The Sciences In the Education of Physicians

Emanuel Suter, M.D.[a], Henry Mandin, M.D.[b], and Parker Small, Jr., M.D.[c]
[a]Professor Emeritus, University of Florida College of Medicine
[b]Department of Medicine, University of Calgary Faculty of Medicine, Calgary, Alberta T2N 4N1 Canada
[c]Department of Microbiology, University of Florida College of Medicine, Gainesville, FL 32610 U.S.A.

[a]E-MAIL: esuter@worldnet.att.net

INTRODUCTION

Although there has been much criticism of how the basic sciences are being taught in many medical schools, medical educators remain convinced that medical sciences are essential as the scientific foundation for the practice of medicine, and hence for medical education. The question is how this can best be accomplished. The traditional two plus two curriculum, in U.S. medical schools and most schools worldwide, was based on the German model of the late 19th Century. This was first adopted in the U.S. by (the then new) Johns Hopkins School of Medicine, and later promulgated by Flexner in his influential report[1]. This model of medical school structure and curriculum organization, together with rapidly expanding research activities, has been remarkably stable for nearly a century. In particular, strong medical science departments have provided the foundation for advances in the biomedical sciences and have produced generations of physicians with strong scientific backgrounds and a near plethora of basic scientists. Unfortunately, this overwhelming success may have blinded us to the fact that some of the original assumptions of this model are no longer tenable and consequently, the model is in need of change.

One such assumption was that the scientific research method was prototypical for clinical reasoning used in medical practice, and thus students should master the sciences and the scientific method before beginning clinical training. Medical students were expected to master all the basic medical sciences (originally anatomy, both macroscopic and microscopic, and embryology, physiology, bacteriology, and pathology) prior to the engagement in clinical medicine. The explosion of the knowledge base of these disciplines and the creation of new disciplines, e.g., biochemistry, neuroscience, pharmacology, immunology, information sciences, have made "mastery" unachievable. Moreover, evolving evidence that integration between basic and clinical sciences may be a critical factor in superior diagnostic performance[2] questions the rationale of separating basic science learning from that of clinical medicine. Since the mid-fifties, and with increasing frequency in recent years, deficiencies of the paradigm have become apparent[3] and initiatives for changes in curriculum and instructional design have been instituted[4-8], in some instances supported by novel concepts of faculty engagement and organization[5,7].

Nevertheless, by design or default, there continues to be a tendency of force feeding students with an indigestible overload of facts that drives them to rote memorization of isolated facts instead of learning to understand basic principles supported by facts[9,10]. Evaluation systems, especially those utilizing multiple choice examinations, promote this approach to teaching/learning the basic sciences. Basic sciences are much too valuable to the process of clinical problem solving to be misused in this fashion. It is now accepted that successful clinical problem solving primarily depends on mastery of domain content[11]. Mastery in turn depends not on information quantity, but its organization. The knowledge of experts is organized into schemata (basic science and clinical information integrated into meaningful networks of concepts and facts) useful for both learning (information storage and retrieval) and problem solving. In the following, we will focus on this century old issue. We will explore how basic science teachers should take a different approach to make the basic sciences the road rather than a roadblock to becoming a physician.

LEARNING AND TEACHING

The goal of education is learning and the demonstration of behavioral changes by students of having acquired cognitive, psychomotor, and professional behavior skills that ultimately are expected of the competent physician. For students to reach that goal, we must define what those skills are, provide experiences that promote acquisition of these skills, and develop assessment tools that provide feedback to students and teachers of what has been accomplished. Hence, objectives, learning experiences, evaluation/feedback are the pillars of education, which must be internally consistent and clear to students and teachers.

Objectives

Objectives must be derived from what the physician is called upon to do and not exclusively from the wealth of factual knowledge of the teacher. They must encompass the skills essential for the physician to solve patient problems or, in other words, make clinical decisions when facing clinical presentations. Physicians, or students, must be able to relate the clinical presentation (its signs and symptoms, investigative findings) to some biomedical and/or psychosocial cause or causes by successfully retrieving from memory and other sources information necessary for problem resolution. The clinical reasoning process used is specific and highly tailored to the complexity of each problem. It is based on the same schemata of integrated basic and clinical science infor-

Dr. Suter is the Founding Chair of the Department of Microbiology at the University of Florida College of Medicine and served as the second Dean of the College. He is now Professor Emeritus and lives in McLean, Virginia.

mation originally utilized in aid of learning.

The consequence for basic science learning objectives is obvious: the knowledge domain of medicine, construed as one large problem area, is made up of a finite number of problem areas, each representing a clinical presentation. Once these problem areas or clinical presentations are defined, the students must have sufficient knowledge of underlying basic science and clinical principles to understand each problem area. They also must have the skills to search for the facts needed to explore and understand the cause(s) of the patient's presentation. This should lead them to an accurate diagnosis, a prognosis, and a management plan. In collaboration with the clinicians, the basic science teachers must define the biomedical and psychosocial principles (some create one word: biopsychosocial) and knowledge base underlying the clinical reasoning process[1]. While the faculty should be responsible for identifying and helping students learn these principles, students must become proficient in finding independently the information specific to the problem area, ascertaining its validity, and deciding the amount of detail required to render the problem area meaningful for them.

