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REVIEW ARTICLE

The Use of Medical Cognition in Medical Curriculum Reform in Taiwan

Tsuen-Chiuan Tsai*

Department of Pediatrics, Wan-Fang Hospital, Taipei Medical University, Taipei, Taiwan

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Medical cognition studies have generated a great deal of knowledge that can be used to improve the quality of medical education. This review summarizes medical cognition research, the trends in medical education, and how the results of cognitive research can be applied to medical curriculum reform in Taiwan. The current trend in medical education is to develop a student-centered, outcome-oriented curriculum that integrates basic and clinical science, introduces students to patients at an early stage, reduces redundancy, and promotes active learning. To help students to develop and maintain their expertise in medicine, extensive supervised training with evaluation and feedback should be provided. The curriculum should also be designed to provide a learning context in which students are helped to develop a knowledge structure and diagnostic strategies similar to those used by experts. Finally, the curriculum should be flexible and responsive to the needs of students to train them to be excellent physicians in the future.

1. Introduction

Medical education in Taiwan, as in the rest of Asia, is currently undergoing reform, which involves moving away from the traditional didactic curriculum. To guarantee the success of a system that can prepare physicians to meet the needs of future generations, improvement of the curriculum should be based on identifying the needs as well as the strengths and weaknesses of the local institutions. The best strategy is to develop a curriculum philosophy based on the results of extensive educational and cognition research. However, research in regional medical education has been lacking owing to manpower shortages and financial constraints, similar to those experienced elsewhere in Southeast Asia.[1] It is believed, however, that the results of medical educational studies can be applied across countries and cultural boundaries. This paper describes the trends in medical education and the advances in medical cognition, and how they can be applied to medical curriculum reform in Taiwan.

2. Trends in Medical Curriculum and Cognition Research

A curriculum is a series of instructional or learning opportunities designed in a coordinated manner to help students achieve a predefined level of competence. The essential principles and features of an educational proposal should be open to critical scrutiny and capable of effective translation into practice. An effective curriculum must be based on a needs assessment, should describe teaching strategies to address those needs, and should be responsive to evaluation and feedback.[2] The medical

*Corresponding author. Department of Pediatrics, Wan-Fang Hospital, Taipei Medical University, No. 111, Section 3, Hsing-Long Road, Taipei 116, Taiwan.
E-mail: tsaitc2003@gmail.com

curriculum is designed to prepare students to provide the best quality of patient care within the health care system.

Like health care,[3] education is a complex system that is self-adaptive and self-organizing. This self-regulation involves a variety of interconnected inputs, pathways, responses, and outcomes. No one educational formula can guarantee a particular outcome in all settings. The desired outcome must therefore be defined, to determine the educational strategies best suited to achieving it within a particular context. Public demand for increased accountability and responsibility on the part of physicians is resulting in a paradigm shift towards competency-based medical education.[4] The focus is now on outcome, rather than on structure and process. The purpose of medical education is now to transmit the knowledge, impart the skills, and inculcate the values of the profession in a balanced and integrated manner.[5]

In North America, the history of medical curricula shows a movement from an apprenticeship model (beginning in 1765), to discipline-based learning (1871), through organ-system-based and problem-based learning (1971), to the more recent clinical presentation model (1991).[6] Each new curriculum model built on the strengths of past innovations while attempting to address identified weaknesses. Desired goals have included the integration of basic and clinical sciences, early introduction of students to patients, reduction of redundancy, and promotion of active, rather than passive, learning. These changes seem to be coming increasingly rapidly. A major motivating factor for recent reforms is an increased understanding of the cognitive processes involved in medicine. Three major components of medical cognition research have a bearing on medical education: (1) identifying characteristics of medical experts; (2) understanding how expertise is acquired; and (3) developing methods that will enhance the teaching and learning of expertise.

