TEACHING CRITICAL THINKING SKILLS IN PHYSIOLOGY

“How can I get my students to think?” is a question asked by many faculty. Research indicates that lectures organized to convey large amounts of information are not necessarily the best way to teach critical thinking skills. This workshop demonstrated recent teaching methods designed to foster such skills, which include 1) organizing information, not just ingesting it; 2) identifying what you do not know and asking questions to address specific areas of need; 3) being able to ask “what is the evidence?”; 4) critically examining evidence; 5) generating ideas and hypotheses about physiological questions; 6) applying previously learned concepts to new situations; and 7) designing experiments to test hypotheses. The workshop was organized by Sheella Mierson and Ann McNeal. Each of four presenters briefly described a method and led an activity giving participants a chance to experience the method as the students would in a classroom.

Sheella Mierson (Creative Learning Solutions, Newark, DE) took the participants through the beginning of a problem-based learning (PBL) case. They worked in small groups; in each group, individuals were designated as facilitator, scribe, and reporter. The case described a patient with neurological symptoms. The task was to come up with possible diagnoses. However, the real purpose was to identify what people knew and did not know about the underlying normal physiology.

In PBL, the students list any topics they need to know more about as “learning issues.” This changes the usual educational dynamic, where students often hide what they do not know. It also encourages students to formulate their own questions. Identification of learning issues leads to further learning when the group members later research these topics. The problem creates a need to know and drives the learning. The goals of PBL are for students to learn and be able to apply the disciplinary content, develop critical thinking abilities, and acquire skills of lifelong learning, communication, and team building. PBL originated for teaching medical and other professional students in their preclinical years; in those settings each small group typically has its own faculty facilitator. One way of adapting PBL for teaching undergraduate or graduate basic science students is to have multiple groups meet in one room with a roving facilitator. Mierson (4) compared the two formats in a recent article; she used the roving facilitator format in this workshop.

After 15 or 20 minutes of working in small groups, the reporters presented the groups’ learning issues and tentative diagnoses. Many participants were pleasantly surprised at how involved they had become in such a short time.

Charles Levinson (University of Texas Health Science Center, San Antonio, TX) described a small group instructional process based on the concept that team learning facilitates active learning of Medical Physiology in a large class (200) of first-year medical students. The significant features of this instructional program are as follows: 1) students are assigned to heterogeneous working units of six per group; 2) weekly readings from a modern textbook (supplemented with few lectures) define the essential core information to be mastered; and 3) learning and comprehension of the week’s assignment are assessed by short tests administered to the individual and then to the small groups.
At the weekly class meeting each student completes the objective quiz. After the answer sheets are collected, students join their assigned groups to discuss individual questions on the same quiz to arrive at a consensus answer. It is during this group discussion that the team learning is most evident. After the group answer sheet is scored, essay questions are distributed. These questions are designed specifically for team interaction, requiring students to apply factual material to the formation of concepts and to the application of these concepts to problem solving. Only a single team answer is turned in for grading.

The intent of this group process is to foster team cooperation as students challenge, learn from, and reinforce one another. This approach was tested on the workshop attendees. The participants worked individually on a short quiz consisting of five questions and then formed groups of six to answer the same questions. There was little doubt that six heads were better than one.

In her exercise, “Teaching Critical Thinking Skills: Questioning the Evidence,” Laura Malloy (Bates College, Lewiston, ME) introduced the idea that too much emphasis on the mean can misdirect our understandings of systems (1, 2). A focus on the concept of variation, instead of on ways to eliminate it, was used to encourage students to ask more specific and analytic questions about experimental design and interpretation.

Workshop participants were shown a flawed bar graph for a measurement called “the index of motor coordination.” They were asked to answer the question, “What do you need to know in order to understand this graph?” and were offered some examples of typical, and rather simplistic, student responses. They then reviewed how the graph’s flaws invite critical evaluation. Participants were subsequently asked to execute the experiment illustrated by the graph and to represent the range, frequency distribution, and a data table. Many individuals in the group were self-conscious about their “motor coordination index” score. This aspect of the exercise showed both how few measurements actually fall at the mean and how socially important and misleading that measure can be.

Finally, participants were asked to identify the many layers of analysis required to generate a bar graph and the kinds of information lost through each layer. Examples were given of later student questions, showing greater sophistication.

Thus participants experienced several ways in which this exercise encouraged students to examine the evidence more critically: 1) it asked them to read first for lack of understanding, to encourage close examination of the graph; 2) it highlighted the use of the mean as an inappropriate standard for performance; and 3) it acknowledged multiple layers of data analysis.

Ann McNeal (Hampshire College, Amherst, MA) invited the workshop participants to create investigative labs. She described traditional “cookbook” labs as structures in which faculty assign both the questions to be investigated and the protocols, and faculty know the “correct” answers in advance. In investigative labs, by contrast, students can take on the new roles of asking the questions and/or designing protocols, and the faculty may not know how experiments will come out. In designing such labs, it is important to balance freedom and structure so that students are well guided but not too constrained.

Three different approaches to investigative labs were described by McNeal, Silverthorn, and Stratton (3) in a recent article. Silverthorn uses a two-week cycle in which groups of students learn the technique the first week and then research the literature, design an experiment, and carry out the experiment in the second week. Stratton uses a similar two-week cycle but assigns the experimental questions to the students in the second week, allowing students to develop the protocols. McNeal uses a three- to four-week cycle, also beginning with the introduction of the technique; she gives the students a framework for the protocol but leaves the choice of experimental questions up to the groups of students.

After this introduction, participants spent five minutes writing down their ideas for transforming a traditional “cookbook” sensory physiology lab into an investigative structure. In small groups, they presented and discussed their individual ideas and then reported an impressive variety of possibilities to the larger group.
Overall, this workshop modeled the practice of active-learning classrooms, in which students participate in structured small-group work. The faculty who attended engaged in learning exercises that challenged them to stretch their ideas of how to teach. Many participants commented that it was a welcome change of pace from the traditional conference format.

References