Changes in Educational Methodologies in Predoctoral Dental Education: Finding the Perfect Intersection

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Abstract: This article describes the evolution of thinking, primarily over the past fifteen years, within the academic dentistry community concerning teaching and learning strategies to facilitate students' acquisition of competence. Readers are encouraged to consider four issues. First, looking back to the time of the Institute of Medicine report *Dental Education at the Crossroads: Challenges and Change* fifteen years ago, in the mid-1990s, where did we think we would be now, in 2011, in regard to the structure of the predoctoral curriculum and use of specific educational methodologies, and to what extent have those predictions come true? The author's own crystal ball predictions from the 1990s are used to kick off a discussion of what connected and what did not among numerous advocated educational reforms, many of them transformative in nature. Second, what is the nature of the evidence supporting our ongoing search for educational best practices, and why are advocacy for educational best practices and prediction of down-the-road outcomes so treacherous? This section distinguishes types of evidence that provide limited guidance for dental educators from evidence that is more helpful for designing educational strategies that might make a difference in student learning, focusing on factors that provide a "perfect intersection" of student, teacher, educational method, and learning environment. Third, readers are asked to revisit four not-so-new teaching/learning methods that are still worthy of consideration in dental education in light of best evidence, upcoming events, and technology that has finally matched its potential. Fourth, a specific rate-limiting factor that hinders the best efforts of both teachers and students in virtually all U.S. dental schools is discussed, concluding with a plea to find a better way so that the good works of dental educators and their students can be more evident.

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It is a privilege to contribute to the seventy-fifth anniversary issue of the *Journal of Dental Education*. The *JDE* has been a meaningful and enjoyable part of my life for thirty years: first as an author of articles reporting educational research in the 1980s and 1990s, as well as a frequent reviewer; then, from 2000 to 2009, as associate editor alongside my University of Texas Health Science Center at San Antonio (UTHSCSA) colleague and mentor, Dr. Olav Alvares; and finally as the coordinator/editor of the twenty-one articles published in the *JDE* between 2006 and 2009 as part of the American Dental Education Association's Commission on Change and Innovation in Dental Education (ADEA CCI), subsequently collected into the volume *Beyond the Crossroads: Change and Innovation in Dental Education*.[1] The *JDE* has been a primary source of work describing new educational techniques since its inception in 1936, and especially in the past dozen years since Dr. Alvares starting the Educational Methodologies section in 2000 and increased the number of issues per year devoted to original manuscript contributions. In preparing to write this article, I reviewed the table of contents of all issues published between January 2000 and October 2011, as well as reread quite a few favorites published during my time with the journal. This review identified more than 600 either descriptive or research articles that shared information about educational strategies with the *JDE* readership. Certainly it is not an exaggeration to say that the *JDE* has become the major mechanism for dissemination of information about teaching and learning methods within the dental professions and increasingly within other areas of health professions education, thanks in large part to the success of the online version of the journal.

My charge is to discuss changes in educational methodologies in dental education. Here is my four-step game plan for this charge:

1. **Consider the source**: Information about my past predictions of future educational directions so readers can place my discussion of teaching and learning methodology into context;
2. **Consider the evidence**: Review of why low-quality evidence makes advocacy for educa-

tional best practices difficult and prediction of down-the-road effects even more treacherous, including sorting out types of evidence that provide limited guidance (i.e., effects of macro, institution-wide interventions, known as transformative changes) from evidence that is more helpful (educational effects of teacher-student interactions using specific teaching/learning techniques);

3. **Consider these educational strategies:** Four not-so-new teaching/learning methods that are still worthy of consideration within dental education; and
4. **One final consideration:** Let's give teachers and students a puncher's chance by eliminating a huge constraint on educational quality in dental school.

I made five assumptions when writing this article. First, dental educators attracted to this subject are already well versed in the pros and cons of the commonly used educational methods and aware of research trends related to the comparative effectiveness of these techniques in facilitating students' acquisition of competence. In other words, this is not a tutorial on instructional design, a historical review of the evolution of teaching/learning strategies, or a comprehensive summary of research findings. Second, readers will understand that when a "perfect intersection" of student, teacher, and environment conditions occurs, learners can master objectives equally well with a wide variety of educational techniques, assuming adept teacher implementation or promotion of particular strategies that are associated with enhancement of learning, shown in Table 1,[2] and desirable conditions among students: strong intrinsic motivation, a disposition to seek answers to questions and explore uncertainties, manageable levels of distraction, diversion, and anxiety, effective study habits, and environmental conditions conducive to learning. Table 2 distinguishes characteristic study habits and other behaviors of high-achieving and underachieving students.[3]

My third assumption is that the long-standing practice of comparing teaching/learning modalities in "racehorse" fashion in search of "winners" (i.e., comparing students' learning from computer-based instruction to learning from lecture-based courses) is not productive. The take-home message from hundreds of racehorse studies in the health professions alone, among thousands in all of higher education, is that well-designed educational experiences in a variety of formats can facilitate students' learning if the fundamental building blocks of adult learning are incorporated as depicted in the P-R-I-M-E[2] Model, shown in Table 3.[4] The variables and processes indicated in Tables 1, 2, and 3 represent the factors most likely to influence students' learning, not particular formats such as lectures, demonstrations, small-group conferences, case-reinforced learning, online modules, videos, DVDs, textbooks, skill practice in labs and simulations, supervised skill performance in authentic work conditions, and a myriad combinations of these formats—assuming, of course, that instructors avoid extreme mismatches of educational method with learning outcomes, such as hoping to facilitate students' acquisition of treatment planning skills by listening to lectures. Of course, there are implementation heuristics unique to specific teaching/learning methods that can optimize the chances of positive outcomes if employed properly.[5]

The fourth assumption is that my objective is to stimulate dialogue within the academic dentistry community about issues influencing instructional design and student learning in dental school: "should we continue to dance with the one that 'brung' us," or should we consider new partners? And my fifth assumption involves the fact that articles on educational methods often use the term "pedagogy." Readers will understand that this term refers to strategies designed

Table 1. Principles of effective instructional design in university-level education

- Clearly stated learning objectives
- Assessments clearly linked to objectives
- Extensive student-teacher contact, including non-class interaction: modeling, mentoring, advising
- Cooperative learning among students
- Active learning by students including case analysis, project planning, and independent research
- Prompt feedback with corrective prescriptions when indicated
- Teachers use multiple methods to accommodate diverse ways of learning
- Rehearsal opportunities: students promptly use newly acquired information/skills in simulations or "real-world" work settings

Table 2. Study habits and learning conditions of high-achieving and underachieving learners

Factor	High-Achieving Learners	Underachieving Learners
Environment	• Quiet and isolated from others • Well-illuminated reading surface • Prefer to sit upright at desk • Prefer to study alone	• Background sound (music, TV) • Seek comfort: read in bed or lying on sofa • Prefer to study around other people or in public places (e.g., Starbucks)
Emotional	• Set priorities and stick to them • Take responsibility for academic problems • Good time management: allocate adequate time to finish tasks • Sacrifice social life	• Don't stick to study plans; easily diverted • Blame others or circumstances • Underestimate time needed to study • Unwilling to sacrifice social time • Desire social rewards for studying
Social	• Willing to be alone, without large social network • Self-reliant for decision making • Interact with good/diligent students • In the loop at school: know what is going on	• Need constant peer contact and social stimulation • Rely on peers for decision making • Associate with poor students or non-students • May be loners (out of student loop)
Physical	• Rely on multiple senses • Study without extended activity breaks • Mentally alert in afternoon and evening • Proper eating habits/good diet	• Mobile (can't sit still; fidgety) • Take long study breaks • Difficulty studying during mid-day • Unhealthy diet and eating habits
Mental	• Flexible thinkers: concrete and abstract • Impulse control (think before speaking) • Good anticipatory guidance: look ahead and see potential problems • Confident; receptive to critique • Optimistic with high expectations	• Lack of comfort with abstraction • Poor impulse control; lack verbal buffers • Lack anticipatory guidance (cannot predict future problems) • Defensive; avoid feedback • Inconsistent expectations: unreasonably high or excessive negativity
Methods	• Self-quizzing while reading • Write own notes in class and review • Keep up with assigned reading • Ask questions during class	• Passive; rely on teacher-provided materials • Passive reading (no notes or quizzing) • Delay reading until exam proximity • Inefficient study time
Summary	• Persistent: "grind it out" • Effective social impulse control • Self-directed, active learning • High expectations	• Easily distracted from academic tasks • Distracting study environment • Kinetic: need for physical activity • Passive learning strategies • Conflict between social and academic

Table 3. P-R-I-M-E^2 model of adult learning

	Building Blocks of Dentistry	Description
P	Problem resolution	Acquire information and skills to resolve problems and/or performance deficits, especially self-identified deficiencies.
R	Rehearse	Practice skills and obtain prompt corrective and/or reinforcing feedback.
I	Immediate	Apply (use) new information and skills promptly.
M	Motivation	Set own learning goals; establish own performance standards and expectations for quality. Learner primarily responds to intrinsic (self-directed) motivation versus extrinsic incentives (externally applied; imposed by others). Contribute to planning of strategies to accomplish personal goals.
E	Express	Contribute own expertise, experience, and values during learning events; engage with instructors in communication about educational issues.
E	Emotional intensity	Make decisions, take positions on issues, propose plans, self-assess, teach peers, provide peer review.

to promote cognitive capacities, acquisition of language, communication and computational skills, and other types of mental development (i.e., rudimentary critical analysis) in children and adolescents, and thus is not a suitable term to use when discussing educational methods to enable learning by adults.

