

# Shifting Paradigms: From Flexner to Competencies

Carol Carraccio, MD, Susan D. Wolfsthal, MD, Robert Englander, MD, MPH,  
Kevin Ferentz, MD, and Christine Martin, PhD

## ABSTRACT

Realizing medical education is on the brink of a major paradigm shift from structure- and process-based to competency-based education and measurement of outcomes, the authors reviewed the existing medical literature to provide practical insight into how to accomplish full implementation and evaluation of this new paradigm. They searched Medline and the Educational Resource Information Clearinghouse from the 1960s until the present, reviewed the titles and abstracts of the 469 articles the search produced, and chose 68 relevant articles for full review.

The authors found that in the 1970s and 1980s much attention was given to the need for and the development of professional competencies for many medical disciplines. Little attention, however, was devoted to defining the

benchmarks of specific competencies, how to attain them, or the evaluation of competence. Lack of evaluation strategies was likely one of the forces responsible for the three-decade lag between initiation of the movement and widespread adoption. Lessons learned from past experiences include the importance of strategic planning and faculty and learner buy-in for defining competencies. In addition, the benchmarks for defining competency and the thresholds for attaining competence must be clearly delineated. The development of appropriate assessment tools to measure competence remains the challenge of this decade, and educators must be responsible for studying the impact of this paradigm shift to determine whether its ultimate effect is the production of more competent physicians.

*Acad. Med.* 2002;77:361–367.

**T**he challenge to medical education at the turn of the 20th century took the form of the Flexnerian revolution.<sup>1</sup> Exposure of poor educational content and processes in the early 1900s captured public attention and concern, precipitating a chain of events that led to drastic reform. In the early 21st century, accountability

and responsibility to the public for the competency of practicing physicians have become a driving force behind an initiative of the American Board of Medical Specialties (ABMS) and the Accreditation Council for Graduate Medical Education (ACGME) to establish competency-based training for all physicians. The current structure- and process-based system defines the training experience by exposure to specific contents for specified periods of time (e.g., one month of adolescent medicine), while a competency-based system defines the desired outcome of training, the outcome driving the educational process (e.g., competence in the care of adolescent patients). The paradigm shift from the current structure- and process-based curriculum to a competency-based curriculum and evaluation of outcomes is the Flexnerian revolution of the 21st century.

We reviewed the literature on competency-based education in medicine to (1) understand the evolution of this educational paradigm, (2) assess the evidence to date of the efficacy of competency-based education, and (3) provide practical insight into how to accomplish full implementation and evaluation of the paradigm shift.

*Dr. Carraccio* is professor and associate chair for education, Department of Pediatrics, *Dr. Wolfsthal* is associate professor and associate chair for education, Department of Medicine, and *Dr. Ferentz* is associate professor of family medicine and residency program director, Department of Family Medicine, all at the University of Maryland, Baltimore. *Dr. Englander* is assistant professor and associate program director, Department of Pediatrics, University of Connecticut, Hartford (held same titles at the University of Maryland, Baltimore, at the time the work was done). *Dr. Martin* is assistant professor and medical educator, Department of Medicine, University of Maryland (was professor of biology, Ursuline College, Pepper Pike, Ohio, at the time the work was done).

Correspondence should be addressed to Dr. Carraccio, Department of Pediatrics, Rm. N5W56, 22 South Greene Street, Baltimore, MD 21201; telephone: 410-328-5213; fax: 410-328-0646; e-mail: [ccarraccio@peds.umaryland.edu](mailto:ccarraccio@peds.umaryland.edu)). Reprints are not available.

## SEARCH STRATEGIES

With the aid of a reference librarian, we searched Medline from 1966 to the present and the Educational Resource Information Clearinghouse (ERIC) from 1967 to the present using “competency-based” as a medical subject heading. Limiting the search to English-language original articles produced 340 references in Medline and almost 10,000 in ERIC. Further modification of the ERIC search by including “competency-based” in the title (9,887) and “medical” or “medicine” (68) as subject heading resulted in 129 articles. We reviewed the titles and abstracts of the 469 references and chose 68 relevant articles for full review.

