What’s happening in education?

Few physiologists have had any formal training in teaching. At best, we received feedback from mentors and colleagues as we practiced presenting our first scientific papers. Nevertheless, shortly after this initial trial by fire, we were expected to organize and deliver a coherent series of lectures on some particular topic about which we might have known very little. Not long after that, we were expected to take charge of a comprehensive physiology course or a more specialized course on some subdiscipline.

While the tradition of learning by doing is an ancient one, there is a growing body of useful theory about learning and teaching that can suggest better ways for us to accomplish our goals as teachers. “What’s Happening in Education?” is an attempt to help colleagues become aware of issues and progress in relevant areas of the education research.

Harold I. Modell, Editor

ANBAR, M., AND J. W. LOONSK. Computer emulated oral exams: rationale and implementation of cue-free interactive computerized tests. Med. Teacher 10: 175-180, 1988.—Some of the shortcomings of multiple choice and short essay tests in medical school can be overcome by using computer assisted testing. It is difficult, however, to use even these tests to effectively examine reasoning and decision making ability. Traditionally, these skills have been most effectively tested by oral examination. Oral exams, however, have severe drawbacks, paramount among which is the faculty time involved. This constraint and other limitations of oral examinations can be alleviated by using the computer to emulate oral testing. This paper describes recently developed software which makes this possible. Preliminary use of this software on microcomputers with a medical school class is described and the implications of this experience are discussed.

ANTHONEY, T. R. A discrepancy in objective and subjective measures of knowledge: do some medical students with learning problems delude themselves? Med. Educ. Oxf. 20: 17-22, 1986.—In general, the rankings of first year medical students on a written test of long-term neuroscience retention (RET) correlated strongly with how many of three neuroscience research presentations given within the following 2 days the students reported understanding. The lowest-ranking sixth of the class on RET, however, reported understanding almost every lecture, even more than the highest-ranking RET students did. Some of these low-ranking students were aware that they had areas of weakness, but simply tolerated more of them without reporting overall lack of understanding. Other low-ranking students, however, seemed genuinely unaware that they had any areas of weakness. This interpretation was further supported by data on small-group problem-solving performance during the first-year neuroscience course, on use of human resources during the final first-year neuroscience take-home examination, and on performance during the third-year clinical clerkships. Persistence of the problem, even after 5 months of instruction specifically designed to improve such information-processing skills, suggests that correction may be difficult to achieve. The need for specific valid evaluative instruments and effective correctional techniques is noted.

BARROWS, H. S., A. MYERS, R. G. WILLIAMS, AND E. J. MOTICKA. Large group problem-based learning: a possible solution for the ‘2 sigma problem.’ Med. Teacher 8: 325-331, 1986.—Problem-based learning is characteristically carried out in small groups with the teacher in a tutorial role and usually five to seven students. It has been difficult for schools interested in using this method to provide teachers with appropriate skills in sufficient numbers. In a second year immunology course the case method, an interactive teaching method requiring only one teacher for an entire class, was blended with the teaching-learning sequences employed in problem-based learning. The result of this experience suggests that large group problem-based learning may be an acceptable and more feasible alternative to small group problem-based learning.

DECK, A. L., AND D. A. BERGMAN. Using structured medical information to improve students’ problem-solving performance. J. Med. Educ. 61: 749-756, 1986. In the study reported here, the authors assessed the use of efficient organization of knowledge and of problem-solving strategies in enhance medical students’ clinical problem-solving skills. Thirty-five preclinical medical students were randomly assigned to an experimental or control group and given a knowledge base containing information on eight congenital heart diseases to learn. Information for the experimental group emphasized disease groupings (based on their similar clinical presentation), symptom disease associations, and clinical problem-solving heuristics. The same information for the control group was presented in a textbook format that emphasized the pathophysiology of the diseases. The students then diagnosed three computerized diagnostic problems of varying difficulty while verbalizing their problem-solving strategies. The results showed that the experimental group acquired a higher ratio of diagnostic to nondiagnostic cues, mentioned the correct diagnosis sooner in their workups, and correctly diagnosed the most difficult case more often than the control group. These results provide support for revisions in the organization and presentation of information that are aimed at improving clinical problem-solving skills.

