Future Directions in Dental School Curriculum, Teaching, and Learning

William D. Hendricson, M.S.; Peter A. Cohen, Ph.D.

Mr. Hendricson is an Educational Specialist, Division of Educational Research and Development, The University of Texas Health Science Center at San Antonio; Dr. Cohen was formerly Associate Dean for Academic Planning and Development, The Texas A & M University System, Baylor College of Dentistry, and is now Dean, School of Allied Health, Wichita State University. Direct correspondence to Mr. Hendricson at Division of Educational Research and Development, The University of Texas Health Science Center at San Antonio, 7703 Floyd Curl Drive, San Antonio, TX 78284-7896; hendricson@uthscsa.edu e-mail.

Abstract: Efforts to reform the predoctoral curriculum are examined in light of the public's past and future oral health needs. Three directions that may make a difference in the preparation of dentists for their professional roles are discussed: competency-based curriculum, blending dental education into the broader system of health professions education, and reform of clinical education. A blueprint for a new and different twenty-first century predoctoral curriculum is unveiled to stimulate discussion and debate within the dental education community. The last section explores the sociology of institutional change, identifies barriers to innovation, and offers recommendations for enhancing future curriculum reform efforts.

Key words: dental education, curriculum, dental students, oral health, institutional change

In 1972, a World Health Organization commission assessed health professions education in many regions of the world including the United States. The commission concluded that education is inextricably interwoven with the health service system, and when questions arise about the delivery of service, questions about the training of health care providers follow soon after.[1] And indeed, in the twenty-six years since that prophetic report, a torrent of questions has been unleashed in the United States about the way medical care is provided for the public, leading to a still evolving reconfiguration of the health care landscape and, as predicted, scrutiny of the way health care providers, including dentists, are prepared for their professional roles in society. Managed care has become the foundation of the health care system, but much of the public does not like it, and health professionals have concerns that a "culture of commercialism" now dictates professional mores and manipulates decision making for patients, leading to a loss of autonomy and personal discretion in care of patients.[2] More than 900 bills were introduced during 1996 and 1997 in state legislatures and Congress to curb the excesses of managed care.[3] Even within the managed care industry, there have been proposals for a "patient-centered" profile rather than a "profit-centered" model, and the new CEO of Columbia/HCA has publicly addressed "cultural" problems within the industry that promote overly aggressive management.[4] Until 1996, the health care marketplace was moving steadily toward capitation and the capture of employee pools by managed care plans that offered enrolled patients limited provider choice or service options. Just three years later, consumer choice has reemerged as a priority, with corresponding focus on improved access and flexibility, convenience, quality of services, and consumer satisfaction. How far the anti-managed care pendulum will swing is unclear, but the next ten to twenty years are likely be marked by continued turmoil in the health care marketplace and, by association, within the institutions that train health care professionals.

The purpose of this paper is to highlight new directions for the dental school curriculum and for teaching and learning within the curriculum. To accomplish this task, we'll start by examining where dentistry, as a health care profession, has been and where it appears to be heading based on the projected oral health needs of the public in the twenty-first century. In the second section, we'll assess the extent to which dental education responded to the changes in the public's oral health needs over the past fifty years and to calls for reform of curricular structure and teaching techniques. In the third section, we'll examine three new directions we believe can make a difference in the way dentists are prepared for their professional responsibilities: 1) development of a competency-based curriculum, 2) blend-

ing the education of dental professionals into the broader system of health professions education by focusing on areas requiring multidisciplinary patient care, and 3) reform of the environment in which clinical education occurs. As we examine these three issues, we will describe a preliminary blueprint for a "new look" predoctoral curriculum for the twenty-first century which we hope will stimulate reflection and discussion about predoctoral dental education in the future. In section four, we'll explore the sociology of institutional change, identify barriers to innovation, and offer recommendations for enhancing efforts to reform the curriculum. Some of the recommendations in section four are based on assessment of major curriculum innovation initiatives at eight U.S. medical schools supported by implementation grants up to $2.5 million each from the Robert Wood Johnson (RWJ) Foundation. RWJ provided substantial support for evaluation of both reform process and curricular product at these schools which contributed to a valuable summary of curriculum development strategies of pertinence to dental schools anticipating a similar journey.

Oral Health Care in the United States and Its Impact on Dental Education

In his post-World War II speeches, Winston Churchill used the words "the winds of change are blowing and we lean into them with equal measures of anticipation and dread" to capture the conflicting emotions that arise when established institutions and methods are questioned.[5] The winds of change have been blowing since the 1980s in U.S. health professions education, first as a gentle breeze but now as a more formidable gale that is more difficult to ignore. The 1984 report of the Association of American Medical Colleges (AAMC) panel on the general professional education of the physician (known as the GPEP report) and the reports of the Pew Health Professions Commission were catalysts for curricular introspection in medical schools and other health professions.[6-8] The dental education community embarked on an analysis of its own curricular health approximately ten years ago. This introspection led to the 1995 Institute of Medicine (IOM) study which proposed reform of curriculum content and modernization of teaching/learning methods.[9] Significant changes in accreditation guidelines also occurred in the 1990s including adoption of an outcomes assessment approach to measure institutional effectiveness and adoption of a competency-based assessment philosophy which is being institutionalized by virtue of the new standard two (educational program) guidelines of the Commission on Dental Accreditation.

In the years immediately following World War II, dental caries and periodontal disease were assumed to be nearly universal, with a high percentage of patients experiencing rampant caries, severe periapical abscesses, and advanced periodontitis. The dental community reached this conclusion without benefit of modern epidemiological techniques, but the estimate was probably not too far off the mark in the pre-fluoride era. Since tooth extraction and physical removal of caries were the primary treatments available, restorative and prosthetic methods dominated the predoctoral curriculum. Several decades of research into the biological etiology and mechanisms of dental infection, leading to enhanced prevention and therapeutic regimens, and the widespread use of fluorides as a prophylactic mechanism have substantially reduced tooth loss and incidence of caries in child, adult, and geriatric age groups.[10] Further progress in prevention and therapy is anticipated as research expands our knowledge of the microbial and genetic underpinning of oral diseases, and our understanding of the relationship between oral health and a variety of systemic disorders such as diabetes mellitus, neutrophil disorders, stress, osteopenia, cardiovascular disease, and perinatal abnormalities. As we enter the twenty-first century, oral health is better than ever for the majority of Americans, but new challenges have emerged. One in four children in the United States live in conditions of poverty normally associated with an impoverished developing nation rather than an industrial power. The health status of these children parallels their economic circumstance and, among this group, indices of oral health are poor. A National Institute of Dental Research study revealed that 80 percent of all childhood dental problems occurs in 25 percent of children, primarily those of low income and minority status.[11] One-third of all Head Start preschoolers and 50 percent of Native American children have early childhood caries (ECC) which has been clinically correlated with compromised oral function, poor nutrition, and diminished height and weight attainment. Although infant mortality rates have decreased over the past twenty years, the overall incidence of low birth weight preterm infants has not declined despite substantial emphasis on prenatal care and preventive interventions, resulting in a significant level of perinatal morbidity,

untold emotional distress among family members, and expenditures in the billions of dollars. Research attention is now focusing on other previously unrecognized risk factors, including periodontal infection. For example, recent investigations suggest that pregnant women with severe periodontal disease are at considerably higher risk to deliver preterm low birth weight newborns.[13] Infectious oral disease has been identified as a potential etiology for up to 20 percent of the one-quarter million premature low birth weight infants born in the United States annually, perhaps as a sequalae of toxins from oral pathogens that reach the placenta and disrupt fetal growth and development. Oral health is also intertwined with childhood diseases including asthma and cystic fibrosis. Asthmatic children have more decay affecting permanent teeth, poorer periodontal status, and more loss of tooth surface than their non-asthmatic peers.[14] The higher incidence of caries in children with restricted airway disease is thought to be associated with their use of beta 2 agonists which contribute to reduced salivary flow, as well as mouthbreathing and esophageal reflux which is common in this population.[15] The poor oral health in children with chronic respiratory and gastrointestinal infections has also been associated with long-term use of liquid medications containing carbohydrates and sugar.[16] More than 150,000 infants are born with birth defects each year in this nation, and defects affecting the orofacial complex are the most common, resulting in more than one billion dollars of expenditures annually for their repair and rehabilitation.[17]

At the other end of the age continuum, the senior citizen (sixty-five years and older) represents the fastest growing segment of our population. In 1900, the median age in the U.S. was twenty-three years and only 4 percent of Americans were sixty-five years of age or older. By 1990, 13 percent of the population was age sixty-five and by 2050, more than 20 percent of the population will be sixty-five years or older.[18] Further, by the year 2020, it is projected that 60 percent of hospital admissions and one-third of all medical outpatient practice will be geriatric patients. Estimates of geriatric patients in dental practices are in a similar range, from 20 to 30 percent, suggesting that in the future a substantial portion of dental patients will present with an array of overlapping medical and oral health problems complicated by physical limitations, mental disabilities, and polypharmacy. Because of technological advances in diagnosis and treatment, many people who in the past would have succumbed to cancer, cardiopulmonary disease, or immunological disorders are living longer but also experiencing the sequelae of treatment, for example the consequences of head and neck radiation. Because senior citizens are losing fewer teeth prematurely, they will be conversely more at risk for dental problems later in life, leading to less reliance on the full denture as a treatment modality and greater need for more sophisticated prosthetic restorations.