## What Does It Mean to Be Competent?

Many definitions of competency emerged in the medical literature beginning in the 1970s.<sup>2-8</sup> Essentially, however, synthesis and simplification of these definitions led us to describe “competency” as a complex set of behaviors built on the components of knowledge, skills, attitudes, and “competence” as personal ability. (These definitions are adapted to reflect language commonly used in educational settings.) In fact, the six ACGME “competencies” actually represent domains in which a physician must ultimately demonstrate competence. Our review supports the competency construct as a complex but demonstrable integration of numerous related objectives, the latter being discrete measurable behaviors. Attainment of defined competencies helps reach a set goal, which is by definition lofty, vague, and far-reaching. The elements of competency-based education are best understood when contrasted with the elements of the structure-

and process-based system that pervades medical education today (see Table 1).

## THE EMERGENCE OF THE COMPETENCY CONSTRUCT IN THE 1970S AND 1980S

In addition to defining competency-based education, early publications focused on the forces behind the paradigm shift and the process of curriculum development. The cultural climate of the 1960s and early 1970s caused a significant fragmentation of curricula and a de-emphasis on basic skills, with a concomitant decline in scores of indicators of educational effectiveness such as Student Achievement Tests and classroom examinations. This deterioration in scores prompted a “back-to-basics” movement with emphasis on minimum standards and performance competencies at all educational levels.<sup>9</sup> At the same time, the public demanded increased competence, even in the “professions” previously immune to consumerism. Public health leaders also called for competency-based training, and sought a workforce equipped to handle the population’s needs by emphasizing competence in the context of the practice setting.<sup>10</sup> Professional organizations, such as the American Dietetic Association<sup>11</sup> and the State Board of Higher Education of the University of Illinois, joined this movement early, establishing guidelines and even edicts for the paradigm shift in the educational institutions over which they presided.<sup>12</sup> These organizations prompted the implementation of several competency-based programs ranging from small-scale projects, such as developing interview skills in residents,<sup>13</sup> to large-scale endeavors, such as creating a competency-based curriculum for first-year psychiatry residents,<sup>14</sup> or a baccalaureate

Table 1

Variable	Educational Program	
	Structure- and Process-based	Competency-based
Driving force for curriculum	Content—knowledge acquisition	Outcome—knowledge application
Driving force for process	Teacher	Learner
Path of learning	Hierarchical (teacher ⇒ student)	Non-hierarchical (teacher ⇔ student)
Responsibility for content	Teacher	Student and teacher
Goal of educational encounter	Knowledge acquisition	Knowledge application
Typical assessment tool	Single subjective measure	Multiple objective measures (“evaluation portfolio”)
Assessment tool	Proxy	Authentic (mimics real tasks of profession)
Setting for evaluation	Removed (gestalt)	“In the trenches” (direct observation)
Evaluation	Norm-referenced	Criterion-referenced
Timing of assessment	Emphasis on summative	Emphasis on formative
Program completion	Fixed time	Variable time

program for physical therapy students.<sup>15</sup> As early as 1972, the American Board of Pediatrics published one of the first comprehensive documents on this subject, entitled *Foundations for Evaluating the Competency of Pediatricians*.<sup>16,17</sup>

Having set the stage for the context in which competency-based education developed, the stepwise approach to curricular design emerged as a consistent theme throughout the literature. The four steps are (1) competency identification, (2) determination of competency components and performance levels, (3) competency evaluation, and (4) overall assessment of the process. Possible methods for identifying competencies (step one) include the Delphi technique, which uses a consensus of individual experts,<sup>18</sup> and the nominal group technique, which relies on group consensus<sup>19</sup>; task analysis, in which a researcher accompanies a physician to document all activities over a period of time<sup>18</sup>; the critical-incident survey, in which qualified practitioners describe observed incidents that reflect good or bad practice<sup>10,19</sup>; the behavioral-event interview, in which star performers describe critical clinical situations and characteristics of a good doctor<sup>10</sup>; and the simplest method—practitioner surveys.<sup>6</sup> The identification of competencies received more attention than the other steps in the process.