CARLIN, R. D. Survey results and a recommendation for a change in U.S. medical physiology curricula. Acad. Med. 64: 202-207, 1989.—Both the recent advances in molecular biology and the dilemma of teaching a larger volume of more detailed material to students from a declining, weaker applicant pool necessitate a critical reappraisal of the medical physiology curriculum and pedagogy. An extensive survey of the physiology curricula in 101 US medical schools conducted during the 1986–87 academic year revealed that physiology was taught as a separate course, averaging 100.1 lecture hours, 24.9 laboratory hours (usually dealing with cardiovascular and pulmonary physiology), and 25.6 conference hours. The physiology courses offered by the schools surveyed averaged 21.8 weeks in duration and were taught by an average of 13 faculty (79.5% with PhD degrees, 21.8% with MD degrees, and 5.4% with both MD and PhD degrees). The
evolution of the physiology curriculum has been slow; as a result the need for change is great. Physiology departments must give a high priority to reorganizing and revitalizing teaching. Additionally, the physiology curriculum must be critically examined. There is an urgent need to reevaluate course content, decide the fate of the student laboratory, and develop new, innovative teaching techniques. The ubiquity of these problems among medical schools suggests that they be addressed at a national level.

Dewhurst, D. G., G. J. Brown, and A. S. Meehan. Computer simulations—an alternative to the use of animals in teaching? J. Biol. Educ. 22: 19–22, 1988.—Two computer simulation programs, ‘Nerve physiology’ and ‘Frog heart’ are described in relation to their use as practical alternatives to the use of animals in class experiments. The programs, which are highly interactive, utilize actual experimental data and present a realistic simulation of the neural or vascular systems. They are used by A-level students and above, contain introductory text and student assignments and come complete with program manual and tutor’s notes. The potential of these programs to provide a realistic alternative to conventional laboratory experiments using animals is discussed in relation to the major teaching objectives of such teaching methods.

Hopkins, R. H., K. B. Campbell, and N. S. Peterson. Representations of perceived relations among the properties and variables of a complex system. IEEE Trans. Syst. Man Cybern. 17: 52–60, 1987.—Three different techniques for representing human understanding of complex systems were compared. Novice veterinary students and cardiovascular research experts made judgments of the relations among the properties and variables of a complex system, the mechanical/arterio-venous vessel system. They also described the variables and properties by a series of bipolar ratings. A variety of analyses showed that the novices tended to conceptualize the system in static anatomic terms. Experts showed a more integrative conceptualization and distinguished more clearly than students between relations involving only system properties and those involving system variables. The methods of multidimensional scaling, agglomerative hierarchical clustering, and elementary digraphs were used to represent perceived relations among system variables and properties. It was concluded that the simplest form of representation, a digraph, has several advantages over the other representations.

Jamison, J. P., and H. F. Ross. Collation of student results in practical class experiments in physiology, using a BBC ECONET computer network. Med. Educ. Oxf. 22: 183–188, 1988.—Funding was provided to Queen’s University by the Department of Education and by the Industrial Development Board for Northern Ireland to provide microcomputers for undergraduate use. An allocation from the grant to the Department of Physiology enabled the purchase of 20 BBC Master 128 microcomputers with monitors used as student work-stations connected together by an ECONET network with a file server, a dual floppy disk drive, two printer servers and two demonstration stations. A basic program was written to analyse the students’ practical class measurements which they entered manually at their work-station keyboards. Class results were presented to the students in the form of frequency distribution histograms or X/Y graphs. Program modifications to suit different practicals can be made relatively easily. The time taken to analyse data has been shortened. It is easy for the students to get immediate comparison of their own results with those of the rest of the class—particularly advantageous if the student’s own experiment did not work. The class can be divided into groups to study different variations of the experiment and provide the data from each group to the whole class. The students’ opinions on whether the equipment had (1) improved the teaching of physiology and (2) provided helpful preparation for the use of computers in medical practice were assessed by a questionnaire which showed that a clear majority felt these aims had been fulfilled.