In spite of the dramatic reduction in caries over the past fifty years, profound oral health problems with significant morbidity and mortality still exist in the adult population and the dynamic interplay between the mouth's microbial ecology and major systemic diseases is being examined more closely. Periodontal diseases, rather than being perceived as a localized infection without systemic repercussions, are now linked to a variety of life-threatening conditions including noninsulin-dependent diabetes mellitus, chronic degenerative diseases such as ulcerative colitis and systemic lupus erythematosus, and heart disease. In the latter, preliminary investigations indicate that the risks of fatal heart disease may be substantially higher for persons with severe periodontal disease.[19] In an effort to investigate the etiologic pathways underlying the periodontal disease-cardiovascular disease relationship, the National Heart, Lung, and Blood Institute of NIH is now sponsoring studies of the role played by biofilm-forming bacteria, which colonize the mouth, in the release of pro-inflammatory mediators by white blood cells which may, in turn, trigger stroke and heart disease. The orofacial complex is also the site of approximately 33,000 new cases of oral, pharyngeal, and nasopharyngeal cancer annually, resulting in 8,000 deaths, making this category of cancers more prevalent than a number of other carcinomas that have received substantially more media and public attention, including leukemia, pancreatic cancer, and cervical cancer.[20]

Dentists in the twenty-first century will also serve the oral health needs of an increasingly multicultural public as the percentages of patients of Hispanic, African-American, and Asian heritage will continue to grow in relation to the Anglo (non-Hispanic Caucasian) population. Overall, the growth rate in the United States has slowed dramatically in the second half of the century to an all-time low of 10 percent per decade in the 1990s as compared to 30 percent per decade in the 1800s, 15 percent from 1900 to 1940, and 19 percent in the "baby boomer" period of 1946 to 1966. The net increase in U.S. population since 1990 has been roughly 19 million, and 67 percent of this growth was accounted for by minority populations.[18] By the year 2020, if current birth and mortality rates continue, 40 percent of the

children and adolescents in the United States will be members of minority groups versus approximately 25 percent in 1980.[21] Accordingly, patients may enter the dental office with different health care beliefs, motivations, and expectations, and providers may experience differences in disease prevalence as the patient pool diversifies. For example, morbidity and mortality from oral and pharyngeal cancer is roughly twice as high for African-Americans as Anglos.[11] A variety of studies have revealed that members of minority populations experience greater risk for morbidity due to language barriers, lack of geographic proximity to health care facilities, lack of reliable transportation, lack of health insurance and culturally based beliefs about health and illness.[22, 23] The economic status of American families is also projected to decline over the next fifty years. Murdock estimates that the average household in the United States will have an income in 2050 that is $2,000 less than in 1990 (measured in 1990 constant dollars). Further, the income differences between Anglo, African-American, and Hispanic households, which are currently substantial (Anglo = $39,000; African-American = $23,500; Hispanic = $25, 000), will continue to spread over the next fifty years.[18] Thus, oral health in the United States is becoming increasingly bi-polar, and patient demographics are changing significantly with the population becoming older, more ethnically diverse, and poorer. At one end of the oral health spectrum, substantial dental problems exist in a sizable group of children living, primarily but not exclusively, in low-income communities. We say "not exclusively" because dental services still account for 25 percent of all health care expenditures for children ages six to eighteen.[12] In the middle of the spectrum, the majority of U.S. citizens have good oral health, a consequence of the research and prevention advances of the past fifty years. At the opposite end of the spectrum, a rapidly growing cohort of elderly patients will confront dental practitioners with intertwined and challenging dental and medical problems. Overall, 9 percent of the U.S. population, or 22 million people, reported unmet dental care needs in a study by the Project Hope Center for Health Affairs based on the 1994 National Access to Care Survey by the Robert Wood Johnson Foundation.[24] This study revealed that 8 million more people reported unmet oral health needs than people reporting medical care needs that were not met. Seventy-four percent of the individuals reporting unmet dental care needs considered their problems to be serious. The researchers found that ethnicity and socioeconomic status contribute significantly to the lack of dental care. Twice as many African-Americans (15 percent) reported unmet oral health needs as Caucasians (7.4 percent). Among those who wanted dental care but did not get it, 72 percent reported it was because they could not afford it, had no insurance, or could not find a dentist who would accept their insurance.

The circumstances under which dentists provide patient care has also changed dramatically over the past fifty years. In 1948, virtually all patients received care under a fee for service arrangement. In 1997, an estimated 47 million people were covered by dental managed care plans, up 18 percent from 1996.[25] By 2010, if current growth rates for DHMO (Dental Health Maintenance Organization) plans remain consistent, it has been predicted that 70 percent of dental patients will receive care under some type of DHMO or PPO plan, while the remaining 30 percent will shift back and forth between fee for service and HMO/PPP plans based on price and convenience or will receive dental care on a purely fee for service basis.[26]

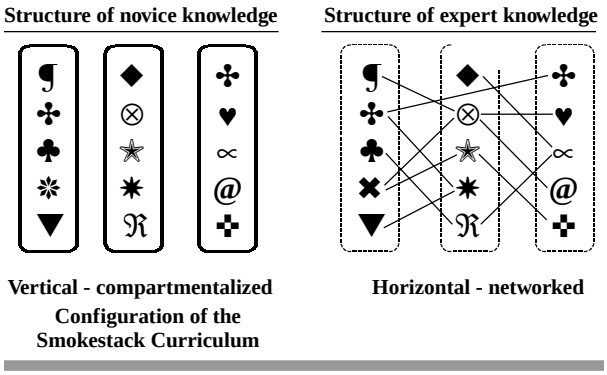
How has the dental education community positioned itself to respond to the evolution of oral health in this nation over the past fifty years? Tedesco documented dental education's response using a number of curriculum reports over the past seventy-five years including the 1926 Gies Report, the 1935 Blauch Report, the 1947 Horner Report, the 1961 Hollinshead Survey, the 1976 Higher Education Critique of the Dental Curriculum, and several clock hour studies. The conclusion? The dental education community has responded to the winds of change with "some growth, and little change."[27-32]

Dental Education's Response to Curriculum Reform Initiatives

In addition to competency-based education, the reform agenda for dental education consists of approximately a dozen recommendations including:

- decompress the curriculum by eliminating outdated and peripherally relevant material,
- increase educational collaboration between dentistry and the other health professions, featuring more curricular emphasis on the interaction of dental and medical problems,
- redirect the curriculum toward production of oral physicians,
- redirect basic science coursework toward disease

Figure 1. Novice and expert knowledge structure



Configuration of the Smokestack Curriculum

pathophysiology and oral medicine taught by problem-based techniques,

- expose students to patients and their oral health and systemic medical problems from the first days of the curriculum to the last,
- revitalize the science underlying clinical decision-making via evidence-based approaches,
- organize group practice teams in the clinical years to promote more continuity in faculty-student relationships and expand peer teaching by students working together in clinical teams,
- increase learning of clinical skills at chairside and decrease time spent in preclinical laboratories,
- increase the use of community-based clinics as clinical training sites for students,
- include a clinical experience in the final year of the curriculum, or a postgraduate internship year, which replicates the comprehensive care environment of the general dental practitioner,
- utilize technology to enrich student learning including informatics and operatory simulations,
- and, rededicate dental school clinics to serving the oral health needs of the public rather than primarily viewing patients as disposable and interchangeable educational material for students.

For the most part, these reforms represent ideas that have been advocated for many years but only sporadically implemented. The IOM study concluded that "the problem in reforming dental education is not so much consensus on directions for change but difficulty in overcoming obstacles to change. Agreement on educational problems is widespread. The curriculum is crowded with redundant or marginally useful material and gives students too little time to consolidate concepts or develop critical thinking skills. Comprehensive care is more an ideal than a reality in clinical education, and instruction still focuses too heavily on procedures rather than on patient care."[9] The dental education reform recommendations, taken collectively, argue for a learning environment that encourages students to learn collaboratively, provides students with opportunities to practice application of newly acquired biomedical information by solving simulated or real patient problems, fosters close and longitudinal contact between instructors and small groups of students, and provides learners with continuous contact with patients, and their health problems, throughout the educational program. These concepts are consistent with contemporary educational theory and are based on the active "inquiry-driven" learning that students use to convert unorganized static information (e.g., data "sponged" from a text or a lecture) into the interlinked chains of networked knowledge (e.g., information that has meaning and perceived utility) that experts access to solve problems (Figure 1).[33,34,35] Advances in PET scan studies (Positron Emission Tomography) have provided neurophysiologists with a technology capable of mapping how the brain functions during complex cognitive, perceptual, and psychomotor tasks.[36] These studies indicate that expert practitioners (represented by the right side of Figure 1) have integrated neural networks that facilitate instantaneous retrieval of chains of knowledge relevant to task performance or problem assessment. The novice (represented by the left side of Figure 1), confronted with the same task or problem, struggles in a trial and error manner to assemble isolated bits of information (represented by the various symbols within the columns) because he or she lacks pre-existing knowledge chains. Current theory indicates that problem-centered, "hands-on" collaborative learning is a strategy that can help novices develop the knowledge networks needed for expert function.[37]

The rationale for these reforms, examples of their application, proposals for future implementation and cautionary observations have been articulated by other authors, and it is not our intention to review this literature that addresses a variety of items on the reform agenda including: competency-based curriculum,[38-39] maximizing the value of the basic science curriculum,[40-41] evidence-based health care,[12,42-43] problem-based learning,[44-49] information technology,[49-51] reforming clinical education,[52-54] and the dentist's role in the overall health care system.[55,56] The poster child for many of these reforms in both dental and medical education has been problem-based learning (PBL), particularly in regard to enhancing the relevance of the basic science curriculum, integration of the clinical and basic sciences, and infusion of active learning (e.g.,

students functioning in small collaborative learning groups) into the curriculum. Assessment of the dental education community's reaction to PBL is instructive and suggests, in part, why this reform and other educational initiatives have made only modest inroads into the predoctoral dental curriculum. The literature on PBL in medical school and other health professions is extensive including several comprehensive reviews of learning outcomes and attitudinal impact on students and faculty.[57-60] A number of dental school applications of the PBL have also been reported.[44,46,47,61] PBL has a four-decade track record of largely successful implementation in health professions education, and the ability of students to learn effectively in PBL programs is no longer seriously debated by individuals familiar with the literature. On the other hand, there is no evidence that PBL provides uniquely better educational outcomes than traditional methods.[62,63] Students and faculty in well-orchestrated PBL programs often express favorable attitudes, citing the energy of intellectual exchange, sense of personal involvement, and stimulation of discovery as they collaborate to solve the health mysteries of the patient portrayed in the case, expressions of excitement about learning that stand in stark contrast to commentary about the tedious monotony of the lecture hall.[64,65] Winston Churchill's commentary on his own education captures the positive attributes of PBL for many students, "I hate to be taught, but I love to learn."[5]