The second step involves determining competency components and performance levels. The former includes “tasks” that, either sequentially or in sum, make up the competency. These “tasks” are often referred to as benchmarks or performance indicators. They must be measurable and in the aggregate determine achievement of the specific competency. Performance criteria set the threshold for demonstrating competence.<sup>2</sup> The expected performance level for each benchmark must be clearly defined to determine whether competence has been achieved. The educator must then determine the methods by which the competency might be attained, such as through didactic learning, small-group discussions, or on-site experiences, or via information technology.<sup>14</sup>

The third step determines how the attainment of competence will be assessed. Criterion-referenced measures that compare performance against a set standard or threshold are the preferred methods.<sup>2</sup> The normative-based assessment, typical of the structure- and process-based curriculum, compares the student’s performance with that of a peer group. However, this assessment fails to provide a clear understanding of what a student can or cannot do, and cannot determine which, if any, benchmarks or performance indicators have been met.<sup>20</sup> As the final step, the competencies, attainment procedures, and assessment system are validated.<sup>2</sup>

While several studies in the 1970s and 1980s furnished a practical description of the competency-based curriculum development process,<sup>2,12,14,21,22</sup> only one provided a comparison between a competency-based curriculum and the traditional

structure- and process-based one.<sup>9</sup> Thurman and Sanders split a class of radiology technician students to receive either a traditional or a competency-based instructional method for one learning block.<sup>9</sup> While the groups were small ( $n = 6$  and  $5$ , respectively) and the participants not masked with regard to study group, scores on the post-test assessments were significantly higher than those on the pre-test assessments among the competency-based group. A study from the nursing literature that evaluated participants of competency-based workshops likewise showed improvements in effectiveness and efficiency of specific skills.<sup>23</sup>

Although the medical education process during the 1970s included generally defined competencies, corresponding curricular objectives or benchmarks to describe the competencies were inadequate. Residency programs classically contained superficial curriculum guidelines without clear definitions of expected competencies.<sup>24</sup> Despite the prediction of Dunn et al. that competency-based education was an “idea whose time seems to have come,” the competency movement of this era dwindled.<sup>18</sup> The lack of a direct link between the desired competencies and curricular objectives, as well as inadequate assessment tools to evaluate competence, may have contributed to its demise.

## THE LAST DECADE

At the beginning of the decade, and coincidentally with revisions in the Essential Requirements for Residency Training in Family Medicine by its residency review committee (RRC), the Society of Teachers of Family Medicine promulgated a new curriculum, entitled “Essentials for Family Practice.”<sup>25</sup> It contained a visionary proposal to develop competency-based curricula and provide objective measurements of competence for each rotation. The authors cautioned against a focus limited to those competencies that can be measured rather than those that need to be learned. The nursing literature shared the concern that emphasis on skill acquisition, which is more easily measured, may replace the development of necessary cognitive and critical thinking<sup>26</sup> as well as the interpersonal skills needed for effective patient interaction.<sup>27,28</sup>

Brown University School of Medicine serves as a model of an institution that has recently adopted the paradigm shift to competency-based education through the MD2000 project.<sup>29</sup> Faculty were intimately involved in the process of defining nine abilities all students must attain prior to graduation and translated each ability into observable behaviors rated at three levels of competence: beginning, intermediate, and advanced. They then developed new assessment methods based on clear performance criteria. Students were required to demonstrate application of knowledge with certification in each course, as well as attain an intermediate

level of competence in all nine abilities and an advanced level in problem solving. Preliminary results on the United States Medical Licensing Examination indicate current students' scores are at the national mean and their pass rates slightly above the mean, using this new educational strategy.<sup>30</sup>