Evolving evidence that integration between basic and clinical sciences may be a critical factor in superior diagnostic performance questions the rationale of separating basic science learning from that of clinical medicine.

Learning Experiences

Objectives developed in the above manner require learning experiences different from the traditional teaching of the basic sciences. The teacher will no longer be responsible for presenting students with endless lists of facts but rather with a well-planned set of fundamentals as an introduction to the world of factual knowledge and as a link to clinical medicine. Incidentally, many faculty perceive themselves as providing the framework, while the students and others perceive that little has changed. Further, basic science teachers will serve the students as guides to facts and not as sources of facts. Organizing clinical problem areas into schemata with specific basic science underpinnings combines the learning of the basic sciences and clinical problem solving. The structures created in the first two years of training are revisited in the clerkship and again in residency training. The transition to postgraduate clinical training is facilitated; there is no need to either re-organize knowledge or re-learn basic sciences. As necessary, the schemata can be altered to accommodate new concepts, new information is inserted into existing scaffolding, and schemata are continuously improved to serve the needs of the learner during changing situations and environments.

Such an approach will change the instructional strategy from teacher to student orientation. It will also lead to the acquisition of facts in relationship to patient problems and apply to their teaching implications for learning from cognitive psychology discoveries. According to these findings, recall of learned facts is facilitated if aspects of the recall situation are encoded in memory when learning occurs. The learner develops idiosyncratic memory structures (schemata or semantic networks), that are meaningful sets of connections among abstract concepts or specific experiences[12]. Thus, structuring of knowledge and its encoding environment (both context and process) should become key elements of the instructional strategy. The approach proposed above fulfills this requirement, as it leads to acquisition of facts in the context of clinical presentations (patient problems) and in the process of problem solving. Students should have fewer problems in recalling this factual information in similar situations than having learned it in the traditional context of basic science teaching. This approach has been referred to as "teaching medicine upside down"[13].

The process of storage and retrieval of information from long-term memory together with the acquisition of skills of locating and retrieving information from other sources must become a major component of the students' learning experiences throughout medical school. Time must be provided for students to have repeated relevant practice in retrieving information in this manner. The hypothetico-deductive strategy, most frequently utilized in problem-based learning curricula, supports the acquisition of information retrieval skills and promotes learning for meaning rather that rote memorization[14]. Yet all evidence available in medical education research suggests that there is no universal, generic problem solving process. There is a clinical reasoning process that is specific and highly tailored to the complexity of each clinical domain. Consequently methods for teaching clinical problem solving should not be based on the assumption of a universal, generic process. The alternative consistent with this view is scheme-driven problem solving, a strategy that preserves many of the best features of problem-based learning, but at the same time ensures a specific, more organized approach to problem solving[15]. Information search, its retrieval, and interpretation will be critical skills of practicing physicians for diagnosis and management decisions. The methodology of evidence-based medicine is rapidly becoming a standard approach[16].

Evaluation and Feedback

Evaluation is frequently degraded to the exclusive function of grading students rather than making it a significant component of student and faculty members learning experiences. Feedback from the evaluations should help students to plan further learning and teachers to assess their instructional efforts. In many respects, evaluation drives learning. Unless teachers accept that reality, they will not be willing to accord the necessary time and effort to conducting evaluations.

In the same manner that we now recognize the absence of a single problem solving process, there is no single ideal evaluation method that can assess the complex set of skills that is the basis of physician competence. Consequently, evaluative methods should be chosen from an array of options to satisfy specific evaluation needs. For instance the "triple jump" method[17], the use of standardized patients[18] with appropriate interstation evaluation, "progress testing"[19], and judiciously selected MCQs should be considered. Recently, methodology has been described to assess personal and professional development by combining student portfolios with faculty interviews. The aim is to foster student self-assessment by means of the portfolio and provide faculty feedback and encouragement in the interview [20]. A combination of this approach with those mentioned above may provide a more comprehensive assessment of the students' progress toward becoming physicians - the ultimate goal.

CONCLUSIONS

Implementation of an educational program based on sound educational principles, such as those outlined above, is not an easy task and requires that some organizational and resource prerequisites such as those outlined below are met[21].

- Institutional leadership that strongly supports a unified approach and provides the necessary resources both human and material. It must clearly show that faculty members will be rewarded for outstanding performance as educators in terms of salary and tenure and promotion.
- Departmental willingness to abrogate total authority over parts of the educational program that usually were considered undisputed departmental domains.
- Budgetary allocations to the departments based on each department's faculty contribution to the educational program considering quantity and quality of effort[22].
- A sustained interdisciplinary effort of the basic science and clinical faculty members throughout the four years (or more) of medical school combined with the creation of interdisciplinary groups of faculty members[23].
- Effective logistics support for program planning, implemen tation, and evaluation, usually provided by an office or center for medical education.
- An office on medical informatics to provide support to students and faculty members in utilizing information resources.
- A faculty development program to ensure that teachers are able to utilize the available information resources and be knowledgeable about the findings of cognitive psychology to be able to apply them to their teaching assignments.
- A facility and resources to develop a standardized patient program for student learning and assessment.