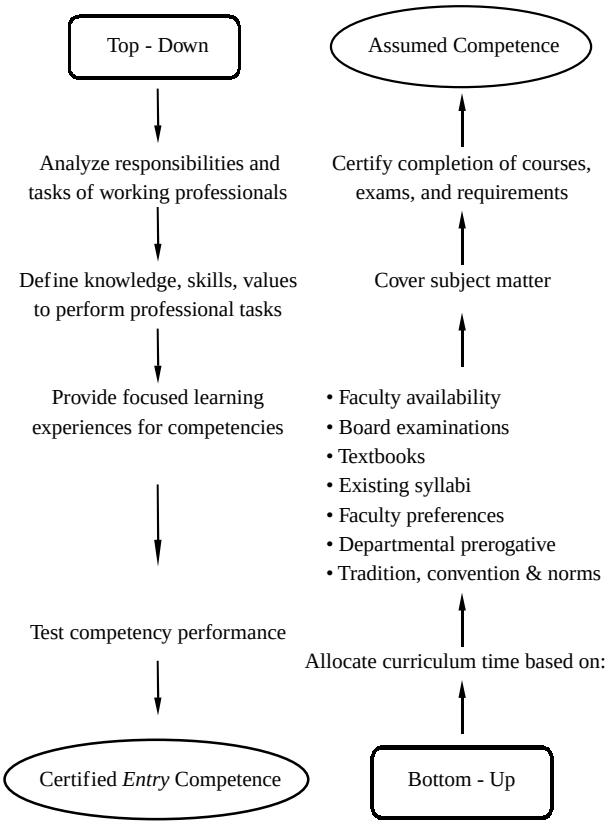
Yet PBL has not captured the imagination of the dental education community to the extent it has in medical school. Four factors may have contributed to PBL's failure to make significant inroads. First, traditional PBL emphasizes the formulation of a broad-spectrum differential diagnosis, followed by systematic data collection to rule out pathogenic options. At its heart, PBL is a detective game designed to help students identify problems, retrieve data, and ultimately solve the mystery. As conceived at McMaster Medical School in the 1960s, the purposes of PBL are to help medical students learn to play this detective game of diagnosis, the core task of the physician, and to help the student acquire, in a palatable manner, scientific information about the normal structure and function of the human body and the pathogenesis of deviations from normal. The latter is accomplished by the trace-back method in which students are requested to trace a patient's symptom back to underlying pathophysiological mechanisms in order to demonstrate their understanding of the disease process. In a medical school PBL case, even relatively benign symptoms, such as cough, wheezing, or fatigue can lead the student to consider pathophysiology pertinent to several organ systems and produce an initial differential diagnosis that includes a wide array of items to be ruled out. The medical detective format of PBL, focusing on diagnosis, may not be ideally suited to the "traditional" dental school curriculum which has tended to emphasize the other end of the spectrum—treatment, via surgical and restorative methodologies, and determining how to deliver therapy in light of anatomical constraints, medical co-morbid conditions that may complicate treatment, and the patient's financial circumstance.

The second factor relates to how PBL has been used in the traditional dental curriculum which, by virtually any standard, is the most dense (e.g., number of courses and clock hours) and consistently demanding (e.g., the number of exams, deadlines, and project/procedural requirements) of all the health professions curricula. Frequently, PBL is added to an already overly dense curriculum as a correlation course to help students tie together basic science and clinical concepts. No free time is created for students to do research between PBL tutorials (e.g., to investigate questions arising during case discussion); thus students perceive the course to be an extra burden that is further stigmatized by having "homework assignments." A well-recognized PBL rule of thumb is that for every tutorial hour, students should have two hours of unprogrammed time during the regular 8 am-5 pm school day to research questions that evolve from analysis of the case.

Faculty concerns about the time and effort-effectiveness of PBL constitute the third factor in PBL's slow diffusion into dental education. In order to strengthen and diversify research programs, establish alliances with other health professions, and offset stagnation in state appropriations, dental schools in the 1990s have converted a substantial number of teaching positions into primarily research-oriented positions. The remaining clinical teaching faculty are expected to devote increasing amounts of time to laboratory and clinical courses. Paradoxically, this has occurred at the same time schools are being urged to incorporate more small group learning into the curriculum which is perceived to be more labor-intensive. Thus, department chairs have been hesitant to commit apparently dwindling teaching resources to PBL.

The fourth factor relates to the nature of PBL itself. The back and forth, sometimes unfocused, dialogue that characterizes a dynamic PBL group as students vocalize and debate ideas, often in a circuitous trial and error process, may appear messy and unpro-

Figure 2. Approaches to educational planning



ductive to many dental faculty who would prefer to "cut to the chase" and simply tell students how to solve the problem rather than watch them flounder. Faculty discomfort with the PBL facilitator role and desire to leap into the expert role are evident in all health professions. But from our experience, it appears to be more prevalent in dental education, possibly because very few dental faculty experienced PBL as students. Thus, the seemingly unstructured dynamics of PBL may not fall within the typical dental faculty member's concept of teaching or learning. In contrast, most medical school faculty educated in the past twenty years probably encountered PBL at some point in their training or perhaps even graduated from one of the thirty to forty medical schools that employ PBL extensively. For these reasons, PBL's impact in dental education has been more of a ripple than a wave, but we project a brighter future for PBL in dental education if it can be used within an appropriate curriculum structure.

New Directions in Dental Education

In this section, we will review three future directions for dental education which may make a difference in the way dental students are educated and will then describe a preliminary blueprint for a new type of curriculum built upon these ideas. The three directions are: 1) developing a competency-based curriculum, 2) blending dental education into the mainstream of health professions education, and 3) reform of the environment in which clinical education occurs.

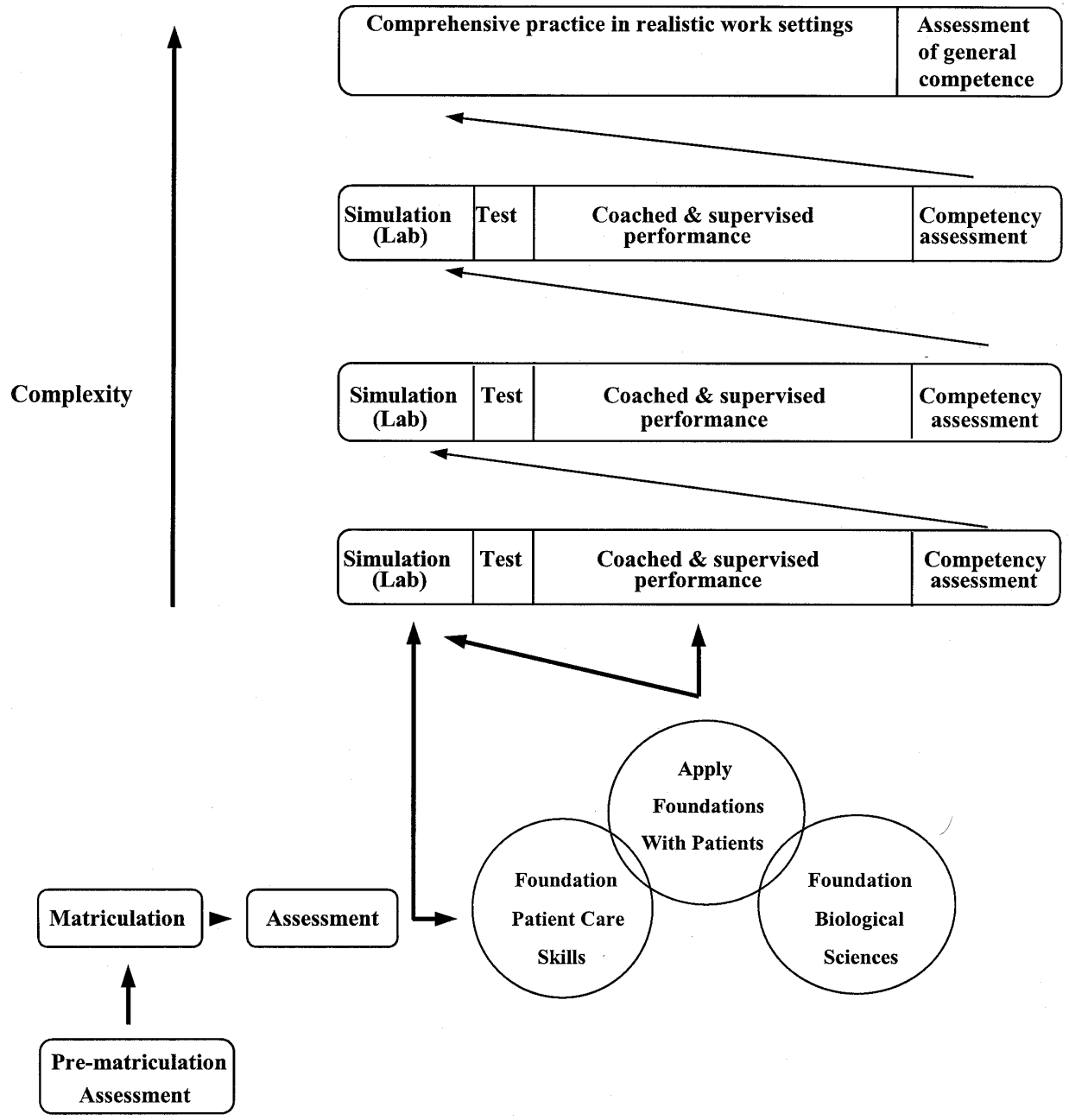
Competency-Based Curriculum (CBC)

Hendricson and Smith have described the three questions that faculty must answer to develop a competency-based curriculum: 1) what knowledge, skills, and professional/personal values should the entry-level general practitioner possess? 2) what learning experiences will enable dental students to acquire these competencies? and 3) how do dental school faculty know if students have attained these competencies—that is what proof, or evidence, is needed to establish competency?[35,66] To date, dental education has focused exclusively on the first and third questions but paid scant attention to the second. In essence, the new Commission on Dental Accreditation standards require competency-based assessment, not competency-based education. A competency-based curriculum has three features that are different from what most dental educators have experienced: 1) top-down planning based on analysis of the responsibilities of practitioners in the field, and forecasts of future societal needs, rather than bottom-up planning which focuses on what the disciplines want to communicate to students; 2) a readiness-based model in which students can progress at different rates through the curriculum than other students; and 3) a horizontal curriculum structure in which students progress through skill layers hierarchically organized by difficulty level and characterized by tight time proximity between laboratory learning and clinical experience.

Top-Down Planning

Grussing first used the term "top-down planning" to convey the idea that competency-based curricula are

Figure 3. Horizontal structure of competency-based curriculum



derived from the roles, responsibilities, and frequently performed tasks of practitioners in the field.[67] Grussing visualized these roles, responsibilities, and tasks as the "top" or pinnacle of the educational mountain that students ascend to attain competency.