Consider the Source

Typically, an article of this sort requires the invited author to predict educational strategies likely to become "hot" in the future, if not advocate instructional techniques that should be used. In preparing, I reviewed several previous "educational strategies for the future" articles and chapters I wrote, including one for the *JDE* (with John Kleffner), one for ADEA (with Peter Cohen), and one for *Academic Medicine,* also with Peter Cohen.[6-8] These crystal ball opportunities occurred between 1995 and 2000. Fifteen years ago, what was I predicting would be educational innovations and reforms in the future—for example, in 2012? To my chagrin, Table 4 indicates my crystal ball was cloudy fifteen years ago, or perhaps more time is needed to let the haze clear. Many ascribe the following observation about the change process to Mao Tse-Tung, although variations of this statement have been attributed to others including Ben Franklin: "Any change of substance, consequence, and merit takes at least fifteen years to find its way into our lives. Changes that take less time must have little substance and should be mistrusted because few rose to oppose them, thus not building the strength that comes from the battle of wills over important matters."[9] In other words, beware of fixes that get fast-tracked.

There are four primary data sources for my observations that appear in the outcome column of Table 4: data reported periodically in the American Dental Association (ADA) Survey of Dental Education since 2000; articles reporting educational innovations published in the *JDE* since 2000; my own impressions based on consultations with thirty-eight U.S. dental schools since 2000; and two ADEA-sponsored surveys of dental curriculum patterns and future educational reform goals conducted in 2002 and 2009 and reported in the *JDE.*[10,11] Overall, the fifteen-years-later scorecard for these eighteen crystal ball visions of the now present "future" is: eight (44 percent) have not been implemented at all (as far as can be determined); five (28 percent) have been implemented to some extent, although not to the level predicted; and five (28 percent) have been substantially implemented

Of the five predictions that have evolved into the fabric of dental school life, two were externally driven by the Commission on Dental Accreditation (CODA): designate trainee outcomes and introduce performance-based testing to measure competence. The other three arguably could be considered minimally invasive of "life as we know it" in the predoctoral education world: evolving the clinical faculty role from checker to coach, employing case-based learning to contextualize and reinforce didactic teaching, and diversifying students' clinical experience to include community-based settings. The outcomes of these predictions are largely consistent with theory and research on change processes in academia.[12,13] The least disruptive (i.e., incremental, piecemeal) changes are the most likely to be adopted and become components of institutional culture, while reforms that are likely to have a transformative impact (i.e., fundamentally alter ways of doing things and possibly alter organizational relationships) are likely to become a part of institutional culture only if the catalyst is external and influential (e.g., CODA) or if the school must respond to an embarrassing crisis that has galvanized the administration and faculty leaders into action. Several of the predictions in Table 4 addressed the concern, which was more prominent in the 1990s, that dental practice and dental education were excessively isolated from other health professions and from the health care delivery system in general, a by-product of the "splendid isolation" tradition of the profession.[14] As many readers will recall, there was much discussion of role conceptualization for the dental professional in the 1990s centering on the "oral physician" concept, and associated educational implications, which has dwindled over the past ten years.[15] To the best of my knowledge, none of the predictions related to providing better integration of the educational components of dentistry and medicine, even in the form of modest proposals for interprofessional learning experiences, have seen the light of day, other than as episodic, small-scale experiments.

Table 5 shows a baker's dozen educational reforms that have framed dialogue about future directions for dental education since 2001 when they appeared in the review "Oral Health Care in the 21st Century: Implications for Dental and Medical Education" commissioned by *Academic Medicine,*[8] with elaboration and refinement by others, including DePaola and Slavkin in the ensuing years.[16] Some of the

Table 4. Circa 1995–2000 predictions for future directions of educational strategies in dental education

Prediction	Status in 2011
Clearly designate trainee outcomes, i.e., identify competencies necessary for graduation	Not a revolutionary prediction even in 1995; now implemented in all schools, driven by CODA
Interdisciplinary biomedical foundations curriculum based on organ systems	Implemented to some extent at roughly 25% of schools, although 2002 and 2009 surveys indicate desire to implement thematic, organ system curricula
Curriculum comprised of interdisciplinary learning modules that form a hierarchical pathway to attainment of competence	Not implemented at the level envisioned
Reduce number of courses from 60–80 at typical dental school to 20–30 “block” courses that integrate many smaller, low clock hour courses	Not implemented at the level envisioned; some course consolidation efforts, but often token in scope
All courses have case-based modules depicting oral health problems	Not a revolutionary prediction even in 1995; implemented at most schools
Biomedical science courses conducted by basic science-clinical science teams (i.e., team-taught)	Not implemented at the level envisioned
Less reliance on lectures and more reliance on small-group learning	Sporadic implementation; lecture still reigns supreme for courses outside of clinic; experimenting with small-group learning by a few teachers at many schools
Differential student progress through curriculum based on individual capacity, i.e., progress is “readiness-dependent”	Not implemented; all curricula remain lock-step, i.e., progress is time-dependent
Flat or horizontal curriculum in “platoon training” model to provide quick transition from preclinical lab to patient care versus 4–8 month delay	Not implemented anywhere as far as I know
Ten-week multidisciplinary module in areas where dentists and other health providers interact: ear, nose, and throat; oncology; hospital-based dentistry; pediatrics; and geriatrics (2-week rotations in each)	Not implemented anywhere as far as I know; some schools have selective opportunities to offer some exposure to medical-dental integrative experiences
Dental and medical students team up in patient screening where medical students conduct/teach H & Ps with dental peers who in turn conduct and teach oral assessment to medical partners	Not implemented anywhere as far as I know
Performance-based testing as ultimate measure of competence	Implemented extensively, driven by CODA; experimentation with alternative assessments
Dental students receive enhanced training in systemic health risk assessment and prevention	Implemented to some extent; more focus at most schools, although not at level envisioned in prediction
Provide extended patient care experiences outside of the dental school in-house clinic	Implemented at virtually all schools
Eliminate “requirement-driven” clinical education	Implemented to some extent at many schools, but numerical requirements are still evident
Clinical faculty function as coaches, role models, and mentors (i.e., as teachers) rather than as checkers, focusing primarily on grading	Implemented extensively; efforts to transition from checker/coverage to proactive teacher model at most schools
Patients are assigned to, and managed by, clinical faculty supported by teams of students, rather than primary patient management by students, often guided by their own needs	50% of schools have implemented a group practice model with elements of original proposal; schools are minimizing requirement-driven patient manipulation by students
Create national goal, with program collaboration, to graduate 25% of dental students with DDS-MPH by 2025	Not implemented

Sources: Hendricson WD, Kleffner JH. Curricular and instructional implications of competency-based dental education. J Dent Educ 1998;62(2):183–96; Hendricson WD, Cohen P. Future directions in dental school curriculum, teaching, and learning. In: Haden K, Tedesco L, eds. Leadership for the future: the dental school in the university. Washington, DC: American Association of Dental Schools, 1999:37–62; Hendricson WD, Cohen PA. Oral health care in the 21st century: implications for dental and medical education. Acad Med 2001;77(12):1181–206.

baker's dozen actions and reforms are similar to the predictions in Table 4 although the focus on blending dentistry more proactively into the mainstream of health care delivery and education is limited, information technology is emphasized, and the tone of the overall agenda is generally more pragmatic.

Based on the four data sources identified earlier, my personal assessment of the 2011 status of these baker's dozen reforms is that good progress (i.e., efforts are evident at a majority of schools) has been made on four items: numbers 1—review the curriculum; 4—evidence-based focus; 6—community-based education; and 7—comprehensive care model. Some progress (i.e., implementation at roughly 50 percent of schools) has been made on seven items: numbers 3—early patient care/clinic experiences; 5—group practice structure for clinical education; 8—use of IT (a discussion of curriculum integration of IT appears below); 9—eliminate requirement-driven clinical assessment; 11—assess students' capacity to use biomedical knowledge to solve patient care problems; 12—focus assessment on students' overall competence; and 13—collaborate with other health professions and emphasize systemic-oral health interactions. Based on my observations and interpretation of the literature, only minimal progress has been made, at the majority of schools, on two items: 2—meaningful blending of basic and clinical sciences, other than at several schools that historically have employed problem-based learning (PBL); and 10—eliminate smokestack, or silo, approach to curriculum. Overall, this is a more promising report card than the outcomes derived from Table 4, perhaps because the baker's dozen reform agenda is less aggressive.