REFERENCES

1. Flexner, A. Medical Education in the United States and Canada: A Report to the Carnegie Foundation for the Advancement of Teaching. Boston, MA, Updyke, 1910.
2. Schmidt, HG, Machiels-Bongaerts, M., Hermans, H., ten Cate, T.J., Venekamp, R., and Boshuizen, H.P.A. The Development of Diagnostic Competence: Comparison of Problem-Based, an Integrated, and a Conventional Medical Curriculum. *Academic Medicine*, 71(6):658-664. 1996.
3. AAMC, Physicians for the Twenty-First Century: The GREP Report, Association of American Medical Colleges, Washington, DC, 1984.
4. Williams, G., and Hemming, M. Western Reserve's Experiment in Medical Education and its Outcome. Oxford University Press, New York/ Oxford, 1980.
5. Neufeld, V., and Barrows, H.S. The "McMaster Philosophy": An Approach to Medical Education. *Journal of Medical Education*, 49(November):1040-1050, 1974.
6. Barrows, H.S., and Tamblyn, R.M. Problem-Based Learning: An Approach to Medical Education. Springer Publishing Company, New York, 1980.
7. Tosteson, D.C., Adelstein, S.J., and Carver, S.T. New Pathways to Medical Education. Harvard University Press, Cambridge, MA, 1994.
8. Mandin, H., Harasym, P., Eagle, C., and Watanabe, M. Developing a "Clinical Presentation" Curriculum at the University of Calgary. *Academic Medicine* 70(3):186-193, 1995.
9. Bordage, G. The Curriculum: Overloaded and Too General. *Medical Education* 21:183-188, 1997.
10. Regan-Smith, M.G., Obenshain, S.S., Woodward, C., Richards, B., Zeitz, H., and Small, P.A., Jr. Rote Learning in Traditional and Problem-Based Curricula. *Journal of the American Medical Association* 272:1380-1381, 1994.
11. Schmidt, H.G., Norman, G.R., and Boshuizen, H.P.A. A Cognitive Perspective on Medical Expertise: Theory and Implications. *Academic Medicine* 65(10):611-621, 1990.
12. Regehr, G. and Norman, G.R. Issues in Cognitive Psychology: Implications for Professional Education. *Academic Medicine* 71(9):988-1001, 1996.
13. Kriel, J.R., Hewson, M.G., Zietsman, A.I., and Coles, C. Teaching Medicine Upside Down: Some Educational Implications of the Theory of Cognitive Structure. *South African Family Practice*, p41-49, 1988
14. Schmidt, H.G., Dauphinee, W.D., and Patel, V.L. Comparing the Effects of Problem-Based and Conventional Curricula in an International Sample. *Journal of Medical Education* 62:305-315, 1987.
15. Mandin, H. , Jones, A., Woloschuk, W., and Harasym, P. Helping Students Learn to Think Like Experts When Solving Clinical Problems. *Academic Medicine* 72(3):173-179, 1997.
16. Evidence-Based Medicine Working Group. Evidence-Based Medicine: A New Approach to Teaching the Practice of Medicine. *Journal of the American Medical Association* 268(17):2420-2425, 1992.
17. Painvin, C., Neufeld, V., Norman, G., Walker, I., and Whelan, G. The "Triple Jump" Exercise: A Structured Measure of Problem Solving and Self-Directed Learning. Proceedings of the 18th Annual Conference on Research in Medical Education, AAMC Annual Meeting. Washington, DC, Nov. 6-7, 1979.
18. Anderson, M.B., and Kassebaum, D.G., editors. Proceedings of the AAMC's Consensus Conference on the Use of Standardized Patients in the Teaching and Evaluation of Clinical Skills. *Academic Medicine* 68(6):437-483, 1993.
19. Blake, J.M., Norman, G.R., Keane, D.R., Mueller, B., Cunnington, J., and Didyk, N. Introducing Progress Testing in McMaster University's Problem-Based Medical Curriculum: Psychometric Properties and Effect on Learning. *Academic Medicine* 71(9):1002-1007, 1996.
20. Gordon, J. Portfolio Based Assessment. DR-ED Digest. Jan. 12, 1998. <DR-ED@MSU.EDU>. The full document can be obtained from Jill Gordon, Assoc. Professor, University of Sidney, Edward Ford Building A27, Sydney, NSW 2006, Australia.
21. Suter, E., Watson, R.T., Romrell, L.J., Harman, E.M., Rooks, L.G., and Neims, A.H. Moving a Graveyard: Creating an Institutional Climate Conducive to Curriculum Renewal. *Submitted for Publication*, 1997.
22. Watson, R.T. "Managed Education": An Approach to Funding Medical Education. *Academic Medicine* 72(2):92-93, 1997.
23. Crown, V. A Study to Examine Whether the Basic Sciences Are Appropriately Organized to Meet the Future Needs of Medical Education. *Academic Medicine* 66(4):226-231, 1991.