3. Characteristics of medical experts

Research into perception, comprehension, reasoning, decision making, and problem solving in medical practice has been conducted for more than 30 years.[7] Medical experts perceive a clinical problem very differently from novices, and are able to arrive at a more suitable solution more quickly.[8] In addition, experts have a greater store of relevant information, as well as the ability to retrieve it, thus allowing them to apply their knowledge more efficiently and appropriately than novices.[8] Schmidt et al proposed a staged theory of clinical reasoning characterized by the emergence of four different knowledge structures associated with increased expertise: elaborated causal networks, compiled abridged networks, illness scripts, and instant scripts.[9] With increasing expertise, knowledge is organized in increasingly efficient ways that allow rapid understanding of and response to particular clinical situations. The knowledge networks and scripts that experts use contain a wealth of information related to the development of illnesses. The way in which experts have acquired and organized their knowledge can also account for their superior perception of patterns.[10] They have developed strategies for applying what they know to solve problems. This involves forward thinking, which includes the use of efficient strategies to discriminate among alternative hypotheses according to an organized mental representation in a stepwise scheme.[11] However, in difficult or ambiguous situations, experts may revert to hypothetic-deductive reasoning or to detailed consideration of the underlying pathophysiology.[7] Using hypothetic-deductive reasoning, physicians typically generate two to five hypotheses for a medical problem. The hypotheses generated determine the information subsequently gathered, with the results either confirming or rejecting the hypotheses. If incorrect hypotheses are suggested, there is no chance that the physician will reach the correct diagnosis. This is a diagnosis-to-data process that is commonly referred to as "backward reasoning".

In some domains, medical judgment relies on a similar prior example, that is, non-analytical, experience-based knowledge.[7] Problem-solving ability generally improves when information is learned in a context and manner similar to that in which it is used.[12]

4. Acquisition of expertise

It takes a relatively long time for medical students to develop professional expertise. The advances of medical cognition are in pursuing efficiency in acquisition of expertise. Ericsson[13] stressed the importance of deliberate practice of efficient reasoning strategies. This requires supervised training with constant evaluation and feedback. Rather than depending on innate abilities, success likely involves planned educational activities that explicitly support problem solving and learning.[13] Experts' problem-solving strategies and knowledge structures should be taught, and effective curriculum models should be developed accordingly. Clinical problem solving is content-specific, in that it is not generalizable from one clinical presentation to another and that content should be covered based on the student's level of education. Skilled teachers educate students (i.e.,

question, challenge, inspire, motivate and teach them problem solving strategies) to think critically. Finally, they help students to see the big picture (the knowledge frame) and think like experts.

5. Educational methods

To help students solve clinical problems, besides deliberated practice, Mandin et al[14] reported the use of "schemes", which they defined as "a mental categorization of knowledge that includes a particular organized way of understanding and responding to a complex situation".[15] Schemes provide a broad basis for making clinical judgments. It is easier to learn problem solving for any particular clinical problem when moving from a broader to a more detailed picture of a disease, i.e., from the general to the specific. This approach combines the creation of a knowledge structure and a search-and-retrieval strategy into a single operation. Retention and recall are enhanced by a curriculum that helps students to acquire the knowledge needed, while simultaneously developing a practical strategy for applying the knowledge to solve clinical problems. This approach also promotes both the transfer of known concepts to new problems and the integration of relevant basic scientific information into clinical problems. Mandin et al stated that there is no one generic problem-solving process that will fit each situation; rather, problem-solving strategies must be taught for specific problems. They recommended replacing the traditional hypothetic-deductive strategy with "scheme-driven" search strategies when training medical novices.[15] Students should be given more opportunities to practice communication, negotiation, decision making, and reflection that characterize critical thinkers.[16] To face the unpredictability of medical practice, students need to learn a flexible, knowledgeable, reflective approach to clinical cues when developing reasoning skills.[17]

At the beginning of the 21st century, the population in Taiwan was about 22.7 million.[18] There were 15 physicians for every 10,000 people.[19] According to the Economist Intelligence Unit, Taiwan ranks number two among 27 major countries in terms of its state of health and quality of medical practice.[20] Under the accreditation pressure of the Taiwan Joint Commission on Hospital Accreditation of 2008 and demands for efficient health care, most hospitals in Taiwan are revenue- and academic-oriented, which drive physicians to pursue patient service volume and publications, rather than teaching. The manpower and financial support in medical education are deemed insufficient at this early stage of medical educational reform. The early introduction of subspecialty training coupled with advanced medical technologies has increasingly raised concerns about the general competency of medical school graduates. Facing similar global challenges, medical curriculum reform aims to make basic science more relevant to the needs of clinical practice, to introduce common patient problems at an early stage, to emphasize health promotion/disease prevention, to move from teacher-centered to student-centered education, to reduce redundancy of content and to match what is learned to what is evaluated.