From my perspective, the principle outcome from the 2009 survey of curriculum patterns and methods in U.S. dental schools, conducted by the Academy for Academic Leadership as an ADEA CCI project, was that the "pot was being stirred" in the form of active curriculum reviews by a majority of schools, expressed willingness to consider future reforms that extended beyond tweaking at the periphery, and reports of considerable curriculum experimentation, as well as a notable expansion of community-based education.[11] Taking the year 2000 as a starting point of the dental education reform advocacy period, coinciding with the issuance of the U.S. surgeon general's report on oral health in America,[17] one could conclude that the 2009 curriculum report was potentially a harbinger of future changes during the remainder of Mao's concept of the long journey to reforms that have "substance, consequence, and merit." Additionally, as described in other articles in this anniversary issue, several of the new dental schools are attempting to implement, or plan to implement, alternative educational models consistent with some of the Table 4 predictions:

Table 5. Advocated educational reforms for predoctoral dental curriculum

1. Review the curriculum in relation to the entry-level competencies needed by general dental practitioners to eliminate outdated and peripheral material.
2. Emphasize application of the basic sciences to patient care by problem-centered learning and other integrative methods to help students understand why they are learning this material and how it can be useful.
3. Expose students to patients and clinical environment from early in curriculum to the last week.
4. Increase emphasis on evidence-based dental practice and process of critical appraisal of evidence to instill a culture that values scientific inquiry.
5. Organize group practice teams in the clinic to promote continuity in faculty-student interaction and coordinate patient care and students' education experiences.
6. All students receive several continuous weeks of experience providing patient care in community clinics coupled with service-learning activities.
7. Seniors provide comprehensive care for at least a semester in a general dentistry model.
8. Use the capacities of information technology to enrich and diversify students' learning experiences.
9. Organize clinical education so patients' needs come first and students do not see patients as "a means to an end."
10. Eliminate the smokestack (silo) curriculum model by increasing coordination and collaboration among departments and providing interdisciplinary teaching.
11. Implement assessments for non-clinical courses that focus on ability to use biomedical knowledge to solve problems and measure students' capacity to explain systemic and oral disease pathophysiology.
12. Clinical evaluation methods focus on students' overall performance during patient care including assessment of patient needs, diagnosis, treatment planning, and professionalism and not just technical skills.
13. Increase educational collaboration between dentistry and other health professions, and emphasize interaction of dental and medical problems.

hybrid modular (e.g., block) curriculum structuring (Roseman and Western), reduced reliance on in-school patient clinics and more focus on community-based sites for clinical education (A.T. Still, East Carolina, New England), and extensive reliance on small-group, peer learning (Roseman).

Consider the Evidence I: Contributors to Success or Failure

By one often-used measure of educational effectiveness and efficiency, contemporary predoctoral dental education in the United States is remarkably successful. Student retention and attrition data compiled by the ADA indicate that 96 percent of all predoctoral dental students who matriculated into U.S. dental schools in 2004–05 graduated within five years of original enrollment and that approximately 92 percent of these students graduated in the minimum time possible: three years at the University of the Pacific and four years for all other programs. This is an outcome to be admired, and certainly a positive reflection on the several thousand hard-working dentist/educators who comprise the academy of the training arm of the profession. One of the foundations of educational research is to determine which attributes of the school environment and instructional practices are the most influential contributors to either success or failure. Given the efficiency of dental education in producing dentists, an analysis of causal factors is of interest for at least three reasons: to generate insights to share with other health professions education programs or other elements of higher education that may struggle with student retention; to guide the design of the new dental schools currently getting off the ground or being conceptualized; and in this era of dwindling financial resources, to pinpoint programmatic attributes that are essential to sustain versus those elements that do not contribute as directly to student retention.

So, let's say we are going to design this study. What would be our hypotheses to drive the research design? Let's write a fill-in-the-blank hypothesis: _______________ is associated with the 96 percent dental student graduation rate. Here are ten factors that potentially could be placed in the blank, selected from a large inventory of possible contributory factors:

1. Design of the curriculum—traditional 2X2 discipline-based versus an alternative model, such as PBL, thematic/integrative structure, combined D.D.S.-M.D. education, block scheduling (one course at a time structure), decentralized, community-based education, readiness-based/differential speed education.
2. Innovative teaching strategies employed by the faculty.
3. Structure and density of the curriculum including uniquely different scheduling formats as employed in other disciplines such as caps on lecture hours per day or per week or restriction of scheduled class time to mornings only. This factor includes many component variables such as contact hours per week, weeks per year, number of concurrent courses, number and concurrency of assessments, and number of hours per week of at-home study required for students to keep pace.
4. Degree of risk the school is willing to accept in the student admissions process and the degree of proactivity in seeking alternative candidates from among underrepresented minority groups and other non-traditional sources of students.
5. Innovative strategies to cultivate and support students' capacity for self-directed learning (so they can succeed no matter what quality of instruction or learning environment they may encounter).
6. The school's level of support and assistance for struggling students, including innovative approaches to remediation or early detection of at-risk students.
7. Innovative educational resources, e.g., high-tech simulation labs, digital curriculum/laptop programs, online courses and resources, digital libraries such as VitalSource Bookshelf.
8. Use of innovative, alternative assessments such as portfolios, objective structured clinical examinations (OSCEs), Triple Jump, 360 Degree, and Spotlight Exams.
9. Unique or alternative grading systems including pass/fail.
10. Innovative ways of grouping students and faculty into teams or colleges to enhance student-teacher continuity and level of interaction.

Each of these items could form a plausible hypothesis related to factors that may be causally associated with dental school graduation rates. The problem is that graduation rates are uniformly high for virtually all U.S. dental schools, which renders moot the viability of comparing schools with or without the above factors, either individually or in combinations. Very high percentages of students graduate from most U.S. dental schools whether or not certain factors play a small or large role at individual schools. Some of these factors are difficult to measure or link with confidence to an outcome, and many others cancel each other out. For example, dental school teachers can be individually or collectively innovative and effective in the classroom, lab, or clinic, but their exemplary coaching and mentoring efforts can be completely overwhelmed by a "competitive curriculum" (more about this below) that diverts students' attention, overwhelms their ability to study coherently, and forces them to backburner certain courses and other learning experiences.[3]

Given that virtually all students graduate on schedule or shortly thereafter, it is understandable why academic program managers might conclude that "frills" are not needed (e.g., any item in the preceding list identified as innovative, unique, alternative, or risky). On the other hand, academic managers in dental schools have spent millions of dollars on various forms of information technology (IT) and elaborate preclinical simulation labs without any consistent evidence that either of these innovations increases the likelihood of producing even higher graduation percentages—which, in reality, will be very difficult to accomplish given the twelve-foot ceiling already established in the dental school house. Of course, much of the expenditures for IT and laboratory training devices have been to upgrade and replace aging equipment with "better mousetraps," much as I am contemplating replacement of my banged-up 2003 Chevy Tahoe with a less clunky 2012 alternative. Both replacements are reasonable responses. However, my sleek new 2012 vehicle will not have a different function than my old Tahoe: it will primarily transport me between home and work and provide "wheels" for weekend errands. It will not transform the nature of my movement from place to place, although the ambiance may be nicer, or dramatically improve travel time or the frequency of my appearance at the university; other factors will determine those outcomes.

Collectively, these ten factors, which are representative of many other potentially contributory variables, represent the primary direction of the research agenda over the past thirty years related to the effects of educational environment in professional education. Unfortunately, because of the large number of intervening and confounding variables that influence both teacher and student behavior in any educational setting, definitive answers are few and far between for these issues, and guidance is elusive for predicting future patterns. For example, the Best Evidence in Medical Education (BEME) project has produced numerous systematic reviews of the evidence related to various aspects of health professions education in an effort to improve educational practices and build a culture among faculty members that is supportive of best evidence approaches related to educational issues. The BEME is an ad hoc international organization of health professions educators who share a mission to move education from "opinion-based education to evidence-based education."[18] For all but a handful of these systematic reviews, the bottom line conclusion from study teams was that available evidence was mildly suggestive of a positive effect for the technique or factor under consideration, but the body of evidence was not of sufficient quality, due to research design deficiencies and/or a dearth of studies with meaningful outcomes, to form a conclusion or make recommendations.