As depicted in Figure 2, faculty plan the curriculum by working down from these practitioner competencies to create an interlinked sequence of learning activities and assessments that prepare students for these responsibilities. The goal of top-down planning is to create an efficient pathway for the student, devoid of marginal and peripheral "nice to know" material, that links competencies to subject matter and learning experiences, which, in turn, are linked to evaluations that measure performance of these competencies. The outcome is a series of hierarchically arranged learning

modules which start with universal foundation material (e.g., building blocks for all subsequent learning), and progress sequentially through more sophisticated competencies. In contrast, most dental school faculty are familiar only with bottom-up planning which has been the standard operational model for twentieth century higher education. In bottom-up planning, certain pre-matriculation courses are accepted by tradition as being suitable prerequisites for entry into the professional program. Various courses are superimposed on top of these prerequisites, with each discipline building its own columns of courses, independent of other specialty areas, and resulting in a "smokestack curriculum" that resembles the left side of Figure 1. When all courses conducted by all disciplines are passed, the student graduates. The assumption is that students, by their own devices, will assimilate, retain, and integrate the information from all these courses and thus become competent, with minimal outside assistance. Bottom-up planning helps faculty answer the questions, "What do we want to teach students about our respective areas of specialization?" In contrast, top-down planning encourages faculty to answer the question "What do our students need to learn?" Competency-based curricula have been implemented with success in military and industrial training programs and have been employed advantageously in some teacher training programs, but have a checkered history in higher academia, including the health professions, possibly due to a mismatch with departmental structure, and also possibly due to the traditions of academic freedom and individuality embedded in the collective faculty consciousness. In the latter case, faculty may rebel against the tightly prescribed "lean and mean" curriculum associated with CBC.

Readiness-Based Model

The use of numerical requirements as a marker of student ability is fundamentally antithetical to the competency-based approach. We have observed many dental schools attempting to craft an assessment process that maintains unit requirements, often renamed with a more politically correct label, in coexistence with competency exams. In a competency-based curriculum, students and instructors jointly determine student readiness for "solo performance" competency assessments (e.g., no helping hands from faculty). One student could be ready after two to three patient encounters, while another may require six to seven experiences. Dental schools desiring to meaningfully implement competency-based education will need to jettison the requirement-based philosophy that has been a significant driving force for the clinical curriculum for decades.

Horizontal Curriculum Structure

Competency-based curricula have a different structure from traditional, discipline-based curricula. As previously noted, a bird's-eye view of the traditional, discipline-based dental curriculum looks much like the left side of Figure 1, a series of smokestacks representing the courses of autonomous disciplines. In contrast, Figure 3 depicts, in simplified form, a bird's-eye view of a competency-based curriculum, derived from training models in the military and industry.[68] A brief review of the principle components of the CBC model in Figure 3 follows with observations about how it could be applied to the education of dental students. In a competency-based curriculum, students are often assessed pre-matriculation for their adaptability to the learning and evaluation methods employed in a competency-based program. After matriculation, students participate in additional assessments to determine baseline skills in order to pinpoint the appropriate starting point for each student. Most, but not all, students will begin with a "foundations" phase in which they learn patient care skills and biological science concepts that serve as the universal underpinnings for all other areas of performance. Students are provided opportunities to apply these foundations by working with patients throughout this introductory phase of the curriculum. For example, in dental education, clinical skills universally applicable to many areas of oral health care that could be learned during a clinical foundations phase include: patient assessment techniques (interviewing, intra and extra oral examination methods), charting, use of instruments, risk assessment, dental imaging, four-handed assisting, measuring vital signs, infection control techniques, periodontal instrumentation, local anesthesia, rubber dam technique, setting teeth, waxing, casting, impressions, prophylaxis/applying sealants, condensing amalgam and marginate, and basic life support. Concurrent with acquisition of these foundation skills, students could be introduced to the world of dental practice, including professional behaviors and ethics, the dentist's social responsibilities, basic elements of oral health needs assessment, and professional issues including patient and provider substance abuse, recognition of physical abuse/nutritional neglect, and interaction/communication with other health profes-

sionals. The foundation biological sciences for the predoctoral curriculum could include six thematically-integrated units: 1) normal and abnormal structure and function of cells, tissues, and organs, learned as an integrated entity in gross anatomy, microscopic anatomy, neuroanatomy, physiology, and pathology modules conducted within a block course instead of a series of separate courses conducted without coordination; 2) normal and abnormal development, structure, and function of the orofacial complex; 3) normal and abnormal biology of the oral cavity focusing on the dynamic interaction among saliva, tooth structure, microflora, and mucosa; 4) concepts of assessment, prevention, and treatment of orofacial diseases and abnormalities, which will provide a foundation for subsequent learning of patient treatment strategies in years two through four; 5) biological interrelationships of the orofacial complex with other organ systems focusing on oral diseases that have clinically significant effects on general health, and the systemic diseases and medical conditions that are risk factors for periodontal disease and other oral health abnormalities; and 6) an introduction to pharmacological and neurochemical receptor sites that will serve as the platform for pharmacotherapeutics, pain management, and behavioral management. Concurrent with these core biological units, frequent clinical exposure to patients, particularly through history-taking and clinical examination, allows students to experience aspects of the pathophysiology being introduced in biological science coursework, to see variations in normal anatomy and function, and to observe the intermingling of dental and medical problems in patients.

After completion of competency tests pertinent to the biological and clinical foundations, students acquire increasingly complex competencies by moving through a hierarchy of learning modules. An important feature of the "hierarchical" CBC model is that interrelated pre-clinical (e.g., practicing basic technical competencies in a laboratory) and clinical experiences with patients both occur within learning modules throughout the curriculum rather than the traditional system of limiting laboratory work to the first half of the educational program and clinical work to the third and fourth years. Thus, in CBC, it is possible that even students in the final phase of the curriculum may spend time learning new skills in a laboratory. Students begin each module with a simulation experience in which they learn and practice the competency in a laboratory environment. On the first day of the laboratory, students are assembled into learning teams of six to eight students led by an instructor who is assisted in the laboratory by a more advanced student who serves as a teaching assistant (TA). The team of students and instructor move together from the laboratory into the clinic to provide continuity of instruction between laboratory and clinic. A key principle underlying the horizontal CBC format is the continuous relationship of an expert practitioner (instructor) with a small group of novice learners in the tradition of the artisan-apprentice training model perfected during the fifteenth and sixteenth century renaissance by the masters of various craft guilds. When students test-out of the laboratory phase of the module, they move into the work environment (e.g., in dentistry, the clinic) and have opportunities to perform the procedure on patients within days of completing the laboratory competency exam.

Competency assessment in the clinical phase of the module is often accomplished by the "triangulation" method which consists of three measurements of different aspects of competence. In the health professions, this typically involves assessment of the student's ability to perform procedural skills, a written assessment of the student's knowledge base and decision-making skills, usually involving analysis of case simulations, and the team leader's overall assessment of the student's performance including patient management abilities, knowledge, technical skills, and professional demeanor. Many competency-based programs also measure a student's progress toward competency on a longitudinal basis beginning early in the program and continuing throughout the curriculum at periodic time intervals. Chambers has described such a system for dental education.[69] Upon successful demonstration of competency, students enter a new module where they are reorganized into new learning teams, meet new instructors and laboratory TAs, and repeat the process. Students who do not demonstrate competency repeat the module. The ultimate layer of the curriculum is an extended period of comprehensive, undifferentiated, practice in realistic on-the-job work settings. To graduate, students must successfully complete competency exams during the final curriculum layer that measure acquisition of key knowledge and skills and their ability to demonstrate professional values.

A significant educational advantage of the horizontal competency-based curriculum is that the time delay between initial exposure to skills in laboratory simulations and the actual utilization of these skills during patient care is greatly reduced. In the traditional vertical dental school curriculum, six to eighteen months may elapse between a student's laboratory experience with a skill and opportunities to perform the

procedure in the clinic. The literature on acquisition and maintenance of complex procedural skills indicates that ability to perform dramatically erodes within three months of initial learning if not continuously practiced and fine-tuned.[70,71] Additionally, in a competency-based curriculum, students work on one competency, or an interrelated group of competencies, at a time before moving on to another area which is also consistent with research on the acquisition of high performance procedural skills. In the discipline-based curriculum, students attempt to learn several different competencies simultaneously—a sequelae of numerous departments administering their own clinical programs in isolation of others. To our knowledge, no U.S. dental school has implemented a curriculum similar to the one depicted in Figure 3, although schools in other nations operate programs with similar features, most notably the Malmo, Sweden, Dental School.

We think this model may be a good fit for the dental school curriculum of the twenty-first century, and from this point on, we'll unveil a preliminary blueprint, in broad strokes, for a predoctoral program based on competency-based techniques. The overall blueprint for this twenty-first century curriculum appears in Figure 6. First, we'll review how the foundations phase of the CBC model has been applied in medical school and then examine how it could be implemented in a dental predoctoral program.

A number of medical schools have introduced a hybrid curriculum combining traditional and PBL techniques in a format we have labeled the "AM-PM Model."[72,73] The AM-PM model varies from school to school, but the basic structure involves these elements. Eight of the ten half-day blocks during the week are scheduled for learning experiences and two half-days are left unscheduled. In the morning (AM), basic science courses are conducted with tighter thematic coordination than normally exists from 8 am to 12 noon four days a week for a total of sixteen hours of contact time. During two afternoons per week (PM), students meet in small tutorial groups guided by clinical and/or basic science faculty to analyze patient cases that require application of concepts and information derived from the biological science classes. The cases are written by teams of basic science and clinical instructors based on the AM syllabi. These case-based sessions are typically two hours in duration (e.g., 1-3 PM), for a total of four hours a week. The remainder of these two afternoons are unscheduled so students can use the time to research questions and issues arising during the tutorials. On a third afternoon each week, the tutorial groups participate in a physical assessment laboratory to learn patient examination techniques related to the anatomical area or pathological mechanism being addressed at that point in the curriculum. Students often practice physical assessment on standardized patients and receive corrective feedback from these individuals who are trained to represent health disorders and give suggestions to students from a patient's perspective, a technique now being used more frequently in dental education.[74] Students also spend two half-days per week at a clinical site conducting in-take interviews (chief complaint, history of present problem, current medications, and vital signs), observing residents and attendings "in action," and assisting junior or senior students with patient procedures. The remaining half-day is also left open which allows additional time for PBL-related research.

Application of AM-PM Model to the Foundations Phase

The AM-PM format appears to be a viable model for the foundations phase of a dental curriculum. To implement the afternoon case tutorials, a class of eighty dental students would require ten faculty tutors who could be drawn from all departments, thus minimizing the burden on any one department. The format of the biological foundations phase of a dental curriculum is depicted below with the biological science thematic units indicated on the left and the titles of dental school courses that traditionally comprise each unit on the right side.