The Baylor College of Dentistry undertook an extensive process of curriculum reform similar to the MD2000 project. The authors noted the importance of developing a competency-based curriculum as an integral part of the school's strategic plan, as well as capitalizing on new accreditation requirements to facilitate change. Including faculty in significant and continuing ways throughout the process emerged as an important feature. The process also required administrative support for developing, managing, and assessing the curriculum, and assurance that the planning process was clearly linked to an assessment plan. The curriculum creators also developed various methods for assessment of students' competence, incorporating evaluations from many observers in different situations to make the final assessments. Observing students doing real work, keeping the faculty close to the assessment process, designing a curricular review process that is competency-based, and developing a competency document that focuses on beginning professional practice were all important to the success of curricular revision. Other dental educators have likewise identified competency-based education as a critical foundation for their education programs.<sup>31-34</sup>

On a smaller scale, additional studies have explored the effect of a competency-based program for selected medical school rotations and residency programs. A pilot program to assess the value of a competency-based clinical skills assessment program was undertaken for third-year medical students during their surgical clerkship.<sup>35</sup> Scores on the checklist skills assessment correlated poorly with those from the standard global evaluation forms and those on standardized national board examinations, but improved when students attended an orientation session with clear delineation of expectations. Martin et al. demonstrated improvement in clinical skills and patient care when a competency-based instruction module on three invasive procedures was introduced into a surgery residency program.<sup>36</sup> Pre-testing, group instruction, and hands-on teaching resulted in residents' reducing their failure and complication rates in all three procedures in the laboratory. This effect translated into a documented reduction in the residents' trauma resuscitation time in the clinical arena.

Few specialties in medicine have undertaken total restructuring of their curricula into a competency-based model. As part of the Brown MD2000, the faculty developed a competency-based curriculum in preventive medicine.<sup>37</sup> On a broader scale, national educators in preventive medicine em-

barked on a project to develop competencies using a consensus process.<sup>38</sup> Engaging faculty and other stakeholders proved to be one of the most critical ingredients for success.<sup>39,40</sup> Indicators were defined for each competency to distinguish successful from unsuccessful performance and identify superior performance. By addressing the reliability, validity, and predictive validity, educators attempted to ensure results would be predictive of future success as a specialist.

Through the 1990s much of the literature focused on the debate surrounding the evaluation of competence. Does a minimum threshold exist that defines one as competent versus incompetent? Chambers and Glassman suggested five stages, beginning with novice; progressing through beginner, competent, and proficient; and culminating in expert.<sup>41</sup> For the novice, the focus concerns isolated facts that tests can evaluate. For the beginner, synthesis and integration of information learned in seminars, in labs, and through supervised work are evaluated via simulations. The competent individual functions as an independent learner and practices in a realistic work setting. Evaluation is authentic and comprises portfolios that contain ratings of supervisors, exemplary products, and test cases. Professional identity and norms characterize proficiency, which is achieved by socialization and specialized training and evaluated by work-related markers. The expert—at the highest level of competence—has an internalized, patient-centered focus, learns through self-direction, and relies on self-assessment and internalized standards of evaluation.

The nursing literature also addressed the need for real-world observation in the evaluation of seasoned nurses, pointing out that current methods are typically geared to beginners.<sup>26</sup> Defined competencies are needed for supervisors to assess staff nursing skills adequately and identify areas requiring remediation.<sup>42,43</sup> Competency-based instruction is preferred for adult learners, who tend to be self-directed and willing to assume responsibility in the learning process.<sup>44,45</sup> Citing similarities between the competency-based model and the adult-learning theory model, studies have highlighted the feedback and evaluation processes that are essential components of active learning.<sup>46</sup> Allowances for differences in learning style and remediation and re-assessment of students who do not meet standards must be considered.<sup>47</sup> One earlier study described the "clinical contract" as a strategy to evaluate clinical performance by identifying how, when, what, where, and by whom the clinical performance will be evaluated.<sup>48</sup> The teacher, acting as facilitator, designs the clinical learning contract based on the elements of adult learning. The individual nature of curricular design is consistent with the concept that attainment of competence is dependent on individual progress. Recently, neurosurgery residents have attained procedural competencies with individually paced

learning much sooner than with fixed time schedules.<sup>49</sup> As such, one may conclude that certification of competence should be independent of time, replacing the predetermined fixed length of training for each subspecialty.