As an aside, the BEME collection of systematic reviews is a terrific resource for health professions educators because these critical appraisals of the evidence apply to educational issues that are germane to all disciplines. Readers are encouraged to visit the BEME website at www2.warwick.ac.uk/fac/med/beme/ (accessed October 3, 2011). Copies of BEME Reports are available from Association for Medical Education in Europe, Tay Park House, 484 Perth Road, Dundee DD2 1LR, UK. The Association for Medical Education in Europe (AMEE), which sponsors the BEME series, also has produced nearly fifty AMEE Guides on a wide range of educational methodologies including such topics as learning in small groups, portfolios for learning and assessments, use of real and simulated patients in clinical assessment, personal learning plans, effective clinical supervision, evaluating educational programs, and many other topics of relevance to dental educators. The AMEE Guides combine summaries of the research evidence pertinent to each topic with best practice recommendations for implementation. These guides are also an excellent resource; an inventory of the guides and purchase information can be accessed at www.amee.org (accessed October 3, 2011).

The BEME group, along with other investigators conducting systematic reviews of educational/training interventions, have used Kirkpatrick's hierarchy of educational outcomes (Table 6) as the framework for classifying and analyzing findings.[19] Kirkpatrick's model has five levels of educational outcomes: 1) the learner's *reaction* to the educational experience (opinions and perceptions); 2) *indicators,* which include changes in attitudes, intentions, and confidence; 3) *learning,* which includes short-term changes in knowledge and skills; 4) *behavior,* which includes changes in practice (i.e., modifications in methods); and 5) *results,* which refer to changes in the practices, policies, or infrastructure of the overall organization and/or changes in the practices/behavior of the students or colleagues of a individual who participated in a training program. Kirkpatrick's model is considered the optimal hierarchy for planning assessments of the outcomes of educational interventions and analyzing the results. As discovered by the BEME group and others, most educational outcome studies limit assessment to levels 1 and 2, and occasionally level 3, and thus fail to generate data that allow "attribution" linkage of an educational innovation (i.e., use of haptic technology to explore human anatomy or practice dental surgery) to altered practice among training participants (level 4, behavior) or macro-level systemic changes that are "transformative" in nature (i.e., stimulating many instructors at a school to create learning experiences that utilize information technology, or converting a large section of the curriculum to online learning), reflecting level 5, results.

The Strength of Recommendation Taxonomy (SORT)[20] is often used to depict the quality of research evidence in both clinical and educational research. If the SORT system (Table 7) was applied to the bulk of the BEME data and other systematic reviews of educational methodology in the health professions, the evidence and associated pedagogical recommendations would grade out at the lowest level, C, which consists of expert opinion, consensus opinion, usual practice heuristics, indirect or surrogate indicators, case series data, and "happiness index" data (participant satisfaction, Kirkpatrick's level 1). Given the limited predictive guidance that can be derived from macro-level (institutional systems) research concerning variables that may contribute to the productivity outcome (e.g., the 96 percent graduation efficiency), there has been a natural human inclination to stick with the status quo when things are apparently going well. On the other hand, there are dental educators who argue that we are looking at misleading outcome measures or at least an insufficient array of outcomes. Are dental schools graduating an entry-level professional with a skill set, professional goals, and/or perception of roles and responsibilities that match up with the oral health needs of the entire spectrum of our society? Or, as some contend, are the outcome measures commonly used to determine readiness for graduation fundamentally flawed, leading to "false positive" assessments of

Table 6. Kirkpatrick's hierarchy of educational outcomes and types of evidence

Outcome Level	Types of Outcome Evidence
Results: changes in practices, policies, or infrastructure of organizations	Evidence of transformative changes that have impact throughout an organization that are attributable to the training intervention.
Results: changes among students, residents, or colleagues of a training participant	Evidence of improvement in student or resident learning and performance that can be directed attributed to an educational intervention, or improvement in colleagues' performance that is attributable to the education intervention.
Behavior: changes in behavior of individuals who participate in an educational intervention	Evidence that training participants have capacity to transfer newly learned skills into the workplace. Measured by observation and audits of performance in actual on-the-job work conditions.
Learning: modification of knowledge or skills	Evidence of the acquisition of concepts, procedural/psychomotor skills, and social or communication skills. Measured during the training program or shortly thereafter.
Indicators: change in attitudes, intentions, and confidence	Evidence of changes in the attitudes or values among training participants; also includes changes in a training participant's intention to use a skill in the future or confidence in using a skill.
Reaction: participants' satisfaction with training	Training participants' views and perspectives on the learning experience: its organization, presentation (delivery), content, learning methods, and overall quality of the training experience.

Table 7. Strength of Recommendation Taxonomy (SORT) grades

Strength of Recommendation	Characteristics of Available Evidence
A	Consistent evidence, good-quality and appropriate study design, learner/provider/patient-oriented evidence that measures outcomes that matter to the target of the training intervention such as providers or teachers. Outcome data are tangible, are reported in understandable ways, and are direct measures of the provider or teacher behavior or performance, not indirect or surrogate.
B	Inconsistent evidence and/or limited quality study design and evidence that consists of indirect or surrogate measures of the outcomes and other methodology deficiencies.
C	Evidence consists of expert opinion, consensus opinion, usual practice heuristics, indirect or surrogate indicators, case series data, participant satisfaction data, attitude, intention to change/use, or confidence data.

students' capacity for independent dental practice and thus leading to inflated graduation percentages? Still others contend that the journey through dental school is not enjoyable, leaving graduates disillusioned with the educational process and harboring negativity toward the school. But these are discussions for a different day and a different article than this one.

Research efforts have largely failed to document the effectiveness of new and alternative ways of implementing health professions education to resolve perceived problems in a single stroke, as if with a miracle drug, with strategies that are so uniquely different that they require transformative change. However, the situation is not as gloomy as it might seem. One positive by-product of our search for the miracle educational drug is enhanced awareness of optimal strategies for designing educational research in the future. For example, two solid resources in the dental education literature that provide guidelines for conducting educational research that have potential to produce outcomes higher up Kirkpatrick's hierarchy are Schleyer and Johnson's heuristics for information technology research[21] and Eva's review of factors to consider in conceptualizing studies that explore effects of instructional strategies.[22] In addition, Meadows et al. reviewed best practice approaches for designing and implementing mixed method research involving qualitative approaches.[23] The BEME and AMEE series also include several useful guides for designing research to explore teaching and learning issues.

Consider the Evidence II: Micro-Level Techniques

We cannot readily determine what factors contribute to the overall, macro-level effectiveness of predoctoral education in providing students with an on-time departure time for their post-dental school endeavors. But there is ample evidence from the professional education sector, military training, and industry to support the educational value of several techniques that dental school teachers can implement at the micro level (at the intersection of teachers and students in classrooms, labs, and clinics) as summarized in the following, derived from a 2006 review of educational strategies pertinent to predoctoral dental education[24] and other sources.

Universal Best Practice Principle

There is an evidence-based, universal principle of learning that provides the foundation for educational best practice, no matter what type of knowledge or skill that students are attempting to acquire. Communicating information independent of the context in which it will be applied is a suboptimal educational strategy and leads to transitory, short-term retention of concepts and skills. Communicating information in an appropriate context, however, with high situational fidelity to the circumstances, environment, and problems encountered in actual task performance, enables students to better retain key concepts and understand their relevance to the profession/discipline that the student hopes to join after training.

Notably, for a surgically based profession such as dentistry, task performance improves when foundational information pertinent to the task is communicated in the context of problems, situations, and work setting (i.e., situated learning) in which the information/skills will be used.[25-29] All educational strategies need to be grounded in this basic principle as a starting point.

Best Practices for Facilitating Different Types of Learning

Cognitive psychologists categorize knowledge into 1) declarative knowledge, 2) procedural knowledge, and 3) a gray zone blending declarative and procedural knowledge that includes reasoning skills such as the capacities to recognize, appraise, and resolve problems often lumped under the term "critical thinking."