6. Philosophy

The results of medical educational cognition research can be used to develop a philosophy for curriculum design that meets the needs described above. The philosophy underlying such an innovative medical curriculum will have the following characteristics:

6.1. Cognitive science-based

The integration of medical cognition and adult learning principles to teaching strategies, curriculum design and the learning environment would facilitate the acquisition of expertise and compensate for the manpower and financial shortages in Asia. The faculty should appreciate the results of cognitive research concerning medical knowledge structure and problem solving, and learn the skills needed to teach students how experts organize, store and retrieve knowledge, and solve problems. Basic and clinical sciences should be integrated to facilitate learning. The "clinical presentation curriculum" of the University of Calgary model is an example; it fosters scheme-directed learning using patients and clinical scenarios to teach basic and clinical medicine as a whole. This curriculum aims to motivate learning, facilitate knowledge transfer into practice, and so enhance retention of knowledge. The teaching sequence is from the general to the specific, meaning that a broad understanding of clinical presentations precedes the teaching of the details of diseases. Successive learning experiences allow students to increase the complexity and breadth of their understanding. Continuity is maintained through reiteration of major recurring concepts. A wide variety of teaching strategies, e.g., lectures, small group discussions, demonstrations and problem-based learning, are applied and thus consume less time and manpower when compared with those in a problem-based learning curriculum. Students are provided with plenty of opportunities for practice with feedback (deliberate practice) to obtain the skills needed to achieve expertise. While there is reinforcement of common concepts and skills,

redundant content is removed and opportunities for self-directed learning are increased. The learning environment is intended to be cooperative, supportive, partnership-oriented and active, as well as less stressful than traditional medical education.

6.2. Outcome-oriented

As no one educational "formula" can guarantee a particular outcome in all settings, the education should be focused on its outcome, which will drive both the development and maintenance of the curriculum. The goal of educational encounters is no longer simply knowledge acquisition, but rather knowledge application. Benchmarks for defining competency and acceptable thresholds for attaining it must be clearly delineated to let students know what they must aim for. Minimal requirements for graduation are clearly defined. Students are not guaranteed to graduate in a fixed period. The curriculum, teaching strategies, and evaluation of competence must be devised by working backwards from explicitly defined, meaningful learning objectives. In particular, considerable efforts must be devoted to training faculty in the use of valid tools to assess competence.

6.3. Comprehensive

The six competences defined by the United States Accreditation Council for Graduate Medical Education[21] that physicians in postgraduate training must ultimately demonstrate are also applied to undergraduate education. These six competencies include: (1) patient care, (2) medical knowledge, (3) practice-based learning and improvement, (4) interpersonal and communication skills, (5) professionalism, and (6) systems-based practice. This requires the identification of both core and marginal material that must be mastered progressively throughout the undergraduate years, which provide the foundation for these general competencies and then continue to be developed during the physicians' graduate education and throughout their professional lives. The emphasis in the curriculum must be on establishing students' habits of self-directed learning, by providing them with adequate spare hours and innovative teaching strategies.

6.4. Integrated and student-centered

Basic and clinical science must be integrated throughout the entire curriculum. However, this means more than teaching basic science with clinical examples given to illustrate its relevance. The integration must occur in the mind of the students. It is a cognitive process that can be facilitated, although not guaranteed, by a well-designed and effectively integrated curriculum. It must be accomplished by doing; that is, the students must practice solving problems in which both basic and clinical science principles are needed. This cannot be accomplished by the traditional hierarchical delivery of information from teachers to learners. Rather, teachers and students share the responsibility for the educational process and outcome. The learning objectives and teaching strategies are tailored to the students' needs and are well delivered.

6.5. Dynamic and flexible

Once the curriculum is established, there must be ongoing evaluation of its strengths and weaknesses, followed by changes to address the weaknesses, and further evaluation to see if the changes are working. We would suggest a subdivision of Medical Education Research and Evaluation be established to develop methods to provide data reflecting the performance of the students, the faculty, and the program itself. In outcome-based education, a medical graduate's professional qualifications should be periodically evaluated by his or her department. The graduates will be asked to continue to provide feedback (e.g., questionnaire, forum) to the Research and Evaluation division, so that their experience can contribute to continuing curriculum refinement.

7. Conclusion

Successful medical curriculum reform requires a comprehensive plan, the enthusiastic involvement of personnel, and support from the community and government. High expectations, good intentions, and expertise alone will not guarantee success. Most of the Western educational theories are applicable in Asia, but it is necessary to combine teaching strategies with curriculum designs that facilitate expertise acquisition to compensate for the regional manpower and financial shortages. It will be the responsibility of everyone involved, i.e., faculty, students, and administrators, to work together to identify what is working well and what needs to be modified or adjusted. The aim of medical educational reform is to be continually responsive to the needs of those it serves, both the students training as physicians and the community whose health they will eventually be responsible for.

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