### INTERNATIONAL EFFORTS

The competency movement has also received some attention in the international arena. For example, a decade of evolving curricular reform of medical education in Canada has set the precedent for competency-based education from undergraduate programs through the maintenance of certification.<sup>50,51</sup> The Web site of the Royal College of Physicians and Surgeons not only focuses on competency-based graduate medical education but places a major emphasis on competence in practice through the maintenance of certification programs.<sup>52</sup> The Educational Commission for Foreign Medical Graduates requires the Clinical Skills Assessment for international medical students seeking training in the United States, which likewise demonstrates the recent focus on evaluation of competence through the use of standardized patients.<sup>53</sup>

Several other countries have reported various efforts at incorporating competency-based training and evaluation for medical students,<sup>54–57</sup> residents,<sup>58,59</sup> and practicing physicians.<sup>7,60,61</sup> The nursing profession in Australia undertook a review of the literature on competency-based learning as early as 1982.<sup>62</sup> Unfortunately, these reports were hampered by a lack of standardized terminology. While assessing and enhancing “competence” is mentioned as the goal in each of these publications, wide variation exists in the extents to which true competency-based learning objectives were instituted. Australian nursing competencies are being written and will be uniform throughout the country,<sup>63</sup> although some raise concern that the competencies may control the curriculum.<sup>28</sup> In the United Kingdom, a method of measurement and evaluation of performance was developed for nurses for use within their first year of employment. Initial results of an in-depth audit showed that measurement instruments developed were clear indicators of performance, although long-term validity studies are pending.<sup>64</sup> At the residency level, one interesting study compared competency-based evaluation with more subjective supervisors’ evaluations of a large cohort of residents.<sup>58</sup> When subjectively evaluated by their supervisors, the majority of residents were judged “competent.” Less than 2% of residents were found competent when more objective criteria were used.

In collaboration with American colleagues and the Chinese Medical Board of New York, three Chinese medical schools incorporated standardized patient programs.<sup>56</sup> One year after implementation, participating students significantly outperformed their counterparts who were not en-

rolled. The new curriculum has been rapidly incorporated and has led to measurable improvement in students’ clinical skills, in both increased performance scores and decreased variation among students.

### THE NEW MILLENNIUM

The driving force behind the recent joint effort of the ACGME and the ABMS to shift from structure- and process-based to competency-based medical education is accountability to the public, particularly in light of the reliance on public funding.<sup>65</sup> Outcomes-based data are needed for informed discussions with policy leaders focused on funding graduate medical education and patient safety. Also, the current system does not directly measure the quality of the educational outcomes of a program. At the February 1999 meeting, the ACGME endorsed six general competencies as the foundation of all graduate medical education: (1) patient care, (2) medical knowledge, (3) practice-based learning and improvement, (4) interpersonal and communication skills, (5) professionalism, and (6) systems-based practice. Some minimal language to address the competencies is being incorporated into the requirements for residency training for each RRC; however, the timeline for full implementation and evaluation will span the next decade.

Review of the literature over the last three decades reflects a defined movement toward competency-based curricula and outcomes evaluation. Despite societal forces for documented competence among medical professionals, widespread adoption is not yet a reality. In addition, our review revealed little scientific evidence evaluating the outcomes of competency-based education. What evidence does exist clearly favors competency-based education over the current structure- and process-based model. Nonetheless, several lessons may be learned from the available evidence. Of critical importance is the strategic planning phase of identifying and defining competencies needed for professional practice. A series of benchmarks or performance indicators describing the outcome expectancy of each competency must be outlined.<sup>66</sup> The knowledge, skills, and attitudes underpinning each competency need to be clearly written, measurable, and in summation reflect the achievement of that competency. The threshold for achieving competence must be predetermined. Assessment tools must be specifically matched to the competency to effectively evaluate outcomes. Evaluation should reflect real-world observation and consist of a “portfolio” of assessment tools. Faculty and learner buy-in with consensus building and coupling with strong administrative support are crucial every step of the way. The final step in achieving successful implementation is to ensure that those intimately involved with this process assume responsibility for the creation of faculty development programs for the clinician educators who teach our trainees.