Kunstetter, R. Intelligent physiologic modeling: an application of knowledge-based systems technology to medical education. Comput. Methods Programs Biomed. 24: 213–225, 1987.—This article describes the design and implementation of a knowledge-based physiologic modeling system (KBPM) and a preliminary evaluation of its use as a learning resource within the context of an experimental medical curriculum—the Harvard New Pathway. KBPM possesses combined numeric and qualitative simulation capabilities and can provide explanations of its knowledge and behavior. It has been implemented on a microcomputer with a user interface incorporating interactive graphics. The preliminary evaluation of KBPM is based on anecdotal data which suggests that the system might have pedagogic potential. Much work remains to be done in enhancing and further evaluating KBPM.

McDermott, L. C., M. L. Rosenquist, and E. H. van Zee. Student difficulties in connecting graphs and physics: examples from kinematics. Am. J. Physics 55: 503–513, 1987.—Some common errors exhibited by students in interpreting graphs in physics are illustrated by examples from kinematics. These are taken from the results of a descriptive study extending over a period of several years and involving several hundred university students who were enrolled in a laboratory-based preparatory physics course. Subsequent testing indicated that the graphing errors made by this group of students are not idiosyncratic, but are found in different populations and across different levels of sophistication. This paper examines two categories of difficulty identified in the investigation: difficulty in connecting graphs to physical concepts and difficulty in connecting graphs to the real world. Specific difficulties in each category are discussed in terms of student performance on written problems and laboratory experiments. A few of the instructional strategies that have been designed to address some of these difficulties are described.

Mitchell, G. Problem-based learning in medical schools: a new approach. Med. Teacher 10: 57–67, 1988.—Problem-based learning offers many advantages. The technique, however, has not been widely adopted because of barriers to its acceptance. These barriers have been overcome in a traditional medical school and in a circum-stanced subject in the curriculum—namely physiology. The intellectual skills involved in clinical problem-solving have been specified and the students have been made aware of the process. Clinical gathering of data and treatment have been excluded from the problem-solving. A feature of the approach is that problems have been created which become progressively more difficult and more complex. It is concluded that the teacher should not be daunted by the introduction of problem-based learning: the process is not complex, is feasible and the results are rewarding.

Patel, V. L., G. J. Groen, and H. M. Scott. Biomedical knowledge in explanations of clinical problems by medical students. Med. Educ. Oxf. 22: 398–406, 1988.—This paper was motivated by a controversy concerning the role of basic sciences in medical education. A problem underlying this issue is that it is unknown how basic science is used in clinical reasoning. The experiment was designed to address this issue. Three texts were constructed dealing with basic science knowledge relevant to a clinical problem. Students were asked to read and recall the texts. Next, the subjects were required to read and recall the clinical text describing a patient problem. Finally, they were asked to provide a diagnosis and an explanation of the underlying pathophysiology. Subjects were first-, second- and fourth-year medical students. Detailed analysis of subjects’ protocols are presented. In general, the results show that when basic science information is given before the clinical problem, the basic science knowledge is used either incorrectly or inconsistently in explaining the clinical problem by all subjects. The authors interpret these results to indicate that the basic sciences and the more practical clinical knowledge form two separate domains with their own theoretical and organizational structures and the clinical information cannot be embedded into the basic science knowledge structure.

Reed, S. K., and A. C. Evans. Learning functional relations: a theoretical and instructional analysis. J. Exp. Psychol. Gen. 116: 106–118, 1987.—Many scientific phenomena can be described by linear functions. In this study, we examined how well students understand the functional relations in a mixture task by asking them to estimate
the concentration of an acid solution created by mixing two other acid solutions. For example, what would be the different concentrations of a 10% mixture created by mixing a 70% acid solution with either 9, 7, 5, or 3% of a 70% acid solution? An examination of group means revealed fair estimates correctly suggested that the students were appropriately following the integration rules of "cognitive algebra" (Anderson, 1981, 1980). However, examination of individual students' data revealed that many of the response sequences were unsystematic. We therefore studied how estimation accuracy of individual students was related to their understanding of three principles (range, monotonicity, and linearity) that relate a concentration of a mixture to the concentration of its components. The results of three learning experiments supported the psychological validity of the proposed principles. First, significant improvements in accuracy were accompanied by significant improvements in the range, monotonicity, and linearity scores. Second, when such a protocol predicted the accuracy of individual subjects, each of these three scores correlated highly with accuracy; the multiple correlation values ranged from .87 to .95 when all three scores were used. Third, a direct statement of the principles was a more effective instructional method than the presentation of examples and a graph of the function. Furthermore, when students could use a familiar model whose principles they understood (mixing water at different temperatures), they reached a near-perfect level of performance in the unfamiliar (acid) domain.

