoped they were learning all the great things that I did and still am, but more importantly, were learning how to learn and how much fun learning is.

History

The students were involved in a program (described below) that was my small attempt to make not just a lesson or a unit relevant, practical and process-oriented, but an entire semester of biology while still adhering to curriculum guidelines. Almost simultaneous with the development of the program I stumbled across a small vein of literature that surprised me. The science education literature, especially in the last 15 years, is not scarce in articles that focus on making biology courses relevant, practical and process-oriented. But what I didn't know was that nearly a century ago, ***Biology***, as its own life science course, was created for that specific intent. Prior to this, the life sciences were represented by rigorous courses in zoology, human anatomy and physiology, and botany. These courses were apparently the lap dogs of scientists and doctors, designed to maintain the scientific community. Biology, an integration of the three original life science courses, was purposely created to be a science of the people, to prepare citizens and legislators to make good decisions about the use and conservation of natural resources, and be conducive towards improving mankind's health and life (Rosenthal & Bybee 1987). It was an attempt to bring science out of the academic atmosphere and onto the dining room tables of the layman by making it relevant and practical to as many students as possible. This was a great idea, but as is the fate of many great ideas, the path to its full realization was littered with obstacles.

Whether this effort to make science courses relevant *was* realized, either at its conception or the years that shortly followed, I am not certain. However, it is apparent, even with the most cursory examination of classrooms and the literature, that there is a remarkable effort to do so now (e.g. Bybee & Mau 1986; Cheek 1992; Christ 1996; Collette & Chiappetta 1994; Ogens 1991; Rubba 1990; Yager 1990). It would be difficult to find an educator, researcher, or curriculum designer who is not aware of this attention to "rediscover the original intent" of biology courses, whether in awareness of the intent or not. Although I am not, by any means, an authority on this subject, especially compared those who have devoted their lives to this pursuit and have repeatedly expressed their ideas clearly in this matter, it was my impression that a large part of this effort was directed towards lessons and/or units *within* a biology course. Because of this impression, it was my goal to create a "program" to encompass an *entire* semester of an introductory biology course, integrating numerous units, making it process-oriented and relevant to the world outside of the classroom. "Curriculum" is not used here because one of my goals was to create a framework that an educator could easily fit in an already existing curriculum.

The Program

The objectives used in the formulation of this program correspond, with minor amendments, to Hurd's (1991) recommendations for improving biology education. They are the following, with my amendments and comments in parentheses:

1. Integrate the sciences (and units within each of the sciences, going from general to specific).
2. Modernize the content (so that it is relevant to current societal and world issues.
3. Teach for higher-order thinking (which comes naturally if the sciences are taught as a process and students are allowed to be part of that process.
4. Use better texts (and encourage and require the use of additional sources other than texts—there are many interesting sources of biological

information from cookbooks and diet and exercise magazines to hospital records and pamphlets.

5. Teach for change so that learning continues (and if science is taught as a process, "a refinement of everyday thinking," said Albert Einstein, to solve problems and find answers; this again comes naturally).
6. (Cultivate cooperation between the course work and the world outside the classroom—let your students know that people everywhere are using science and the results of science to improve their lives and the world in which they live, and provide a way for your students and those people to interact.)

The program uses a theme to integrate units and provide relevancy. The theme I use in my class, because of my prior residence and student summer trips to Africa, is an outbreak of malaria due to new irrigation in a hypothetical village in east Africa. The above theme is used as an example here, but the program was specifically designed so that any number of themes can be used, depending on teacher and student interest, school and community resources, and current societal and/or world issues (e.g. AIDS, drug-resistant tuberculosis, deforestation, urban development, etc.). The teacher just needs to select appropriate units. There are seven units used in this example:

1. The scientific method and Biology as a process for describing and understanding life
2. Evolution and natural selection
3. Community ecology
4. Structure and dynamics of populations
5. Mendelian genetics and inheritance patterns
6. Human anatomy and physiology (with emphasis on circulatory and immune systems)
7. Cell structure and function and protozoans (covered in that order within a semester time frame).