## CHALLENGES

The challenges identified in the conclusion of *The Federated Council of Internal Medicine's Resource Guide for Residency Education* include coordinating medical student and residency curricula, expanding programs for faculty development, creating better systems of evaluation, and garnering the resources to develop learner-centered residency programs.<sup>67</sup> In addition, active rather than passive learning needs to provide the infrastructure for the educational process. This will require a change in ethos on the teacher's part as well as the learner's, resulting in "socialization into the new paradigm."<sup>30</sup>

## PRESCRIPTION FOR THE FUTURE HEALTH AND WELL-BEING OF MEDICAL EDUCATION

Much descriptive work has defined competencies and outlined processes that can be used in creating competency-based curricula. Assessment tools to evaluate competence have received less attention. The creation of tools that are valid, reliable, and predictive of future success is our immediate challenge. As educators we must take the lead in defining and studying the outcomes that result from this paradigm shift to competency-based education with the same rigor we use in basic science laboratories and randomized clinical trials. Only then will we know whether competency-based training produces more competent physicians, and whether the paradigm shift of the new century is as significant as the Flexnerian revolution of the last one.

The authors thank Mary Alice Parsons, executive director, Residency Review Committee for Pediatrics and Family Medicine, for her critical review of the manuscript. This work was funded in part through a grant from the Health Resources and Services Administration, Bureau of Health Professions.