Declarative knowledge. Declarative knowledge consists of two memory components. The first is explicit memory that is overtly retrieved by sending a request for information access to the brain. This is known as "dial-up" knowledge as in dialing a phone as the first step in sending a message. Explicit memory includes memories that contain factual data such as names, places, dates, terminology, and past events that an individual has personally experienced, which may have emotional components. Seven educational strategies are associated with establishment of explicit knowledge: 1) communication of learning objectives for each class session; 2) organization of the subject matter in a manner that makes sense to the learner rather than in a manner that makes sense to the subject matter expert; 3) frequent in-class activity such as writing notes, analyzing problems, or answering questions; 4) use of mnemonics to aid memorization of factual information; 5) frequent in-class quizzing with immediate feedback on response correctness; 6) rehearsal opportunities that allow students to make decisions using newly acquired information; and 7) summary of key points to remember ("take-home messages") at the end of each lesson.[30,31] A number of these strategies (items 3–7) are intended to help students convert static factoids into usable knowledge, in a cognitive process known as encoding—e.g., making it your own by combining new information with what you already know and by reflecting on the meaning and value of the new information. Encoding is the critical cognitive portal by which information, briefly held in working memory for no more than a few seconds (under ideal, distraction-free conditions), is incorporated into long-term, sustained, and retrieval memory.[32]

The second aspect of declarative knowledge is generalizable rules that guide an individual's behaviors. These rules are embedded in subconsciously retrieved memory, known as implicit memory, so that the guiding action happens automatically without overt thought, in other words, "functioning on automatic pilot" (i.e., memory of previous experiences assists or guides task performance without conscious awareness of these previous experiences).[33-39] Implicit memory is known as pop-up memory because these guiding rules literally "pop" into consciousness without active retrieval when a person recognizes certain cues. Implicit memory consists of experiences that influence our current behavior—for example, memory of how a difficult restoration was successfully managed on a previous patient. Implicit memories are subconsciously blended into our thought formation and, if employed frequently, become instantly available. If not triggered frequently, it's "use or lose it." Implicit memory is comprised of mental skills that are necessary for expert-level thinking: subconscious pattern recognition based on multiple prior exposures to similar stimuli, coping and adapting responses (successful actions used in the past when specific stimuli are encountered), mental vigilance for cues that indicate a coming event, rapid recognition of deviations from normal patterns, and ability to look forward to envision, even predict, likely problems and outcomes. The last three capacities (cue vigilance, deviation recognition, future vision) are cornerstones of expert performance.[40] Five strategies promote the development of implicit (pop-up) memory: 1) simulations in which students apply decision making for both well-defined, frequently seen problems and ill-structured, rarely encountered problems; 2) prospective simulations in which students practice anticipatory guidance by analyzing scenarios to predict likely problems and then develop coping strategies; 3) retrospective critique of case scenarios in which actions are reviewed to identify errors as well as exemplary performance; 4) self-assessment of performance in comparison to best practice benchmarks; and 5) written or verbal reflection on the meaning of experiences, especially how to avoid errors.[31,37-39]

Procedural knowledge. Procedural knowledge is a "doing" component of implicit memory. Implicit learning, via techniques identified above, is essential to the development of any motor skill. Procedural memory is established through repeating a complex activity until our brain determines, through the corrective guidance acquired from trial and error and successive approximation in pursuit of an ideal (i.e., a performance standard), how to connect the necessary neural systems to automatically produce the activity.[41,42] Procedural knowledge is divided into discrete (isolated action) performance and continuous action performance. Discrete procedures have discernible and predictable start and stop points, conveniently measured outcomes, and a number of steps that do not tax memory limits (three to seven steps). Continuous procedures involve an ongoing series of actions that must be coordinated with environmental monitoring: driving a car, or in dentistry, precise placement and movement of the high-speed handpiece, often with indirect vision via a mirror. Multiple senses are employed to "read" the environment during continuous procedures, and the metacognitive centers of the brain are critical to success. Metacognition is the process of internal self-review that allows an individual to assess how things are going and modify actions based on this personal environmental scan.[43] Ten strategies, implemented in a mostly linear sequence and based on three skill acquisition phases (*cognitive:* learn skill components; *associative:* successive approximation practice, as in learning to associate specific maneuvers with outcomes; and *autonomous:* refining and perfecting) help individuals develop procedural skills:

1. Conceptualization: why, when, contraindications, ideal outcome, range of acceptable outcomes, precautions.
2. Visualization: see skill demonstrated start to end at learning time pace.
3. Verbalization: narration of steps and tasks by demonstrator; return narration by the learner during trial performance.
4. Practice supported by timely coaching and feedback.
5. Self-assessment by learner.
6. Immediate correction of skill errors.
7. Fidelity to on-the-job (OTJ) working conditions (authentic setting for learning).
8. Practice under less than ideal conditions.
9. Mastery learning: criterion based assessment; high standards for "pass."
10. Rapid application of skill in work setting (quick translation from simulation training to actual skill performance).[44-48]

Putting them together. Putting these educational techniques all together, what are the best evidence strategies for cultivating students' critical thinking, soon to be emphasized with renewed vigor in the revised CODA predoctoral education standards that go into effect July 1, 2013? Six interrelated educational strategies are associated with the maturation of critical thought processes in adult learners and are also important for the associated capacity for self-directed learning (SDL). The cornerstone is providing students with frequent opportunities to use the reflective judgment process (summarized below) to analyze biomedical problems and seek answers to unknowns and uncertainties that arise during patient care, first in scenario-based simulations and then in debriefings of actual patient care events in the clinical phase of training.[49-53] The data seeking and analysis required to accomplish the reflective judgment process facilitate students' acquisition of SDL skills through learning by doing. Students who routinely use this process to explore problems, presented in various forms of simulation and also via problem-centered learning processes, develop more sophisticated SDL than do students in lecture-based curricula.[54-56]

The components of the reflective judgment process are as follows: identify the issues and facts in a problem or dilemma; identify and explore causal factors; retrieve and assess knowledge needed to appraise response options and guide actions; compare the strengths and limitations of options; skillfully implement the option most likely to resolve the problem; monitor implementation and outcomes and modify the strategy/action as needed; and finally, candidly appraise the outcomes of actions, both positively and negatively. In addition to learning experiences that require application of reflective judgment, five other educational strategies are associated with enhancement of critical thinking: 1) frequent use of questions by instructors that require students to analyze problem etiology, compare alternative approaches, provide rationales for plans of action, and predict outcomes; 2) listening to the reasoning of expert practitioners as they talk through and visually diagram their approaches to analyzing and solving problems; 3) comparing data searching steps, strategies implemented, decisions made, and outcomes to that of expert practitioners who work through the same case scenarios; 4) writing assignments that request students to analyze problems by discussing theories about causal factors, compare alternative solutions, and defend decisions about proposed actions; and 5) mentoring, over extended time, by an expert practitioner who role-models clinical problem solving and guides the learner's refinement of reasoning through feedback and case examples.[24,57-60]

Take-Home Message

If we desire predoctoral teaching/learning to be more firmly grounded in evidence, future reform initiatives in dental education might be more productive when focused at the micro level (the intersection of students and teachers) rather than at the macro level (trying to alter major institutional processes in transformational reforms such as overall design of the curriculum). These micro-level educational enhancement initiatives should focus on expanding application of foundational principles of learning and maximizing use of the educational best practices described in the preceding synopsis. No matter what the educational format (lecture, demonstration, small-group conferences, case-reinforced learning, online modules, laboratory exercises, self-study, simulations, or supervised patient care experience), the foundational educational strategies described for contextual/situated learning, explicit, implicit, or procedural knowledge, critical thinking, and self-directed assessment should guide design of students' learning experiences. Instead of racing to identify a winner when comparing teaching/learning formats, we should be racing to determine how best to incorporate educational best practices into standard teaching/learning formats in an effort to find the perfect intersection of motivated teachers and students, effective educational methods, and a positive, supportive learning environment.

Consider These Educational Strategies

Here are my recommendations for four not-so-new teaching/learning methods and other reforms that are still worthy of consideration within dental education. I will start with the most enduring (oldest) of the so-called "new" ideas about educational strategies in dental school. These not-so-new ideas are 1) let the biomedical sciences tell their story; 2) make online learning an entree instead of a side dish on the curriculum menu; 3) utilize virtual reality, haptics, and all that jazz—where information technology meets its promise; and 4) use evidence for teaching evidence-based practice. As an aside, we need to stop referring to ideas that have been with us for thirty to forty years as new, innovative, or unique or as reforms.

Let the Biomedical Sciences Tell Their Story

In the process of consulting with dental schools over the past thirty years, I have interviewed hundreds of community practitioners (all of whom are dental school alumni, or so I hope), analyzed survey data from thousands of dental residents and soon-to-graduate seniors who were requested to look back at their education, and conducted focus groups and other data-gathering activities with countless other current and former students. Practitioners, residents, and current students have a consistent vision of how they, from an educational consumers' perspective, would like to see the biomedical sciences structured. This vision is markedly different from what most of these individuals experienced in dental school. The vision that I have heard repeatedly for thirty years reflects one of the major tenets of human learning: people at all ages remember information embedded in stories better than they remember isolated facts communicated to them without the framing and situational context of a story.[61]

In contrast to the discipline-specific, or silo, approach still used at many dental schools for communicating biological principles, dental school graduates prefer what they frequently called a "lined-up" curriculum that coordinates morphology, anatomy, physiology, pathology, and treatment both for the head and neck region (craniofacial) and for the organ systems of the human body into a coherent story.[8] Such a curriculum is arranged horizontally as depicted in Table 8 by interconnected topics arranged like chapters in a novel, each moving the story of the system forward and progressively embellishing the learners' understanding of the plot. For example, chapter one: development (introduction of the characters and how they developed; i.e., growth and development of structures of the human body); chapter two: specification of different structures and systems (what are they? where are they? how do they interact?); chapter three: normal function (what do they do and how do they do it?); chapter four: principle disorders (protagonists and villains appear; introduction to pathology); chapter five: clinical presentation (the plot unfolds and bad things happen; what are the main symptoms and manifestations of disorders?); chapter six: pathophysiology (how do the villains alter function and why?); and chapter seven: therapy (the hero intervenes; how are disorders treated?).

