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Philosophy of CBL

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By Katayoun Chamany

Science education at the undergraduate level faces an ever-growing challenge. As the wealth of scientific knowledge in a field such as cell biology grows, we are understandably pressed to present more and more information in order to keep undergraduate education up to date with the most exciting advances in research. This translates directly into demands for time in our classrooms and space in our textbooks devoted to conveying complex ideas and information. Yet, as classroom experience and study after study demonstrate, students learn more effectively, acquiring a deeper understanding of science, if they do more than try to absorb information passively.

It is also important for students to make connections and bridge the gap between what they learn in the classroom and everyday life. From the everyday side, news stories sometimes highlight the societal implications of scientific advances, but too often they skim over the basic science, if they discuss it at all. From the more academic side, some textbook publishers have developed curricular materials within their books such as concept boxes, interactive discs with microscopic movies and animations and questions designed to stimulate critical reflection. *Essential Cell Biology*, Second Edition, by Bruce Alberts, et al., is an example of a book that incorporates these features throughout.

For a sound education, however, nothing can replace an engaging classroom experience. Studies in cognitive science suggest that education is greatly enriched when students are given the opportunity to learn through reflection, explanation, elaboration and application (Springer 1999). These pedagogical approaches are central to the case study method of teaching, a method which has been used with much success for two decades in business, medical, and law schools. It is also of note that this type of education may better suit women and students from other groups currently under-represented in science.

To address these needs and in consultation with the authors of *Essential Cell Biology* and *Molecular Biology of the Cell*, I have developed *Cell Biology for Life* (CBL), a collection of curriculum supplements based on the case study model of teaching. This collection is also based on my experiences in my cell biology course at Eugene Lang College. Over the last five years, as the course evolved, the case study model had such success that it has been introduced in most of the biology courses in the college. In some cases, the technique spans an entire course, while in others it works as a springboard for mini-lectures or other types of teaching.

The activities constituting the CBL collection are organized in two ways. First, CBL is divided into three modules. Each module focuses on an area of biological research with multiple avenues of social relevance: botulinum toxin and secretion, stem cell research and cell signaling, and human papillomavirus (HPV) and oncogenesis. The prevalence of coverage in the media of the threat of bioterrorism, potential bans on scientific research, and the increasing rates and awareness of STD infections all contributed to the choice of these topics. Beyond this, however, each module spans three or four chapters of *Essential Cell Biology* and *Molecular Biology of the Cell*. In designing these modules, I also consulted syllabi from many cell biology courses to ascertain which chapters were most frequently covered. Together the CBL modules cover more than half the textbooks. Therefore, the theme of each CBL module ties information from many textbook chapters together and highlights the fundamental principles and methods of cell biology. The module topics, if used in succession, move from basic cell biology to more sophisticated cell biology: students learn about cell structures, cell division, and cell differentiation in the stem cell module, are introduced to prokaryotic cells and specialized cell processes such as neurotransmission and muscle contraction in the botulinum toxin module, and investigate the role that genetics and viruses play in cell pathology in the HPV module. In turn, this emphasizes the integrated nature of cell biological processes and moves students away from a fragmented understanding of cell structures and functions.

The second form of organization of the CBL collection is found within each of the modules: the activities constituting each module follow a specific progression. Building upon the idea of a learning cycle, each module contains four basic types of learning activities, beginning with engagement, moving through exploration and elaboration and ending with application (Allard, 1994). These four stages are outlined in the table below. Instructors are encouraged to explore the various activities within the modules for more concrete sense of what each entails.

Activity	**Pedagogical Value**
Social Impact Discussions	Stimulates student interest by having students pose and respond to questions about the ethical and social aspects of the topic.
Data Analysis	Requires students to use study guides to analyze primary literature and give oral and/or written summaries of the research.
Molecular Skits	Encourages students to use diachronic thinking to understand temporal and spatial relationships of molecular processes.
Decision-Based Writing	Presents students with dilemmas and asks them to formulate solutions, using role-play, written proposals, small-group work, and peer review to include different perspectives and needs.

Though this pedagogy originated in the elementary and secondary school systems, it has been applied with much success in college science courses. While addressing the variance in student learning styles, these activities are also based on Piaget's philosophy of "learning by doing" and the premise of the National Science Education Standards that "learning science is something that students do, not something that is done to them."