Foundations Phase of Twenty-first Century Dental Curriculum

Biological Science Thematic Units	Dental School Courses That Traditionally Comprise Each Thematic Area
Development, structure, function, and abnormalities of cells, tissues, and organs	Gross anatomy, microscopic anatomy, neuroanatomy, general pathology, physiology (or pathophysiology), biochemistry
Normal and abnormal development, structure and function of the orofacial complex	Gross anatomy/embryology, growth and development, dental anatomy, pediatric dentistry, occlusion, orthodontics, TMD, craniofacial abnormalities, oral diagnosis, radiographic interpretation

Normal and abnormal biology of the oral cavity	Microbiology, biochemistry, cariology, oral pathology, immunology periodontics, nutrition, prevention, endodontics, oral diagnosis
Assessment, prevention, and treatment of abnormalities of the orofacial complex	Oral diagnosis, oral pathology, preventive dentistry, community dentistry, public health
Biological interrelationships of the orofacial complex with other organ systems	Oral and general pathology, oral medicine, systemic disease, oral diagnosis, treatment planning, gerontology, hospital dentistry
Pharmacological agents and neurochemical receptor sites	Pharmacology, neuroscience, biochemistry

Clinical Foundations

Foundation clinical skills interviewing, oral examination, charting, use of instruments, risk assessment, dental imaging, four-handed assisting, measuring vital signs, infection control, etc.

Introduction to the dental profession and community preceptorships

Patient care experiences working in teams with third- and fourth-year students (one day/week)

The thematic unit on structure, function, and abnormalities of human tissues and organs would include modules on cell structure and function, metabolism and nutrition, microscopic and gross anatomy of tissues and organs, and infectious processes and host response. After study of normal development, structure, and function in this unit, students explore pathophysiology pertinent to the major organ systems. The other thematic units also incorporate material often presented in as many as twenty different courses in the traditional, departmentally based predoctoral curriculum.

For the clinical foundations phase**,** two-thirds of the sessions in the PM clinical skills laboratory would be devoted to the foundation dental skills described previously. One-third of the lab sessions would be devoted to learning physical assessment skills pertaining to the rest of the human body. The rationale for learning these skills will be reviewed when we discuss strategies to blend dental education into the broader context of health professions education.

The clinical skills laboratories also provide a forum for introducing students to behavioral and psychosocial issues central to the relationship of patient and care provider. For the one day of clinical experience per week, the same ratio would be appropriate: 2/3 for assisting in the dental clinic and 1/3 in a medical primary care setting performing patient work-ups. Concurrent with the clinical skills laboratories, students begin their socialization into the profession in the previously described course, "Introduction to the Dental Profession," which includes preceptorships in the offices of community practitioners and at community clinics. A valuable resource for dental school faculty contemplating similar structural changes to the curriculum changes is Hilary Schmidt's description of "lessons learned" from recent efforts to integrate the teaching of the basic sciences, clinical sciences, and biopsychosocial issues in medical schools.[75]

Structure of a Competency-Based Clinical Curriculum

To maximize the students' learning opportunities and maximize utilization of dental school resources/facilities, we recommend an academic year consisting of forty-four weeks. As depicted in Figure 6, each clinical year can be divided into four ten-week competency modules with two-week mini-modules scheduled after blocks one (October) and three (March) for focused pursuit of elective topics. We recommend that two of the mini-modules address oral health research and require the student to conduct an evidence-based investigation of an oral health topic. For the remaining four mini-module slots, students could choose from a variety of options including an additional research module, clinical experiences in dental or medical subspecialties, comprehensive dentistry experience in a community-based setting, or patient care in the school's walk-in or emergency care clinic.

This plan will create a total of twelve ten-week modules in the sophomore, junior, and senior years with at least three of these modules (25 percent) devoted to comprehensive dental care in a private practice environment (e.g., students function as care providers supported by assistants, laboratory technicians, and patient coordinators). Seniors would also serve one-half day per week as teaching assistants in the foundation skill labs for first-year students. Parenthetically, we are assuming that hesitancy to further compound the problem of dental student debt will ensure the maintenance of the traditional four-year curriculum. The laboratory to clinic ratio within the modules could be three weeks for labs (at thirty hours per week) and seven weeks (also thirty hours per week) for clinical work, although this ratio would obviously vary from competency to competency. We envision a variety of learning activities within the modules including case-based conferences, retrospective case reviews in a CPC (Clinical Patho-

logical Conference) format, evidence-based literature review, CD ROM diagnostic modules to expose students to patient problems not frequently encountered in the clinic,[76,77] visits to practitioners' offices and community clinics, and unprogrammed time for students to investigate and report on issues in oral health care relevant to the module competencies. In the clinical phase of the module, eight half-day sessions per week can be scheduled for supervised development of competencies in patient-care situations. Students would also devote the remaining two half-day sessions per week (one day equivalent) to a vertically organized comprehensive care clinic (CCC) comprised of freshman, sophomore, junior, and senior teams. During the sophomore, junior, and senior years, students would participate in a weekly interdisciplinary course, "Clinical Practice of Dentistry (CPD)," addressing important patient care and professional issues including management of pain, clinical pharmacology, dental economics, health care systems, clinical pathology, dental informatics, and management of the dental practice. CPD would be conducted two hours per week, for example, on Wednesdays at either 8-10 am before clinic or 3-5 pm after clinic. The competency modules are arranged in a competency continuum and, just as an example to stimulate thought, a hypothetical sequence might include the modules in the following chart. We are confident that dental educators will envision other configurations for competency modules, but the key principles in any arrangement are: 1) students primarily focus on one area of patient care at a time, and 2) the time interval between laboratory learning and use of skills with patients is as brief as possible.

Hypothetical Configuration of Competency Modules

Sophomore Year Competency Modules

- Diagnosis, prevention, and treatment of periodontal disease, including an interdisciplinary rotation on surgical skills
- Restoration of dentition: amalgams and composites
- Restoration of dentition: inlays, onlays, crowns (child and adult)
- Multidisciplinary health care (geriatrics, oncology, pediatrics, and ENT rotations) and public health dentistry (five weeks each)
- Two mini-modules for clinical or research electives (two weeks each)

Clinical Practice of Dentistry = two hours per week for: 1) Integrated Pain Management/Clinical Pharmacology, and 2) Economic Basis of Dental Care/ Health Care Systems, scheduled in ten-week blocks.

Junior Year Competency Modules

- Endodontics and interarch fixed restorations
- Management of dysfunction/abnormalities of the craniofacial complex (a multidisciplinary module addressing growth and development abnormalities from childhood to adulthood)
- Removable restorations (partial and complete dentures)
- Primary dental care (comprehensive care)
- Two mini-modules for clinical or research electives (two weeks each)

Clinical Practice of Dentistry = two hours per week for: 1) Clinical Pathological Conferences stressing recognition/treatment of oral pathologies and systemic interrelationships between oral cavity and other organ systems, 2) Clinical Pharmacology, and 3) Dental Informatics scheduled in eight-week blocks.

Senior Year Competency Modules

- Oral surgery, management of trauma and emergencies, and/or dental walk-in clinic
- Implant dentistry and esthetic dentistry (five weeks each)
- Primary care (including a two-week hospital dentistry rotation)
- Primary care (including a two-week practice management preceptorship/project)
- Two mini-modules for clinical or research electives (two weeks each)

Clinical Practice of Dentistry = two hours per week for: 1) the Dentist in Society (Professional Ethics and Jurisprudence), and 2) Management of the Dental Practice, scheduled in ten-week blocks.

Module scheduling will require a "lottery" start for each curriculum layer. For example, using the hypothetical competency continuum outlined above, the sophomore year could involve dividing a class of eighty students into three groups who would rotate among the modules. One-fourth (n=20) would start with the periodontics/prevention module, one-half (n=40) would start with the restoration modules, which would be completed as a combined semester-long block, and the remaining one-fourth (n=20) would start with multidisciplinary health care and public health module. The multidisciplinary health care component of this module would consist of rotations in geriatrics, oncology, pediatrics, and ENT. In the public health compo-

nent of this module, students would learn about dental public health and epidemiological principles in seminars, provide preventive and educational services at various community sites, and complete a public health research project involving field investigation (e.g., documenting the oral health/medical problems of a specific geographic community or population group and developing a plan to enhance access to dental/medical services). In the periodontics/prevention and restoration modules, students can be organized into learning teams consisting of six to seven students, an instructor, and a senior laboratory TA. Patient treatment in junior year modules that may extend beyond the confines of a ten week rotation (for example, multi-unit fixed bridges or partial dentures) can be completed during the weekly comprehensive care days scheduled throughout the academic year and/or during the Primary Care Module depending on the student's rotation schedule.

Blending Dental Education into the Mainstream of Health Professions Education

The IOM study recommended that "dental educators should work with their colleagues in medical schools and academic health centers to require and provide for dental students at least one rotation, or clerkship, or equivalent experience in relevant areas of medicine, and offer opportunities for additional elective experience in hospitals, nursing homes, ambulatory care clinics, and other settings."[9] We view the dentist as a health care practitioner who has received specialized training in the assessment and treatment of diseases and abnormalities of the orofacial complex, an anatomically and functionally defined region similar to the anatomic or functional parameters that establish practice domains for other medical specialties/subspecialties such as ophthalmology, dermatology, urology, and otorhinolaryngology.

Consequently, a fundamental "twenty-first century curriculum vision" question for dental educators to ponder is: Should the student training to function as an orofacial specialist receive an education that closely parallels, and is better assimilated with, the predoctoral training provided for students preparing for careers in other areas of medical specialization? A number of factors suggest to us that the answer is "yes." With the advance of research, it is becoming increasingly clear that high morbidity diseases and abnormalities of the orofacial complex require multidisciplinary approaches to assessment and treatment including craniofacial anomalies with genetic etiology such as cleft lip and palate, temporomandibular pain and dysfunction, oral manifestations of HIV infection and AIDS, and oropharyngeal cancer. Recent studies linking periodontal status and cardiovascular disease and linking maternal oral health and the incidence of pre-term low birth weight infants suggest the need for additional multidisciplinary research and, ultimately, interventions in these areas. The growth in the number of elderly patients with medical co-morbidity seeking treatment for oral health problems will place dentists and physicians in more frequent collaboration to coordinate treatment for this population. Serving the oral health needs of an expanding elderly population will also undoubtedly place dentists in more frequent contact with assisted living facilities and with allied health professionals who play important roles in the care of the geriatric patient in these settings. The substandard health, including substantial dental pathology, for millions of children living in our nations' expanding "pockets of poverty," will also require coordination of effort with medical colleagues and increase the dentist's exposure to public health facilities and the community clinic environment. Advances in microbiology suggest that reducing maternal reservoirs of *mutans streptococci*, preventing transmission of bacteria from mothers to infants, and enhancing the child's resistance to bacterial implantation are viable approaches to primary caries prevention.[12] Implementing these preventive measures and educating the public about the infectious transmission of caries will require teamwork between oral health care providers and pediatricians.