Typically, this thematically integrated structure for the biomedical science foundations of dental practice is described as an organ system model or a systems approach.[62,63] Virtually all U.S. medical schools have implemented an approximation of the systems model (e.g., thematically integrated versus purely discipline-based courses) for the biomedical sciences.[64] In contrast, integrated basic science curricula in U.S. dental schools are still rare, even though Haden et al. reported that a majority of academic deans in 2009 desired to implement this curriculum format and there has been some experimentation in this area.[11] With the advent of a blended National Board Dental Examination looming on the horizon, I think it represents educational malpractice not to prepare dental students by means of educational strategies that promote learning in a story format and provide an integrated learning experience. Note that dental students should experience a distinct course devoted to the orofacial region, also following the organizational framework depicted in Table 8.

Make Online Learning an Entree Instead of a Side Dish

My colleague at UTHSCSA, Dr. Ed Wright, has described electronic curricula (e-curricula or e-learning) as computer-assisted learning including educational materials available to students by CD or DVD; online courses and web mechanisms used to search the literature; electronic systems used to enhance academic programs such as e-mail; online testing and course evaluations; and various applications of information technology including providing laptops to students, multimedia projection systems, and Internet-compatible, wireless classrooms.[65] Table 9 provides a summary of the proposed advantages of e-learning.[66-68]

From my perspective, there are two levels of information technology that can be used for educational purposes: 1) low-complexity information technology (LIT), in which program development protocols are often accessible to the general public and usable by nonprofessionals, and 2) high-complexity information technology (HIT), such as virtual reality, three-dimensional, and haptic (tactile) simulators, discussed in the next section of this article, in which development capacity is beyond the reach of the general public. Today, LIT in higher education primarily includes online learning modules and interactive modules accessible by DVDs. In 2011, if you gather any group of ten dental students, there likely will be at least one or two who will know how to create websites and do other background programming or use paint-by-numbers protocols to create relatively sophisticated online learning modules and online testing mechanisms—a testimony to the pervasive infusion of IT capacities into the general public, especially among individuals aged twenty-five years and younger.

Numerous educational trials have been conducted in health professions education to evaluate student learning via LIT such as online learning modules/courses in comparison to traditional lecture-based instruction and other standard educational methods. The most typical finding is that students can learn equally well by either method if the online modules includes a substantial degree of learner control,

Table 8. Schematic of "lined-up" seamless curriculum structure

First Year				
System	Development	Structure	Normal Function	Principle Disorders
Cardiac GI Hematologic Pulmonary Renal Etc.	Embryology Morphology	What and where is it?	What does it do? How does it work?	What goes wrong? Basic mechanisms of disease
Second Year				
System	Presenting Health Problems	Clinical Presentation	Pathophysiology	Therapy
Cardiac GI Hematologic Pulmonary Renal Etc.	Main disorders per system "Begin with the Problem"	Symptoms Manifestations Lab studies Images Examples Variations	Etiology of breakdowns and triggering factors Cell to gross	Tx options Complications and constraints Outcomes Prognosis EBP

such as making treatment decisions in a patient care scenario or analyzing sources of problems in a dental procedure and identifying solutions.[69,70] Yet faculty have been hesitant to use online learning as a primary educational format for a variety of reasons, instead relegating LIT to the side dish section of the curriculum menu, primarily as an adjunctive resource.[66,71,72] My message regarding this educational methodology is brief: it's time we moved online learning from the side of the menu to the entree section. For a curriculum that is desperately overloaded with in-class contact time (dental students graduating in 2009 had spent nearly 2,000 hours sitting in lectures during their dental school careers: 40 percent of the curriculum[73]), more extensive use of online learning seems like a no-brainer to tap into Gen Y students' proclivity for ATAW (anytime, anywhere) access to educational materials.[74] My experience is that dental schools have numerous students with capacities to develop LIT and many who are quite eager to collaborate with faculty on developmental efforts.

Utilize Virtual Reality, Haptics, and All That Jazz

This section deals with the other end of the sophistication spectrum: high-complexity information technology (HIT), in which development is limited to individuals with specialized skills that have not yet been infused into the general population. HIT primarily involves haptics, three-dimensional representation systems, virtual reality simulation, and combinations of these formats. Haptics is the science of applying touch sensation and movement control to computer applications to allow users to "feel" what is pictured on a computer screen, often using simulated dental instruments to cut or move tissue in simulated treatment procedures. The Colleges of Dentistry and Engineering at the University of Illinois at Chicago collaborated to develop a simulator called PerioSim that uses haptic virtual reality technology to allow dental students to guide a stylus on screen that resembles an explorer. Students can feel lifelike tactile sensations as they navigate through patient examination and prophylaxis procedures.[75]

My ability to discuss the technical nuances of HIT is limited; however, I am not a complete neophyte in application of HIT to dental students' learning. I wrote a grant proposal seeking start-up funding for a virtual reality training system for dental students with a haptic component in 1986, twenty-five years ago (yes, this technology was available back then, albeit in crude form) and later in the mid-1990s was a co-investigator on a project that investigated use of haptics in the teaching of anatomy and oral surgery (fifteen years ago). One of my first publications in the *JDE* dealt with a computer-based learning device that allowed dental students to observe video clips of dentist-patient interactions, propose strategies for the dentist to follow, and via a branching system, allowed students to see what happened if their recommendations were implemented—an unsophisticated HIT application by today's standards, but surprisingly effective as a learning tool, even if the computer was an Atari![76]

Most of the educational best practices described above center on various forms of case/situational analysis, clinical decision making, and critical appraisal of actions and evidence. The breakthroughs in HIT now make sophisticated levels of learner control very feasible, mimicking the wildly popular computer games dominating the home entertainment industry. These learner control capacities provide considerable potential to develop realistic and engaging simula-

Table 9. Proposed educational benefits of e-learning

- Enhances student enthusiasm and motivation
- Enhances anytime, anywhere access to educational materials by students
- Improves learning outcomes
- Increases speed of learning
- Increases efficiency and effectiveness of students' study habits
- Increases student control over the pace and sequencing of learning
- Stimulates teachers to make courses less lecture-based and more problem- or issue-centered
- Improves communication and sharing between teachers and students and among students
- Provides students with a portal to all materials in one interactive system
- Provides students with better imagery and visualization
- Allows high-fidelity simulations
- Allows students to actively engage with content by making decisions and receiving feedback on the accuracy and consequences of these decisions

tions that can trigger the types of learning activities associated with acquisition of pop-up knowledge and critical thinking.[77,78] A brief synopsis of the online and virtual reality case-building capabilities available to dental faculty members follows.

Types of educational simulations. There are four basic formats of computer-based patient simulations used for educational purposes. Issenberg et al. provide a nice review of simulations pertinent to the health professions and also summarize the available high-quality evidence concerning learning outcomes from these simulators in BEME Systematic Review Number 4.[79] First are online or computer-based (DVD) simulations that do not provide animated patients, but allow simulation users to request and review various types of data pertinent to the patient's condition, make a wide range of inquiries, make decisions, and receive feedback and information about consequences and outcomes of therapeutic actions. These are typically called interactive patient simulations (IPS). Second are virtual patient simulations, constructed by techniques employed in the gaming industry (think "Grand Theft Auto" or "Madden NFL") that allow animated patients, to some degree, to interact with simulation users and respond to users' inquiries and decisions. These simulations are usually called Virtual Patients (VPs) or Virtual Interactive Patients (VIPs). VPs are discussed in more detail later in this section. Third are patient scenarios that are provided to students via a combination of media, typically including videotaped scenarios displaying a patient who is encountering some type of health problem, coupled with online or computer-based simulations (as described above) that allow the user to "manage" the patient's medical care. The fourth format is patient simulations that employ mannequins that can be programmed to display symptoms of medical conditions and physiological responses to assessments and treatment (pulse at various anatomical locations, respiration, blood pressure, cardiac rhythms, breath sounds, fluid volume, EKG patterns, etc.).