## REFERENCES

- Flexner A. Medical Education in the United States and Canada. A Report to the Carnegie Foundation for the Advancement of Teaching. Bulletin No. 4. Boston, MA: Updyke, 1910.
- Brown TC, McCleary LE, Stenchever MA, Poulson AM. A competency-based educational approach to reproductive biology. *Am J Obstet Gynecol.* 1973;116:1036-43.
- Spady WG. Competency-based education: a bandwagon in search of a definition. *Educ Res.* 1977;6:9-14.
- Bell CG. Role vs. entry-level competencies in competency-based education. *J Am Diet Assoc.* 1976;69:133-7.
- Rinke WJ. Competency-based education. *J Am Diet Assoc.* 1980;76:247-52.
- Grassing PG. Education and practice: is competency-based education closing the gap? *Am J Pharm Educ.* 1984;48:117-24.
- Hager P, Gonczy A. Competency-based standards: a boon for continuing professional education? *Stud Cont Educ.* 1991;13:24-40.
- Bell HS, Kozakowski SM, Winter RO. Competency-based education in family practice. *Fam Med.* 1997;29:701-4.
- Thurman GK, Sanders MK. Competency-based education versus traditional education: a comparison of effectiveness. *Radiol Technol.* 1987;59:164-9.
- McGaghie WC, Miller GE, Sajid AW, Telder TV. Competency-based curriculum development in medical education: an introduction. *Public Health Pap.* 1978;68:11-91.
- Argo JK, Watson DR, Lee EC. A computer-managed clinical evaluation system: implications for competency-based dietetic education programs. *J Am Diet Assoc.* 1984;4:36-41.
- Quinlan TH. The Rockford experience: competency-based medical curriculum. *Am J Pharm Educ.* 1975;39:435-9.
- Stillman PL, Sabers DL. Using a competency-based program to assess interviewing skills of pediatric housestaff. *J Med Educ.* 1978;53:493-6.
- Weinstein HM, Russell ML. Competency-based psychiatric education. *Am J Psychiatry.* 1976;133:935-9.
- May BJ. Evaluation in a competency-based educational system. *Phys Ther.* 1976;57:28-33.
- Burg FD, Brownlee RC, Wright FH, et al. A method for defining competency in pediatrics. *J Med Educ.* 1974;51:824-8.
- American Board of Pediatrics. Foundations for Evaluating the Competency of Pediatricians. Chicago, IL: American Board of Pediatrics, 1974.
- Dunn WR, Hamilton DD, Harden RM. Techniques of identifying competencies needed of doctors. *Med Teach.* 1985;7:15-25.
- Pierleoni RG. Clinical evaluations techniques for the health professions. *Improv Hum Performance Q.* 1978;7:204-16.
- Turnbull J. What is . . . normative versus criterion-referenced assessment. *Med Teach.* 1989;1:145-50.
- Bair JN, Powell PJ. Structured competency-based hospital pharmacy internship program. *Am J Hosp Pharm.* 1981;38:1705-8.
- Poole SR, Morrison JD, Adolf A, Reed FM. Pediatric training in family practice: a core curriculum. *J Fam Pract.* 1982;15:1145-56.
- Greaves PE, Loquist RS. Impact evaluation: a competency-based approach. *Nurs Admin Q.* 1983;7:81-6.
- Bashook PG, Sandlow LJ, Reinhard JW. Defining a universe of expected competencies: a methodological example for internal medicine. Proceedings of the American Educational Research Association, Toronto, ON, Canada, March 27-31, 1978.
- Merenstein JH, Schulte JJ. STFM Task Force on Residency Curriculum of the Future. a residency curriculum for the future. *Fam Med.* 1990;22:467-73.
- Bechtel GA, Davidhizar R, Bradshaw MJ. Problem-based learning in a competency-based world. *Nurse Educ Today.* 1999;19:182-7.
- Benner P. Issues in competency-based testing. *Nurs Outlook.* 1982;30:303-9.
- Chapman H. Some important limitations of competency-based education with respect to nurse education: an Australian perspective. *Nurse Educ Today.* 1999;19:129-35.
- Smith SR, Fuller B. MD2000: a competency-based curriculum for the Brown University School of Medicine. *Med Health RI.* 1996;79:292-8.
- Smith SR, Dollase R. AMEE guide no. 14: outcome-based education: Part 2—planning, implementing and evaluating a competency-based curriculum. *Med Teach.* 1999;21:15-23.
- McCann AL, Babler WJ, Cohen PA. Lessons learned from the competency-based curriculum initiative at Baylor College of Dentistry. *J Dent Educ.* 1998;62:197-206.
- Hendricson WD, Kleffner JH. Curricular and instructional implications of competency-based dental education. *J Dent Educ.* 1998;62:183-96.
- Chambers DW. Competency-based dental education in context. *Eur J Dent Educ.* 1998;2:8-13.