Research in molecular biology, investigation of the genetic basis of disease, and breakthroughs in genetic engineering have also transcended traditional disciplinary boundaries, blending the efforts of dental and medical school investigators with basic scientists, a collaboration that will almost certainly lead to cross-disciplinary clinical trials of diagnostic techniques and therapeutic regimens in the coming decades. Access to the Internet and other sources of health information has enhanced the public's awareness of disease processes, medications, non-pharmacological therapy, diet and fitness, nutritional supplements, and alternative medicine, which in turn places pressure on all health care providers to stay abreast of developments across a broad spectrum of biomedical knowledge. And finally, academic health centers (AHCs) are struggling to de-

termine the "winning combination" for their managed health plans that will enable them to compete in the marketplace with other managed care organizations. Many AHCs hope to entice patient enrollments by capitalizing on their ability to assemble an attractive package of multidisciplinary service teams.

Given the uncertainties of core financing for university-operated clinics, it is imperative for dental schools to demonstrate the "value-added" potential of the dental practitioner and the dental school-based clinic, within an overall spectrum of health care services.[78] The Blue Ridge Health Group, which consists of academic health professionals, sociologists, economists, and businesspersons, advises AHC administrators who are developing organizational structures appropriate to the changing face of health care. The Blue Ridge Group recommends that: "AHCs must base their management structures and programs on the collective enterprise. Individual components of AHCs that currently perceive themselves as independent and isolated must come to view themselves as an integral part of a common enterprise, and must commit to collaborative accomplishment of common goals and objectives."[79]

How can the education of dentists be blended with that of other health professionals, particularly physicians-in-training? The IOM recommendation to add a medical clerkship, presumably in Internal Medicine, to the dental curriculum appears highly problematic. Clerkship directors in medical schools are already hard-pressed to locate appropriate training sites and adequate numbers of university-based physicians or community preceptors for their own students, so the logistical feasibility of adding a sizable cohort of dental students to the clerkship mix is doubtful. However, there are other ways to accomplish the goals of broadening and diversifying the dental student's clinical experience, increasing student exposure to the disease processes he or she will encounter among the patient population, and increasing exposure to members of other health professions and their work environments. As we have proposed, a starting point would be to emphasize "whole body" physical assessment in the foundations phase of the curriculum. Dental students should learn to conduct a comprehensive "executive" physical examination, including a full medical history and techniques of regional system assessment (e.g., musculoskeletal, neurological, mental status), in the same depth as medical students. Patients with chronic disease should be recruited to serve as subjects during physical assessment labs in the foundations phase of the dental school curriculum. Obtaining, writing-up, and presenting comprehensive medical histories of individuals with chronic disease, at the same time as pathophysiology coursework, will help orient students to the presentation and natural history of medical diseases they will encounter in dental practice. The Multidisciplinary Health Care Module in the second year of our twenty-first century curriculum will provide dental students with a ten-week immersion in four areas where oral health care providers and other types of health care professionals are likely to interact on an ever-increasing basis. Because of anatomic proximity and the cross-disciplinary nature of many diseases and abnormalities involving the head and neck, dental schools should pursue arrangements with an affiliated medical school to provide a two-week ENT rotation for dental students during this Multidisciplinary Health Care Module. Dental students should also experience a two-week clinical rotation in oncology because of the prevalence of oropharyngeal cancers.

Strong exposure to geriatric and pediatric health issues will be an essential ingredient in the preparation of the twenty-first century dentist and thus should be included in this module. The geriatric rotation could begin with visits to the home environment of the elderly and exploration of the senior citizen's world. For example, pairs of freshman medical students at the University of Texas Health Science Center at San Antonio meet with "senior professors" who are geriatric volunteers willing to share their life experiences and medical histories with students. During meetings which take place in the geriatric mentor's private homes or in assisted living facilities, the mentors share with students their observations about health, the aging process, communication problems, dealing with physical and mental limitations, and family issues. Students interview the mentor to gain an appreciation of the senior's longitudinal health history and learn about pivotal life events from the point of view of the geriatric mentor.[80] A similar program would be valuable for dental students, perhaps involving geriatric mentor visits by mixed teams of dental and medical students. During subsequent modules in the clinical phase of training, dental students should provide dental care to geriatric patients at the school clinic and at long-term care facilities or older adult residential communities. The case mix of geriatric patients should include marginally impaired, functionally dependent, and the frail elderly in addition to well patients, so that students encounter the full spectrum of health status. Development of mechanisms to support the training of dental gerontologists should continue to be a priority for the dental

education community. The pediatrics rotation in the Multidisciplinary Health Care Module should expose the dental student to the dynamic interplay between oral health problems and childhood diseases such as asthma, upper respiratory infections, cystic fibrosis, and nutritionally based developmental problems.

The two-week mini-modules scheduled twice annually in the second, third, and fourth years of the predoctoral program can also provide opportunities for cross-disciplinary clinical experiences. During mini-modules, dental students could acquire additional exposure to ear-nose-throat disorders, head and neck oncology, care of the elderly, and pediatrics. The mini-module menu could also include experiences in other multidisciplinary areas—for example, genetically based craniofacial anomalies, maxillofacial prosthetics, TMD, reconstructive surgery for facial trauma, oral manifestations of immunosuppression and other systemic diseases, substance abuse, and psychosocial/behavioral issues including neglect and physical/sexual abuse.

Building Alliances for Multidisciplinary Education

Creating the alliances with other components of the academic health center that are needed to implement cross-disciplinary education will not happen overnight; in reality, we're looking at a ten to twenty year "runway" to launch these collaborative activities. However, medical-dental school alliances already exist in several well-recognized areas which suggests that obstacles are not insurmountable. The anesthesia and surgery departments in medical schools have a long history of cooperation with dental school oral surgery departments in support of predoctoral and graduate-level training and the training of individuals for the D.D.S.- M.D. dual degree. At many academic health centers, dental and medical faculty collaborate actively in the research and teaching activities of federally funded Geriatric Education Centers and provide joint staffing for university-operated extended care treatment centers for the elderly. The staff of clinical centers established to treat craniofacial disorders and create maxillofacial prosthetic devices typically include both dentists and physicians working in collaboration. All dental schools have established hospital dentistry rotations over the past twenty years, and several dental schools provide four to six-week hospital externships for their students. From our perspective, at least five long-term strategies for cross-disciplinary "alliance-building" are available: 1) establishing an institutional priority to actively compete for the federal dollars that support multidisciplinary research which historically has led to cross-disciplinary teaching when "cutting-edge" biomedical science is diffused into the curriculum; 2) cross-appointment of dental and medical school faculty in areas with overlapping teaching, research, and clinical service domains such as Pediatric Dentistry with Medical Pediatrics, General Dentistry/Community Dentistry/Public Health Dentistry with Family Medicine, and Periodontics with Cardiology, Endocrinology, and/or Neonatal Care; we have observed that such cross-appointments often produce a beneficial "trickle-down" effect on the curriculum over the long term; 3) budget re-direction in which schools purchase the services of departments in other AHC components—this is a model already used by many dental and medical schools to acquire the faculty time and teaching expertise needed to implement the basic science phase of the curriculum; could a similar approach be used for multidisciplinary aspects of the clinical curriculum? 4) recruitment of dual degree faculty who have the breadth of training and experience to cross over traditional disciplinary boundaries; many dental schools have D.D.S.-Ph.D. programs and employ individuals with dual degrees to enhance the research and teaching missions of the institution; could a D.D.S.-M.D. interdisciplinary specialist be a viable mechanism for blending dental student training with medicine? and 5) service exchange programs in which departments enhance each other's educational or research programs in repayment for clinical services; for example, the dental school provides staffing and equipment for mobile health vans or clinics operated by the medical school's community outreach health program and, in exchange, the medical school provides slots for dental students to participate in specified clinical electives, or, hypothetically, the ENT department provides faculty to support physical assessment labs for dental students in exchange for use of clinical research facilities located in the dental school. Dental schools committed to broadening the educational experience of their students will need to proactively explore these and other strategies. Alliance-building strategies 1 (aggressively compete for multidisciplinary funding) and 2 (cross-appointment of faculty) may be reasonable starting points for this process in that they carry lower levels of threat and implied "turf-intrusion" than strategies 3 through 5.

Reform of the Clinical Education Environment

Implementation of the curriculum blueprint we have described requires changes in the philosophy of the clinical curriculum, the role of the clinical faculty, and the way patients are managed. We recognize that many schools are implementing new approaches to the clinical curriculum including organization of group practice teams, strategies to provide a comprehensive care experience for patients, and provision of better support services for students. However, we also recognize there is not universal agreement among dental school faculty that these are positive changes. New patient or student-centered approaches to clinical education are struggling to gain acceptance in the face of time-honored routines and departmental prerogatives. In this section, we will describe four systemic diseases of the traditional clinical curriculum and recommend enhancements to the clinical learning environment that support the competency-based model proposed in this paper.

Systemic Problems of Traditional Clinical Education

The essence of traditional clinical education in dental school was captured recently in this vivid description: "Our teaching clinics are filled with student-clinicians to whom we provide a list of people in need of dental procedures. We tell the students to contact these people, schedule them into a physical facility that we graciously provide in response to the student's tuition payment, and complete a specific number of procedural requirements within a designated time frame. We then allow these neophyte clinicians, having had the opportunity to complete a few previous procedures on plastic teeth, to simultaneously act as provider and assistant and flounder away. We keep the faculty close by to look over their shoulders, give periodic advice, and request that they redo procedures that do not meet certain criteria. At the conclusion of each procedure, we expect the student to transform from doctor to cashier, and then to appointment clerk, sterilization supervisor, and laboratory technician, so they continue their journey toward graduation."[81]

Although this review of the dental student's clinical environment highlights several curricular health issues, the most critical systemic problem of clinical dental education is the use of requirements to drive student activity. For many years, the dental school clinic has functioned unlike any other clinical training site in the health professions in that it primarily serves the needs of students in their efforts to complete procedural requirements, with patient care as a secondary outcome. But there has been discontent with this model. Ismail observed that "dental schools cannot continue to operate clinics like sandboxes for the future dental professional," providing dental care as a mechanism to meet requirements for graduation.[82] Galbally observed that dental school clinics can no longer be "places where the apprentice dentist learns his/her trade, and where education comes before service."[83] Dodge identified faculty assumptions about student behavior that may explain support for requirement-driven clinical training.[52] He concluded that many faculty believe numerical requirements and time deadlines are essential because dental students are not adequately self-motivated to obtain the clinical experiences necessary to reach competency and, without the threat of punitive incentives, students will not work productively or use chairtime wisely. In spite of faculty reservations about student motivation, several studies have demonstrated that students operating without requirements are equally or more productive than peers in a requirement-driven system, receive an equally diverse clinical experience if not more so, perform as well or better on various indices of clinical performance, and report lower levels of stress.[52,84,85,86] The Commission on Dental Accreditation guidelines clearly stipulate that student educational requirements are not to interfere with the care of patients.