Medical and nursing education, as well as emergency health services, have for years used evolving iterations of *SimMan* developed by Laerdal. The current version, *SimMan 3G*, is a life-size and animated mannequin that portrays various physiological functions and simulates a variety of medical conditions. *SimMan* can be programmed to respond to users' actions in various ways by manipulation of physiological parameters. The *SimMan* website is at www.laerdal.com/document.asp?docID=33199898 (accessed October 3, 2011). The American Heart Association Advanced Cardiovascular Life Support (ACLS) course uses *SimMan* in scenarios for candidates to assess and manage at testing stations. The ACLS *SimMan* scenarios contain more than thirty patient cases that address core learning objectives of the ACLS course. ACLS also uses mixed media simulations in which course participants observe videotaped patient scenarios and then make assessment and management decisions via computer or on the *SimMan*. Mosby JEMS created a series of ACLS linked patient simulations in the VPE format for EMS personnel available at http://evolve.elsevier.com/staticPages/i_vpe_als.html (accessed October 3, 2011).[80]

Case-builder systems for patient simulations. There are numerous case-builder (case-authoring) systems available for educational simulations in the IPS and VP formats in other health professions, yet none currently exist in dentistry that I can identify. These authoring programs provide a "plug-in" template and authoring protocol in which faculty/practitioners can insert text, various types of images, patient records, photographs, video of patients, illustrations, animations, and lab data to build online simulated patient cases. These cases are designed to allow students (or practitioners in CE and certification courses) to practice patient assessment, diagnosis, and treatment planning or to demonstrate competence in these skills. Typically, the simulated patient cases provide guiding questions, scenario branching based on decisions, feedback about decision correctness/accuracy, display of consequences of actions, presentations of outcomes/prognosis, and pre- and post-testing of case-related knowledge. Most authoring systems allow case developers to embed links so students can access information resources pertinent to components of the patient's condition. The design of the case can be manipulated in some instances, or case authors can select a particular design from a menu of options.

Several organizations are developing specifications for IPS and VP cases, templates for case authoring, and formats for creating cases that can be easily shared across computer platforms. The most prominent of these organizations are MedBiquitous (UK),[81,82] CAMPUS (Germany),[83] and Web SP (Sweden).[84,85] MedBiquitous has seventy-five member organizations including the Association of American Medical Colleges, National Board of Medical Examiners, and U.S. Department of Veterans Affairs. Related to the development of virtual patients, the European Union has established E-VIP (Electronic

Virtual Interactive Patients) to create a bank of multicultural and multilingual virtual patient cases from across health professions schools in Europe that are available in formats that can be disseminated and used without technological barriers to access.[86]

Virtual patients. A virtual patient (VP) is an interactive computer simulation of real-life clinical scenarios for the purpose of medical training, education, or assessment. VP simulations employ computer-generated images, other animation techniques, and programming to allow interactivity and responsiveness to create patients who can move, respond to questions, portray emotions, and in some cases, recognize speech and respond in natural language. An Internet search conducting while writing this article revealed dozens of medical school and other health professions education websites describing development of VPs.

Several U.S. dental and medical schools are creating VPs that allow students to interact verbally and/or by touch screens with computer-generated patients who can respond in natural language to students' inquiries.[87-90] At the University of Southern California (USC), the School of Dentistry and School of Engineering are experimenting with creating dental patient cases in the virtual community Second Life.[91] Virtual patients created at USC respond to 400 questions and can portray more than a dozen craniofacial and systemic disorders. The USC School of Medicine and USC Institute for Creative Technologies have also collaborated to create animated virtual patients to help medical students practice interviewing, assessment, and diagnosis.[92,93] At Case School of Dental Medicine, Dr. Kristin Victoroff directed a project in conjunction with the Virtual Immersion Center for Simulation Research at that university to create virtual patients, also in Second Life, to help dental students learn communication skills and patient interviewing techniques. The project was funded by an ADA Innovative Dental Assessment Research and Development Grant.[94] Phillips and Berge[95] provide a good review of potential applications of Second Life VR technology for dental education and describe a number of projects at dental schools using virtual patients.[96,97]

Computer-based simulations that provide students with the learner control capacity to respond realistically to inquiries, decisions, and actions are extremely complex and time-consuming to construct, even with case-building software.[98,99] However, a potentially perfect intersection now exists between best practice educational strategies and HIT capacity to produce sophisticated patient care simulations that, with resources, could approximate the sophistication of the video game industry, but for educational purposes.

Use Evidence for Teaching Evidence-Based Practice

Several systematic reviews of teaching methodologies for evidence-based practice (EBP) have reached similar conclusions: that the teaching of EBP needs to be hands-on with incorporation of EBP training throughout the curriculum but focusing on the clinical setting. These findings are consistent with research demonstrating the power of contextual/situated learning. Coormarasamy and Khan concluded, "It is important that teachers of critical literature appraisal and evidence-based medical practice consciously find ways of integrating and incorporating the teaching of critical appraisal into routine clinical practice."[100] In spite of the findings from these systematic reviews, other reports indicate that health professions educators still primarily restrict EBP training to classroom exercises rather than more authentic learning experiences pertinent to patient care.[101-103]

As many readers may recognize and may have personally experienced, an EBP course taught by lecture may not be the most scintillating component of the curriculum, if not downright dull. However, the teaching/learning of EBP is a prime candidate for many of the active learning strategies identified in Tables 1–3 and provides an opportunity for the perfect intersection of teacher and student capacities to occur. It has been my extremely good fortune over the past four years to be involved in an initiative to create a dynamic, multifaceted approach to teaching EBP led by Dr. John Rugh at San Antonio. The following synopsis illustrates how active contextually based learning can be used to create a robust catalyst for student learning and also to promote student and faculty collaboration on educational tasks.

UTHSCSA CATs initiative. The UTHSCSA Dental School recognized the need for new learning approaches to enhance students' capacity in critical appraisal and develop their appreciation and readiness for lifelong learning after graduation. To accomplish these goals, the school implemented an initiative on Critically Appraised Topics (CATs) with the support of a National Institutes of Health R-25 Educational Research Grant (NIH R25 DE018663).[104,105] The aim of CATs is to teach lifelong learning and critical thinking skills that students can apply during their practice career. The approach involves collaborative student and faculty preparation of CATs, the establishment of a searchable online database of these CATs, and an academic detailing outreach program to connect the Dental School and its students to dentists in the community. The initiative provides a mechanism whereby clinical and research faculty members, residents, and alumni in private practice collaborate on the common task of establishing the best possible answers to clinically relevant questions.

During year two of the curriculum, the Evidence-Based Practice Course, which was converted from a lecture-based course to a hands-on and project-oriented course, provides dental students with the foundational skills for evidence searching and appraisal necessary to keep up-to-date and critically evaluate emerging knowledge during their professional careers. These skills, which comprise the heart of the CATs process, are the ability to 1) formulate focused questions based on uncertainties in patient care, 2) search the literature, 3) critically read and evaluate various sources of evidence (articles published in the dental and medical literature, advertisements, Internet sources, and information presented in continuing education programs), and 4) make judgments about the applicability of the knowledge to patients and other clinical problems. These four skills are taught, practiced, and evaluated in the context of the students' primary objective in the EBP course: learning how to write CATs summaries. For the final examination, students write CATs based on evidence search and appraisal for cases provided to them. Figure 1 displays the format of a CAT summary and indicates evaluation criteria. CAT exercises occur in clinical didactic courses during year 2 and in the students' clinical activities embedded in the clinical practice teams in years 3 and 4. Third- and fourth-year students make CAT presentations, in PowerPoint format, based on patients they have treated. These CAT presentations occur during clinical teams' case conferences where students and faculty analyze the evidence and conclusions for each CAT presented.

The training of faculty in EBP and CATs skills is a key component of the initiative. Over 80 percent of the faculty received training in the past four years, and seventy-eight faculty members now annually supervise the development of CATs by students. In the spring semester of year two, students develop CATs under the guidance of faculty mentors in an Evidence-Based Practice Module that is a component of the students' Clinical Introduction course. During this activity, student and faculty teams develop a focused clinical question using the PICO (Patient/Problem, Intervention, Comparison, and Outcome) format and then students conduct a search for best available evidence and write a CAT summary. During the same semester, students also participate in an EBP OSCE that assesses their ability to use appropriate PubMed search strategies to find the best evidence needed to answer a clinical question. During the OSCE, students are provided two clinical scenarios and corresponding PICO questions. Students have twenty minutes to read each scenario and question, search PubMed, and identify the strongest evidence to answer the question.

CATs online library, FAST CATs, and outcome assessment. CATs developed by students and faculty members are published in an online CATs library to promote the transfer of new knowledge to other students, faculty, private practitioners, and ultimately the public. The online CATs library provides users with rapid and up-to-date answers to focused clinical questions. The library is searchable by keywords and is accessible in the clinics and classrooms. To date, approximately 400 CATs have been created. The CATs online library is available at https://cats.uthscsa.edu/search.php (accessed October 3, 2011).