Reif, P. Instructional design, cognition, and technology: applications to the teaching of scientific concepts. J. Res. Sci. Teaching 24: 309-324, 1987.—The effective educational use of information technologies depends crucially on good instructional design based on an adequate understanding of cognitive processes. To teach flexible intellectual performance, such design must ensure that the knowledge acquired by students be explicit, coherent, reliably interpretable, and testable. For example, the ability to use scientific or mathematical concepts requires both explicit general interpretation procedures and knowledge about various special cases. Detailed observation indicates that this is the case for students of higher average intelligence, but that students exhibit many mistakes traceable to knowledge that is fragmented and uninterpretable. Instructional guidelines, based on such cognitive considerations, were tested in an experiment where students were taught an explicit procedure specifying the concept “acceleration,” and then diagnosed and corrected mistakes committed by themselves or others. Such teaching greatly improved students' concept interpretations and blocked previous misconceptions. Computers can provide powerful tools for research on instructional design and for implementing more effective teaching.

Reif, P. Interpretation of scientific or mathematical concepts: cognitive issues and instructional implications. Cognit. Sci. 11: 395-416, 1987.—Scientific and mathematical concepts are significantly different from everyday concepts and are notoriously difficult to learn. It is shown that particular instances of such concepts can be identified or generated by different possible modes of concept interpretation. Some of these modes use formally explicit knowledge and thought processes; others rely on less formal case-based knowledge and more automatic recognition processes. The various modes differ in attainable precision, likely errors, and ease of use. A combination of such modes can be used to formulate on “ideal” model for interpreting scientific concepts both reliably and efficiently. Comparisons are made with the actual concept interpretations of expert scientists and novice students. The discussion elucidates some cognitive and metacognitive reasons why the learning of scientific or mathematical concepts is difficult. It also suggests instructional guidelines for teaching such concepts more effectively.

Rivers, R. H., and E. Vockell. Computer simulations to stimulate scientific problem solving. J. Res. Sci. Teaching 24: 403-415, 1987.—Computer simulations were employed by high school biology students in an attempt to enhance their problem solving skills. The simulations were administered under two conditions: (a) unguided discovery and (b) guided discovery. In addition, a control group received no computer involvement. The effectiveness of the simulations in enhancing problem solving abilities, performance was compared on (a) subsequent unit pretests, (b) standardized tests measuring scientific thought processes, and (c) a standardized test of critical thinking. The results indicate that (a) the students using the simulations met the unit objectives at least as well as the control students, and (b) the students using the guided version of the simulations surpassed the other students on the subsequent simulation pretests, on the tests of scientific thinking, and on the test of critical thinking. The authors discuss the apparent usefulness of the programs in terms of the opportunities they provide students (a) to be actively involved in the learning process and (b) to repeatedly practice applying principles that would otherwise be practiced much less often.

Small, P. A., Jr. Consequences for medical education of problem-solving in science and medicine. J. Med. Educ. 63: 848-853, 1988.—The problem-solving process used by scientists and by clinicians is compared and contrasted. The most creative step for both groups is the ability to make an association between some external stimulus or situation and concepts stored in memory. Medical education must put more emphasis on teaching that improves students' abilities to make these associations. Two teaching methods that can promote development of the necessary association skills in clinical contexts—"wait time" and "concept mapping"—are briefly reviewed. Concept mapping consists of connecting words that represent concepts with lines that represent relationships and then labeling the lines. Wait time is waiting three to five seconds between asking a group of students a question and calling on a student to answer or waiting three to five seconds before responding to the student's answer.