A second systemic problem of traditional dental school clinical education is the lack of faculty role-modeling. Dental students rarely observe faculty treating patients. Faculty are primarily perceived by students as checkers or graders because that is the role they have been asked to play in a clinic system in which the student, not the faculty member, has primary responsibility for the patient. In contrast, students in the educational programs of other health professions spend considerable time shadowing and assisting clinical instructors and advanced students, which provides opportunities to observe more experienced individuals in action as they care for patients.

The third systemic problem is the distracting and disconcerting learning environment created when as many as nine departments (e.g., Restorative, Prosthodontics, Orthodontics, Oral Surgery, Endodontics, Pediatric Dentistry, Periodontics, Community/Public

Health Dentistry, Oral Diagnosis) simultaneously operate clinical training programs and literally compete for the student's attention. Students devote an inordinate amount of time to noneducational tasks, bouncing from department to department attempting to figure out schedules, expectations, deadlines, forms that need faculty signatures, payment procedures, charting procedures, grading criteria, grading forms, and how to sign up for faculty coverage. In this environment, faculty who are perceived by students to be good teachers are invariably individuals who help students cope with the system and overcome logistical barriers, in effect, "running interference" for the students.

Lack of efficiency and patient-friendliness is the fourth systemic problem of traditional clinical education. This is a dangerous combination in an era when AHC administrators are evaluating which clinical services will or will not enhance the attractiveness of their university health plan and also comparing the financial viability of the AHC's component schools. If the dental school and its clinics are to position themselves as a magnet that can attract additional patient populations to the academic health center's medical plan and generate sufficient income to sustain operations, it is essential to create an efficient patient-first clinic operation that stresses service, convenience, flexibility, and quality. Given the projections of DHMO growth, dental student education is not complete without caring for patients in an environment that is service-oriented, and dental school clinics without a patient-first, service orientation will not be competitive with other providers of oral health care.

Clinical Curriculum Enhancements

Philosophically and operationally, patient care should be the top priority of the dental school clinic with education as a by-product of delivering prompt, convenient, and high-quality patient care services. The modular system integral to a competency-based curriculum should be implemented throughout the clinical phase of the student's education. This format will allow students to focus on one set of competencies and one aspect of dentistry at a time without the time-consuming and frustrating distraction of trying to deal with several clinical departments simultaneously. We agree with Mulvihill's recommendation that the school's patients should be the responsibility of the faculty, not the students.[56] Faculty should assume primary responsibility for the appropriateness, quality, and timeliness of care provided to patients and should actively mentor students in patient management techniques. This arrangement will require collaboration between faculty and students to triage patient status, develop plans, and deliver the care patients need, a process that will increase opportunities for students to learn from faculty. It will also allow students to observe faculty in a care provider role. Resources will need to be devoted to professional development programs that prepare faculty for these new roles. The outcomes of the Robert Wood Johnson curriculum innovation project and evaluations of other instructional improvement efforts demonstrate that preparation of faculty to assume new academic duties is vital to successful implementation and maintenance of the reform.[87,88,89] The structure and characteristics of effective professional development programs in the health professions for improving teaching practices have been studied extensively. Cohen and Wilkerson provide guidelines for conducting faculty development programs that should assist dental schools in establishing this essential part of curricular renewal.[90,91]

Clinical requirements and daily grades should be eliminated. With the sophisticated computer software packages available today, there should be no reason not to implement an "invisible hand" system that monitors student productivity and performance and indicates areas in which the students need additional experiences. Daily grades require tremendous effort to collect, enter into databases, and tabulate, but they add very little to our understanding of student competence since the mean scores for all students almost always fall within a very narrow range. Well-prepared and poorly prepared students often have very similar clinical averages based on daily grades. Daily grades also have been shown to correlate poorly with clinical practical examinations in which the student must show what he or she can do when working alone.[92] As a substitute for daily grades, student assessment should be based on the three triangulation data sources previously discussed: 1) the team leader's evaluation of the student's longitudinal progress during the module, including patient management, technical skills, and professional demeanor, 2) competency examinations, and 3) a written, case-based examination for each module prepared in the same format as the cases in part two of the dental national boards. The patient screening process should be modified so students come into contact with more patients with medical co-morbidities and more frail or elderly patients. More emphasis should be placed on promptly resolving the patient's immediate oral health problems and reducing the number of treatment planning appointments to the number that patients would tolerate in private practice.

We recommend that students spend at least one week per year providing dental care at an off-campus community site, particularly in underserved areas. Teleconference technology can link students at remote clinical sites to the dental school so they can participate in conferences and meetings. Team leaders of the modules can also consult with community site students on patient care issues via the same technology. Town-gown issues always cloud discussion of dental school movement into the community, but we believe it is in the best long-range interest of schools and students to pursue opportunities to diversify clinical training environments. Other AHC components are pressing ahead with efforts to provide a continuum of services and educational sites that include high-technology tertiary care, ambulatory outpatient clinics, day surgery facilities, community primary care clinics, rehabilitation services, mobile clinics, and home-based care.[56] In another reach-extending mechanism, AHCs are also creating or joining hospital and clinic consortiums in various locations throughout their states, thus expanding the school's service area and patient pool as well as creating more clinical sites for students and residents.[79] If dental schools are to build and maintain professional relationships with other health professions and improve public access to services, they "must be willing to migrate from the relatively peaceful and often artificial isolation of student and faculty dental clinics."[56]

The Sociology of Change in Dental Schools

After assessing the wreckage of a failed attempt to revise the curriculum, a medical school dean once succinctly captured the challenge of reform: "It is not enough to have good ideas. There are other factors that are much more powerful."[93] To explore these "other factors," we'll return to Churchill's adage—"the winds of change are blowing and we lean into them with equal measures of anticipation and dread." It has been our experience that the winds of change are likely to stimulate more dread than anticipation among faculty and administrators in higher education institutions. Goffee and Jones and Berquist studied the culture of universities and the values of faculty as the basis for analyzing adaptability to change, and Delbecq examined the extent to which health center administrators valued teamwork and collaboration.[94-96] They observe that university faculty value independence, desire autonomy, and do not value collaboration, but have a strong need for job security and insulation from risk. Goffee and Jones depict the organizational culture of an institution on a matrix with two axes—solidarity (defined as the cohesiveness of purpose among components of an organization) and sociability (refers to the interpersonal relationships among individuals working in the organization). The levels of solidarity and sociability among the institution's members can be high (strong sense of solidarity and much sociability) or low (weak solidarity and minimal effort at sociability). Goffee and Jones conclude that "university faculty, identifying more strongly with their disciplines than with the university itself, typically lack solidarity. Their interpersonal relationships (sociability) may be distant as well, placing the university low on both solidarity and sociability," thus making the university culture unusually resistant to change.[94] Delbecq found that administrators of medical centers placed low value on teamwork among disciplines and that conventional rationales for collaborative effort were unsuccessful motivators in this environment. Dentists have been described as cautious, and conservative, valuing orderliness and conformity, with a desire to control events.[97] Not surprisingly, the

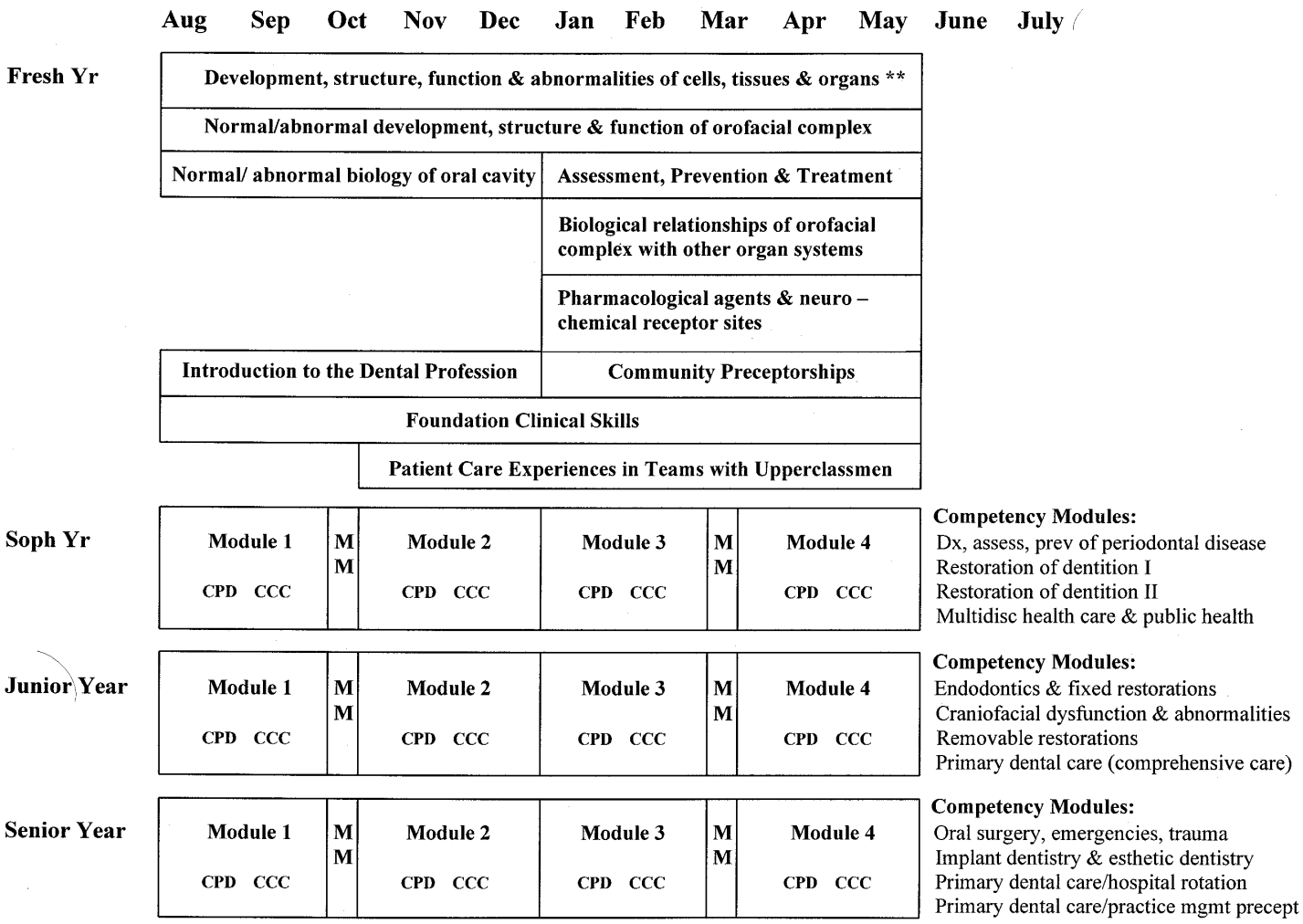
Figure 4. Response to institutional change

Denial	Self-protective state to avoid being overwhelmed
Resistance	Mourning & distress; passive-aggressive resistance
Acceptance	Inevitability of impending change is recognized
Bargaining	Attempts to piecemeal or sequester the new plan
Exploration	Future-focused thinking about how to integrate new plan into mainstream of institution
Commitment	Proactive efforts to make new plan work effectively
Comfort	Plan is no longer "new" but is perceived as routine and "our way"

Figure 5. Approaches to curriculum development

Mount Olympus	"This is what we're going to do!"
Preemptive Strike (Sneak Attack)	"Oh, by the way, we now have a new clinical ..."
Attilla the Hun	Mandated across-the-board percentage cuts (scorched earth policy)
Fire-Fighting	The most common form of curriculum change but basically "pothole-filling"
Departmental Review	Produces minimal reform due to effect of "fox guarding the chicken coop"
Interdisciplinary Peer Review	Curriculum plastic surgery (nip & tuck) due to faculty hesitancy to be critical
Assessment and Diagnosis Model	Parallels scientific decision-making process (See Figure 7)
Competency-Based Planning	Top-down process linking practice behaviors to competencies and then to subject matter

Figure 6. Proposed twenty-first century curriculum



** Includes modules on development, structure, function and abnormalities of cells, tissues and organs (except the orofacial complex), metabolism and nutrition, and infectious processes/host response.