A major component of the CATs initiative is the Faculty, Alumni, Student Team (FAST CATs) Program, which involves private practice dentists in the CATs program.[106] Twenty dental students participate each summer in a selective course that involves writing a CAT with a faculty mentor and then visiting five dental offices to discuss the CAT with practicing dentists and obtain their perspectives. Practitioners are asked to comment on the practicality and efficacy of the new diagnostic and treatment modalities that are communicated in the CATs. The practitioner receives one-hour CE credit for review and comments on the CAT. To date, fifty-nine students have visited 177 dental offices with enthusiastic ratings from both students and practitioners. In 2011, twelve third-year students were nominated by the directors of their clinical practice teams, based on previous EBP and CAT presentations, to produce CAT videos for use in the FAST CATs program and for posting on the CATs website. Each five-minute video summarizes a CAT pertinent to dentistry and provides references and links to online resources. Students who visited dental offices in the 2011 FAST CATs program provided these videos to the dentists they visited and discussed the findings of the evidence-

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Title Pain in Subepithelial vs. Free Soft Tissue Grafts

Clinical Question In healthy adults who are being treated for gingival recession does a subepithelial connective tissue graft (SCTG) or a free soft tissue graft (FSTG) cause more postoperative pain?

Clinical Bottom Line More studies are needed to confirm this finding, but these studies show that patients who undergo a free soft tissue graft procedure are more likely to develop postoperative pain than those who receive a subepithelial connective tissue graft.

Best Evidence/ References (you may view more info by clicking on the PubMed ID link)

PubMed ID	Author / Year	Patient Group	Study type (level of evidence)
17209793	Griffin TJ/2006	228 Adults receiving 75 FSTG and 256 receiving SCTG	Case Series/Clinical Trial
Key results	Patients who underwent free soft tissue grafts were three times more likely to develop postoperative pain (P=0.002) when compared to those who received a subepithelial connective tissue graft.		
18315424	Wessel JR/2008	23 Adults receiving FSTG and 12 receiving SCTG	Case Series/Clinical Trial
Key results	Patients who underwent free soft tissue grafts were more likely to have donor site pain at 3 days (early postoperative period) when compared to those who received a subepithelial connective tissue graft (P=0.05).		

Evidence Search Search “Adult”[Mesh], “Pain, Postoperative”[Mesh] Search “Gingival Recession”[Mesh]

Comments on the Evidence In the first study, patients who underwent free soft tissue grafts were more likely to develop postoperative pain (P=0.002) when compared to those who received a subepithelial connective tissue graft. In addition, the duration of surgical procedures was highly correlated with pain or swelling post-surgically (P=0.001). Therefore, the length could influence the pain perceived by the patient more than the type of tissue graft they received. The study was designed fairly well considering the goals of the investigation. The groups were similar at the start and there was a greater than 90% completion rate. The patients generally were treated the same, receiving one of two types of connective tissue grafts. However, the operator was not obligated to use a randomized method of treatment allocation and based his treatment on the surgical goal of obtaining root coverage or increasing the width of keratinized gingiva. The study was not double-blind as the operator was not blind to the state of the patient during treatment planning. There was adequate follow-up with only one patient not reporting pain status. There is also a potential for a bias in this study, because different patients have different thresholds for pain. The authors also noted that the application of dressing materials may have influenced the patients’ feelings postoperatively and that the difference in pain might have been greater without the application of the dressing. Due to the bias and lack of randomization, this study should not be used alone to make clinical judgments. In the second study, patients who underwent free soft tissue grafts were more likely to have donor site pain at three days (early postoperative period) when compared to those who received a subepithelial connective tissue graft. The groups were similar at the start of the study, but there was not a completion rate of 90% or more. Three of the twenty-six subjects did not complete the study because of failure to comply with postoperative protocol. The patients in this study were not treated the same, because there were many different operators who performed the surgeries. The experience of the operator could have impacted the length of surgery and therefore the amount pain the patient experienced. Another limitation of this study is the difference in patients' pain perceptions. The authors suggest a crossover study design where subjects have both a subepithelial connective tissue graft and a free soft tissue graft performed by the same operator at different times. More studies are needed to confirm the results presented here and the practitioner might want to incorporate their own patient experiences into the decision making process.

Applicability This information can be useful for patients who are trying to decide between subepithelial and free soft tissue grafts and want to know which one is more painful.

Specialty (Periodontics)

Keywords Gingival recession, subepithelial connective tissue graft, free soft tissue graft, postoperative pain

Comments on the CAT
(RESERVED FOR PRACTICING DENTISTS' and/or FACULTY COMMENTS ON PUBLISHED CATs)

None available

Figure 1. Example of a Critically Appraised Topic Summary developed by a dental student

based review. Examples of the CATS videos can be accessed at https://cats.uthscsa.edu/CATsVideosList.php (accessed October 3, 2011).

Multiple outcome measures are being used to track the impact of the program including a thirty-five-item assessment to measure EBP knowledge, attitudes, evidence-accessing strategies, and confidence in critical appraisal before and after training. This instrument is the EBP KACE (Knowledge, Attitudes, Accessing, Confidence Evaluation).[107] Pre- and post-training assessment with the KACE (2009–11) indicates that dental students', dental residents', and faculty members' comprehension of core EBP concepts, their attitudes about using EBP, their diversity of sources and methods for obtaining information, and their level of confidence in critical appraisal skills have improved substantially. Unexpected but desirable outcomes have been an increase in the number of students engaged in research activities in collaboration with faculty members and a parallel increase in the number of students participating in the school's research honors track. The long-range plan for the CATs initiative is to assess the impact of the program on practice behaviors.

One More Consideration

I think it is finally time to give teachers and students a puncher's chance at educational quality by eliminating a huge constraint, which is the competitive curriculum that both students and teachers must fight through at most U.S. dental schools. This curriculum is not "competitive" in the sense that standards are high and it is difficult to excel, which may well be the case. Rather it is "competitive" in the sense that the majority of dental schools schedule many courses concurrently (I've seen as many as eleven at a time) and force students to bounce from assignment to assignment and exam to exam—a process that diverts attention, fragments their focus, and overwhelms their ability to study systematically without worrying about other looming "big ticket" assessments.

A competitive curriculum demands a cram and purge approach to test preparation and leaves minimal time for reflection or consolidation of concepts. Compartmentalization and concurrency largely result from the traditional discipline-centric silo curriculum. From what I have seen at more than fifty U.S. and Canadian dental schools during my career, most courses are internally well organized within their particular silos in the overall curriculum. However, students experience the curriculum in a different manner as they try to make sense of information communicated in multiple concurrent courses taught back to back, hour by hour, day after day (horizontally, across discipline silos).

To illustrate this point, Table 10 is a list of the topics that students encountered on a single day during their first year at a dental school with a discipline-based curriculum.[8] Each course was well organized as a distinct entity, but what is the impact on dental students as they attempt to make sense of fragmented and uncoordinated bits of information from five different courses, each conducted independently, without topic coordination among the courses? What does diuretics have to do with basal ganglia or gastrointestinal motility, and what do specific immunity concepts and metallurgy have to do with any other topic in that particular day? This disjointed process occurs every day throughout the first two years of the curriculum. So here is a modest recommendation for future educational best practice: let's figure out a way to limit a student's span of attention to no more than four courses at a time. Certainly, ways to accomplish this goal can be identified to provide a better learning environment for the creativity of our dental school teachers, the talents of our students, and educational best practices to intersect.

Final Thought

I close with a paragraph that led off an article on assessment of struggling students ten years ago and which seems fitting as a concluding note for this article:

> Memory is the foundation of learning: without the ability to retain and retrieve information and experiences, we could not perform the tasks of daily living or take on the responsibilities associated with our occupations. One of the profound mysteries of human life is how self-awareness and thought emerge from the movement of electrical charges from brain cell to brain cell. This electrical-to-chemical-to-electrical transmission process involves the axon of one neuron connecting to a dendrite of another neuron, a process that occurs billions of times every second. How does the miracle of thought emerge from this process? That is, how are we able to generate ideas, observations, reactions, and questions? How are we able to talk to ourselves (for example, conduct our private inner conversations)? And how are we able to communicate our thoughts to others? Another mystery, less theological in nature but just as profound for teachers, is why in any group of students a few individuals who have seemingly equivalent abilities and incentives perform less well than others or deviate so dramatically from the norms of expected behavior that they become labeled as problem students.[3]

The main take-away from this article is that we need to focus on the factors that actually determine the extent and quality of students' learning, and try to use these factors to work toward a perfect intersection of teacher, student, and learning environment. This article has attempted to point dental education in that direction.

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Table 10. Competitive curriculum: a day in a first-year dental student's life

Time	Course	Topic
8:00–9:00 am	Pharmacology	Diuretics
9:00 am–12 noon	Gross Anatomy	Neuroanatomy of basal ganglia
	Lunch	
1:00–3:00 pm	Physiology	GI motility
3:00–4:00 pm	Microbiology	Specific immunity
4:00–5:00 pm	Biomaterials	Metallurgy

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