34. Yip HK, Smales RJ. Review of competency-based education in dentistry. *Br Dent J.* 2000;189:324–6.
35. Dunnington GL, Wright K. A pilot experience with competency-based clinical skills assessment in a surgical clerkship. *Am J Surg.* 1994;167:604–7.
36. Martin M, Vashisht B, Frezza E, et al. Competency-based instruction in critical invasive skills improves both resident performance and patient safety. *Surgery.* 1998;124:313–7.
37. Pololi LH, Coletta EM, Kern DG, et al. Developing a competency-based preventive medicine curriculum for medical schools. *Am J Prev Med.* 1994;10:240–4.
38. Lane DS, Ross V, Parkinson MD, Chen DW. Performance indicators for assessing competencies of preventive medicine residents. *Am J Prev Med.* 1995;11:1–8.
39. Lane DS, Ross V. Consensus on core competencies for preventive medicine residents. *Am J Prev Med.* 1994;10:52–5.
40. Lane DS, Ross V. The importance of defining physicians' competencies: lessons from preventive medicine. *Acad Med.* 1994;69:972–4.
41. Chambers DW, Glassman P. A primer on competency-based evaluation. *J Dent Educ.* 1997;61:651–66.
42. Feeney J, Benson-Landau M. Competency-based evaluation: not just for new nurses. *Dimens Crit Care Nurs.* 1987;6:368–72.
43. Helm A. Legal perspective on competency-based evaluation. *Dimens Crit Care Nurs.* 1987;6:373–6.
44. Redus KM. A literature review of competency-based orientation for nurses. *J Nurs Staff Dev.* 1994;10:239–43.
45. del Bueno DJ. Competency based education. *Nurse Educ.* 1986;3:10–4.
46. Musinski BA. Educated as an adult: a competency-based practical nurse program. *J Pract Nurs.* 1996;46:20–3.
47. Tutuska AM, Nahigian E. Competency-based evaluation: one hospital's approach. *J Nurs Staff Dev.* 1997;13:44–6.
48. Beare P. The clinical contract—an approach to competency-based clinical learning and evaluation. *J Nurs Educ.* 1985;24:75–82.
49. Long DM. Competency-based residency training: the next advance in graduate medical education. *Acad Med.* 2000;75:1178–83.
50. Mandin H, Harasym P, Eagle C, Watanabe M. Developing a “clinical presentation” curriculum at the University of Calgary. *Acad Med.* 1995;70:186–93.
51. Mandin H, Dauphinee WD. Conceptual guidelines for developing and maintaining curriculum and examination objectives. *Acad Med.* 2000;75:1031–7.
52. General information and regulations on residency requirements and examinations leading to certification, (<http://rcpsc.medical.org/english/>). Accessed 2/1/02. The Royal College of Physicians and Surgeons of Canada, Ottawa, ON, Canada, 2001.
53. ECFMG certification—clinical skills assessment (<http://www.ECFMG.org>). Accessed 4/10/01. Educational Commission for Foreign Medical Graduates, Philadelphia, PA, 2001.
54. Stone DH. A method of deriving definitions of specific medical competencies: a framework for curriculum planning and evaluation. *Med Teach.* 1987;9:155–9.
55. Jeffery HE, Henderson-Smart DJ, Hill DA. Competency-based learning in neonatology. *Med Educ.* 1996;30:440–4.
56. Stillman PL, Wang Y, Quyang Q, Zhang S, Yang Y, Sawyer WD. Teaching and assessing clinical skills: a competency-based programme in China. *Med Educ.* 1997;31:33–40.
57. Eldin M, Magzoub MA, Schmidt HG, Abel-Hameed AA, Dolmans D, Mustafa SE. Student assessment in community settings: a comprehensive approach. *Med Educ.* 1998;32:50–9.
58. Al-Chalabi TS, Al-Na'Ama MR, Al-Thamery DM, et al. Critical performance analysis of rotating resident doctors in Iraq. *Med Educ.* 1983;17:378–84.
59. Rourke J. Postgraduate medical education for rural family practice in Canada. *J Rural Health.* 2000;16:280–7.
60. Yuen K, Barrington D, Headford N, et al. Educating doctors in palliative medicine: development of a competency-based training program. *J Palliat Care.* 1998;14:79–82.
61. Hartley R. Area health services as learning organizations: the rural experience. *Aust J Rural Health.* 2000;8:77–80.
62. Scott B. Competency based learning: a literature review. *Int J Nurs Stud.* 1982;19:119–24.
63. Parkes R. Competency-based training: Australia moves to a competency-based system of training and education. *Aust Nurs J.* 1991;21:12–13.
64. O'Connor SE, Pearce J, Smith RL, Vogeli D, Walton, P. Monitoring the quality of pre-registration education: development, validation and piloting of competency-based performance indicators for newly qualified nurses. *Nurs Educ Today.* 1999;19:334–41.
65. Outcomes Project (<http://www.acgme.org>). Accessed 1/31/02. The Accreditation Council for Graduate Medical Education, Chicago, IL, 2001.
66. Lemons DE, Griswold JG. Defining the boundaries of physiological understanding: the benchmarks curriculum model. *Adv Physiol Educ.* 1998;20:S35–S45.
67. Ende J, Kelley M, Sox H. The Federated Council of Internal Medicine's resource guide for residency education: an instrument for curricular change. *Ann Intern Med.* 1997;127:454–7.