To help students see the impact of scientific research, each module contains a capstone activity that builds on previous knowledge and requires application of this knowledge to solve a pressing social issue. By requiring students to research and investigate a controversy, they encourage students to think as civic scientists, which is an objective of the American Association for the Advancement of Science (AAAS, 1990). These open-ended individual experiences allow students to develop their own processes and ideas, synthesize new knowledge, and address a problem or controversy from their own scientifically educated point of view.

Classroom Management and Assessment

Since so much of science is collaborative, built through written communications and oral presentations, many of the learning activities require students to work in groups or present their work to peers. The group activities designed for introductory students are all cooperative in nature and highly structured, aiming to expose students to fundamentals of cell biology or foundational knowledge. They present students with a well-defined task and ask them to interact with one another in small groups using an established format to achieve a common goal or product. The activities targeted to more advanced students also incorporate communication-oriented tasks, though ones which require more independent work, such as writing review articles after surveying a section of primary literature and conducting peer review, or engaging in a mock symposium or debate.

For many students and instructors, group learning in an academic setting may be new, and some may feel challenged. To alleviate some of the pressures associated with these activities and to provide students and faculty with structure, I have developed a set of assessment tools for collaborative, written, and oral work. Many of the tools are based on versions of classroom assessment techniques that have been developed, used, and tested by educators around the nation to obtain fair and comprehensive assessment of individuals and groups (Dancy, 2002; Kaleidoscope, 1991; Angelo, 1993). These tools provide guidelines for various forms of peer, self, and group assessment that maximize the benefit of group work and peer review.

Cell Biology for Life also strives to include a broad collection of student achievement targets and a variety of evaluation and assessment methods that are useful for both instructor and student. Although traditional methods of teaching address student acquisition of knowledge and skills, progressive teaching considers a wider variety of learning outcomes: higher-order thinking, the process of creating and developing products (papers, proposals, web pages), and overall student dispositions towards the discipline. Both the activities and the methods of evaluation and assessment follow recommendations put forth by the National Institute for Science Education (NISE), the National Academy of Sciences, and the Joint Committee on Standards (coalition of 16 institutions). This broader range of outcomes helps students identify the areas in which they are progressing, as well as those areas which need more work. Instructors can then use this information to adjust the curriculum to address specific needs. Sharing the results of these assessments with students teaches them that process and content are both important to the learning experience.

It is clear that group work experiences increase a student's ability to take another's perspective and to recognize and respect differing opinions and ideas. However, the benefits of this type of learning activity are balanced by the lack of guaranteed accountability of each member of the group. To promote the advantageous aspects of group work and build in accountability, I suggest using a combination of clear guidelines and a variety of peer, self, and group assessment worksheets which are described below.

Resources

Resource One: Group Role Profiles
Resource one lists five group roles that promote successful working relationships. By assuming these roles, students learn to question reasoning, be aware of process, work through conflict, prioritize goals, communicate ideas clearly, and be respectful of differing views. A few ideas are listed as suggestions for optimal group work management. Having a clearly defined role and method of communication will promote accountability of all members of the group.

Many students may feel challenged by the task of dealing with group dynamics. Some students have reported that open-ended unsupervised group activities left them feeling abandoned by the instructor and unsure where to start or how to resolve dissent. Having groups assign roles for each member of the group may help to alleviate some of the pressures associated with group activities and to provide students with some structure.

Resource Two: Group Work Self Assessment
Resource two is a self-assessment worksheet that encourages students to consider their own performance in a small group setting. The worksheet contains areas for quantitative ratings for quick review by the instructor. The worksheet also leaves room for qualitative statements that may describe problems or difficulties that the student encountered and suggestions for resolving those issues in future group work settings.

Resource Three: Group Work Peer Assessment
Resource three asks students to evaluate the contributions of each member of the group. This resource also includes a reflective piece that allows students and the instructor to acknowledge where the group is successful and to define ways in which the group process can be improved.