These units were chosen because the concepts within them provide clues to the malaria outbreak. They were covered in that order because they go from general to specific. Units for an AIDS theme, for example, would be the same as above except substituting protozoan for viral study. (Remaining units are then covered the next semester, using another theme or in the traditional way.)

The program begins and ends as a cooperative, problem-solving one. At the beginning of the semester the students are assigned to groups called Task Forces, and receive a "top secret" folder. The "top secret" folder in the malaria theme details the demographics of the village, its history of drought and famine, and the introduction of a system of irrigation ditches following construction of a dam on the distant Nile River followed by the occurrence of fevers and death in many village children. This is done without saying much about malaria and what causes it. The Task Forces represent special areas of concentration and study dealing with an outbreak of malaria. In this theme there are six Task Forces:

1. The vector, *Anopheles*
2. The pathogen, *Plasmodium*
3. Genetics, and inherited immunity
4. The target, human blood
5. Defense, and acquired immunity
6. The victim, *Homo sapiens*.

Use of a different theme would require different background information and introduction, and selection of different Task Forces.

Throughout the semester the students collect information in their area in and out of class through independent study and research, group work and activities, lab and field experiences, guest lecturers, audio-visual materials, Internet, interviews, and class lectures and discussions. I encourage them to use as many different resources as possible. Students in the past have spoken with government agencies, professors, wildlife biologists, hospital staff, and Africans. They have visited mosquito habitats, hospitals, and genetic engineering labs. They have designed and/or conducted experiments on mosquito egg-laying preferences and the effects of pesticide concentrations on adult mosquito survival. They have used the Internet to find information and communicate with other people who share this interest.

My classroom runs fairly normally compared to other introductory biology classes. In a typical week I lecture and give notes. We discuss the material and readings from the textbook or other sources and have associated laboratory or group activities. We review and have supplementary videos, and there are weekly quizzes and exams every three to four weeks. The main difference is that all the information is presented and learned as tools for solving the problem; e.g. how the concepts of natural selection relate to how and why mosquitoes have become resistant to pesticides and the protozoan to malarial drugs; how populations grow and what affects their limits give clues to why pesticides don't work in the long run while modifying habitats may, etc. Every two weeks the students get one to three hours of class time to work in their Task Force groups—they conduct or research experiments on topics related to their Task Force groups, work on the Internet, exchange information they found outside of class, research library texts and journals, and clear up questions with me.

Towards the end of the semester, when the concepts within the units have been covered and the students have become "experts" in their area (each Task Force has a set of printed guidelines that helps them to do this thoroughly), each Task Force group presents a 5 to 10 minute summary of their information to the class, and each student hands in a typewritten summary of the semester's research in his/her area. Finally—and this is the most important part—the groups are then split up so that each new group has a representative from each area of expertise [see Slavin (1985) for information on cooperative learning]. The students in the new groups, in the next three to four days, teach each other their information, their expertise, and then each of the new groups formally addresses the problem of the village using the following format:

1. What is the problem?
2. What is/are the cause(s) of the problem?
3. What are the possible solutions to the problem?
4. What are the negative and positive consequences and attributes of each solution (including cost and implementation)?
5 What is the best overall solution?
6. How will it be implemented?

They address not only the solutions but how they will be implemented and with what cost. They are required to make a cost assessment, finding the costs of materials and labor, for implementing their solution. It is like a seminar and a business meeting all in one. Each group then presents its conclusions (in the six-part format outlined above) to the chief of the village, the teacher, on the last day of the semester.

I have used this program at college and high school levels for four years and have had enormous success. Although no quantitative data have been gathered on its effect on attitudes and achievement, student responses on questionnaires and evaluations are very positive and encouraging. They find it challenging and fun. Many of them get so carried away in studying, doing experiments, finding clues, and searching for a solution, that I have had to make sure they are doing work in their other classes as well. They love studying the content in a context that means something to them and to the world. It's useful to them, and they are thinking and learning some important concepts as well. They are learning that learning is fun and valuable. The study of biology then approaches what it was originally designed to do.

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