Stewart, R. I., and J. De V. Lochner. How we teach applied integrated physiological sciences. Med. Teacher 9: 277-285, 1986. Integrated Physiological Sciences is a second year course in Human Physiology, Biochemistry and Basic Pharmacology and is offered to an integrated class of students of medicine, dentistry, nutrition science and pharmacy. The Applied course was specifically designed to complement didactic lectures by assisting students to learn by controlled self discovery and problem-solving. Specific constraints are a student group size of approximately 20 and approximately 45 weekly class meeting hours. The Applied course is based on a structure of seven staggered cycles of 3 weeks each, with every cycle consisting of a formal practical (under lecturer supervision) in the first week, an open practical (practicals with minimal supervision or demonstration/exhibits) in the second week and finally a problem-solving tutorial session (under lecturer direction, but not under strict/rigid control). Each lecturer is assigned two groups of approximately 20 students who he directs through each of the 21 weekly activities of the course. The content of the Applied course is designed to complement the theory given in lectures and is also directed towards useful or instructive practical aspects of the students' careers. Student evaluation includes examination by true false questions, a slide test, written tests of data analysis and problem solving and enthusiasm/initiative shown during tutorials.

Stravorn, G. Effect of a major curriculum revision on students' perceptions of well-being. Acad. Med. 54: 25-29, 1989.—The impact of a major curriculum revision on students perceptions of the quality of the medical school learning environment, social supports, and their own mental and social well-being was determined. First-year students' perceptions one year before the curriculum revision were compared with first-year students' perceptions two years after the introduction of the new curriculum. In the new curriculum, students reported better overall quality of the learning environment (p = .019), a trend toward fewer stresses (p = .091), no difference in social supports (p = .721), better mental well-being (p = .043), and a trend toward better social well-being (p = .099). Students at a comparison school that did not undergo curriculum revision did not have more favorable perceptions during the study period. The findings suggest that well-considered and well-executed efforts to improve the quality of a medical school's learning environment can be successful and can raise students' perceptions of their overall well being.

Tennyson, R. D., and M. J. Cocchiarella. An empirically based instructional design theory for teaching concepts. Rev. Educ. Res. 56: 40-71, 1986.—An instructional design theory for concept teaching is presented. The theory is based on direct empirical validation, from a programmatic line of instructional systems research. Concept learning is viewed as a two-phase process: (a) formation of conceptual knowledge and (b) development of procedural knowledge. Two funda
mental components of the proposed theoretical model are content structure variables and instructional design variables. A rational combination of these components, based on a content analysis that takes into account the learning model, provides the means for the selection of one of four basic instructional design strategies. Research studies that contribute to the model are reviewed, and the model is described with reference to instructional methods and cognitive processes.

Whitman, N., and P. R. Burgess. Teaching basic science: Dr Fox in the physiology chicken coop. Med. Educ. Oxf. 22: 393-397, 1988.—In a variation of the Dr Fox study, an educational specialist delivered a lecture in the first-year course on physiology. A highly expressive teaching style was used for content which was determined by physiology teachers. The aim was to determine whether students would note a difference. According to student evaluations, this was the highest rated lecture in the 1984 course. The lecture was repeated in the 1985 and 1986 courses with positive, but less high ratings. No students detected that the lecturer was not a physiologist.

Wilkerson, L., and J. A. Maxwell. A qualitative study of initial faculty tutors in a problem-based curriculum. J. Med. Educ. 63: 892-899, 1988.—Numerous medical schools are beginning to plan single courses, separate curricular tracks, or entire curricula using problem-based, small-group methods. The use of these methods places a high demand on faculty members' time and support. In the present study, the authors examined the characteristics and beliefs of those faculty members who volunteered as tutors for problem-based teaching during the first two years of the New Pathway Project at Harvard Medical School. The results confirm several major conclusions of innovation research: that an individual's adoption of an innovation is heavily influenced by his or her perceived need for change and the benefits that might result from becoming involved in this change; that initial adopters tend to be oriented toward institutional collegialism; and that personal contacts with colleagues play an essential role in their decision to participate. In addition, the desire to improve medical education emerged as a major motive for involvement in the problem-based curriculum.