The worksheet will reveal experiences and perceptions that are common to all group members and highlight unique student experiences or perceptions. For example the members of one group may indicate that finding time outside of class was a challenge and the instructor may choose to add time in class in future sessions or to assign students to groups based on geographic proximity or class scheduling.

This worksheet also builds in accountability for each group member. If all group members note that one member is not executing a pre-assigned role, it would be hard for that one member to refute their claims. Some instructors may wish to consider allowing a group to "fire" a member. That individual

must then "apply" to re-enter that group or join another by writing a contract that is satisfactory to the group.

Instructors may also build in accountability by using these assessments to calculate an individual student's grade. This grade can then stand alone or be combined with a group grade where some percent of the grade comes from individual work and the rest from the group work. Other instructors have developed elaborate mechanisms for weighting each student's contribution to the group project based on peer assessments. In this example, the total number of points for the group grade is multiplied by the weight ratio that reflects the amount of work done by the individual.

If peer assessments become a tool for grading rather than a tool for monitoring process, students may be dissuaded from being honest. On the other hand, if assessments are not graded, students may feel that the assessments are simply tedious tasks and not worth doing. One way to encourage students to take assessments seriously is to require assessments for completion of a project. Completed assessments would not add or subtract from a grade total, but would be necessary components of a complete project.

Resource Four: Class Assessment of Group Work Presentation
Resource four is a worksheet for the class to score and rank all group presentations other than their own. Instructors can then review the completed sheets, remove the names from the sheets and give them to the individual groups so that they may review multiple critiques of their presentations. Alternatively, the instructor can summarize the most frequent positive and negative responses and give these to the individual groups. In my experience, students are harsh critics. By pointing out shortcomings in the work of others they learn how to improve their own future work

Resource Five: Peer Assessment of Writing
Resource Five is a peer assessment of student writing, or a peer review worksheet. The peer critique or assessment saves the instructor a great deal of work because the first draft of the written work will have been critiqued by at least one other member of the class before being given to the instructor. Students tend to take their work more seriously if they know that their peers will view it. I have found peer critiques to be extremely effective, honest and supportive, because the students are part of a collective struggle and have built a community around the experience. Depending on the course, you may choose to grade the peer critiques so that students view this assignment as contributing to their own self-awareness of the writing process.

Resource Six: Self Assessment of Writing
Resource six is a self-reflective guide to writing. By having students describe in their own words their intent, approach, and process for a written piece of work, they gain insight to their own methodology. Instructors also benefit from the student self reflection, since patterns or themes of struggle may surface when viewing all student responses. It is important to address these collective frustrations and offer more direction if needed. Even if these these questions are not addressed during class, however, students might still benefit greatly from considering this resource on their own.

Resource Seven: Worksheet for Reading Primary Literature
Resource seven is a worksheet designed to guide students through a reading of primary literature. If this worksheet is used repeatedly in a course, students will become aware of behaviors that help them understand the material (analysis of figures and tables, defining new terms, summation of important points, outlining the article) and behaviors that inhibit their understanding of material (skipping unknown terms, overlooking figures and tables, skimming paragraphs, concentrating on details without seeing the overall picture). Again, students might find this resource helpful, even it it is not discussed during class.

Resource Eight: A Collection of Grading Rubrics
Working with nontraditional curricula can be particularly challenging when it comes to evaluation of student work. Both students and instructors benefit when objective standards of evaluation are set out clearly from the beginning of an activity. I include in this resource a collection of grading rubrics that serve as models of evaluation standards appropriate for some of the nontraditional learning activities

employed in CBL. These rubrics are based on personal and collective educational experience. In particular, these strategies of evaluation have been developed extensively by the College Level One Team of the National Institute for Science Education (www.flaguide.org) and by Elaine Seymour in her related project of developing Student Assessments of Learning Gains (http://www.wcer.wisc.edu/salgains/instructor/default.asp).

Parting Thought

The activities and resources presented in each module are a starting point and instructors should tailor the modules to suit their specific goals, learning styles, and teaching styles. Since class time and size vary and present constraints upon teaching activities, alternative suggestions for implementation are also included in the Teaching Notes to each activity.

By incorporating *Cell Biology for Life* with traditional methods of teaching, students will remain curious and develop the skills necessary to become life long learners of biology and become more contributive members of society.

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