Modules = 10 weeks duration; students devote 30 hours per week to module theme
MM = 2 week mini-module for clinical or research electives or patient care in a walk-in clinic
CPD (Clinical Practice of Dentistry) = Two hours per week during modules
CCC (Comprehensive Care Clinic) = One day per week (8 hours) modules

independent yet cautious nature of faculty is reflected in the overall structure of higher learning institutions including dental schools. Hutchins's observation that universities are a series of separate departments held together by a central air-conditioning system remains an apt description of the discipline-based structure of dental and medical schools in the 1990s.[93] Ebert and Ginzberg describe medical schools as "a confederation of semi-autonomous fiefdoms" which seemingly exist to compete with each other for treasure (institutional resources), territory (office, laboratory, and clinic space), and political influence (curriculum time).[98] Our experience suggests that the fiefdom analogy is applicable to the majority of dental schools. If, as Julius Caesar observed, "commerce follows transportation," then curriculum follows the school's organizational chart.[99]

Given these factors, resistance to change in the university and health center environment is the norm rather than the exception. Dental education is not alone in its inability to institute meaningful reforms. In 1989, Samuel Bloom published a classic case-study of medical education: "Structure and Ideology in Medical Education: An Analysis of Resistance to Change."[100] Bloom reviewed the myriad efforts since 1920 to improve the content and structure of medical education and observed that the process was characterized by "reform without change," a conclusion echoed by Christakis who assessed the impact of nineteen national-level reform efforts this century.[101] Bloom and Christakis concluded that organizational structure and the cultural environment of the institution are major barriers to educational revitalization. Several studies have also linked curriculum reform failures to the power imbalance between academic departments that control budget and personnel assignments and school committees charged with curriculum review and development.[102,103] The latter have responsibility, but no budgetary or personnel control to ensure recommendations are implemented. On the positive side, Bussigel's case-histories of curricular innovation demonstrated that forceful leadership by the dean can mitigate the effects of this power imbalance.[104] The goal of the Robert Wood Johnson Foundation's curriculum innovation project which provided funding to eight medical schools was to "introduce new methods of instruction into curricular revisions and to find innovative ways to support learning in students' preparation for practice in the 21st century."[75] Assessment of curriculum innovations in these schools reinforces the critical role of the dean in the pivotal stages of reform: visualizing the need for change, selecting appropriate leaders to guide the reform effort, deflecting departmental resistance as the reform plan takes shape, and standing up for the reforms in "crunch-time."[105]

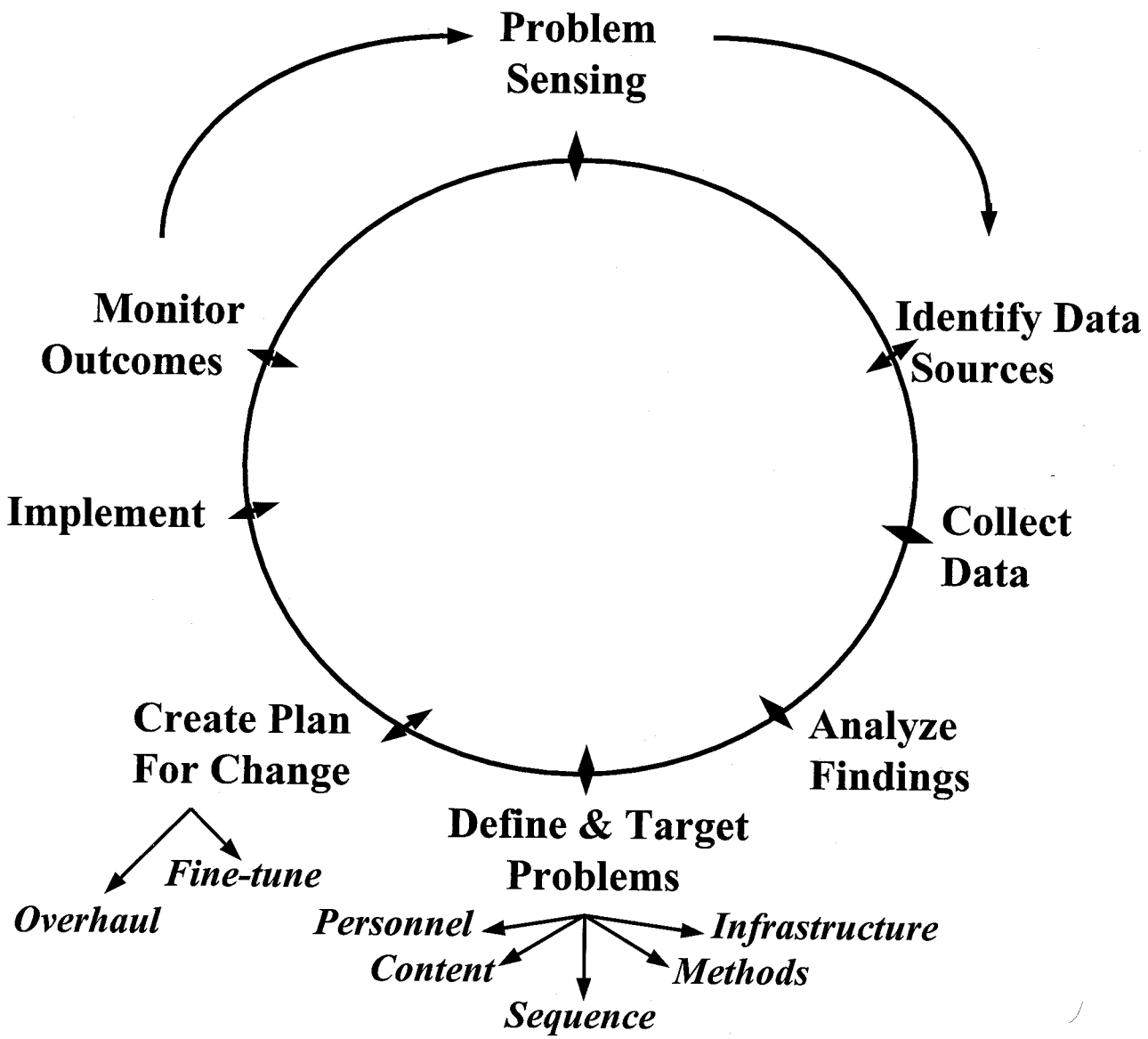
The process by which educational institutions respond to impending changes in policy, resource allocation, or structure is also predictable. Reform efforts in institutions with complex infrastructures proceed through the phases represented in Figure 4.[35,106] Most reform efforts fail to move beyond the denial or resistance stages, particularly when they are not provoked by a galvanizing event that reflects poorly and publicly on the institution. Reforms may reach the bargaining stage if leadership persistently focuses attention on the problem and articulates a viable solution (e.g., a new organizational reality), a process known as "reality framing."[107] Levine identified enclaving and piecemealing as effective bargaining strategies that block educational innovations.[106] Reforms often are enclaved, or quarantined, as a detached "special" program that sequesters reformers away from conventionally minded faculty. In piecemealing, departments selectively adopt certain components of a reform package while ignoring less-agreeable aspects. Because enclaved or piecemealed reforms can be implemented without disrupting discipline boundaries, departments will bargain-down to these limited reforms that have negligible impact on the school as a whole, a minimalization process leading to Bloom's "reform without change."

Enhancing Efforts to Reform the Curriculum

Figure 5 reviews approaches to management of curriculum reform we have observed over the years. Draconian strategies (e.g., Mount Olympus, Preemptive Strike, Attilla the Hun) are tempting but are likely to produce passive-aggressive resistance and subtle sabotage. Imposed reforms erode when the CEO that dictated the change departs the institution. The Robert Wood Johnson curriculum innovation project, and our own experience, indicates that educational reform is more likely to evolve from a well-managed and broadly based review.[87] Accordingly, we believe the following recommendations will help future curriculum reform efforts:

1. The AADS should establish a task force to create and disseminate models of predoctoral curricula that

Figure 7. Monitoring and revising educational programs



incorporate the various reforms. Most dental schools have operated the standard discipline-based curriculum for decades (yr 1 = basic science lecture courses with a few preclinical labs; yr 2 = preclinical lecture and lab courses, a few basic science courses, and a get-ready for clinic experience; yrs 3 and 4 = primarily clinical, often divided into specialty-focused and generalist-focused components). Few faculty have experienced educational programs that are not close approximations of this standard model. This is a limiting factor when seeking new approaches because teachers teach the way they were taught.

2. The AADS should develop training workshops that demonstrate how to orchestrate a curriculum remodeling process. In consulting with dental schools over the years, we have encountered stories of failed reform efforts that produce faculty cynicism about curriculum renewal efforts. Often, the individuals placed in charge of curriculum overhauls have no experience with such endeavors. One common shortcoming is the failure to base the review on a model that identifies data collection, analysis, planning, and implementation steps and which can be used to communicate the overall process to the varied constitu-

encies of the dental school community. For example, we have found that the cyclical "assessment and diagnosis" curriculum review process in Figure 7 is readily understood by faculty because it corresponds to the sequential scheme of scientific inquiry.

3. One of the barriers to curriculum reform is that the characteristics of the desired product are vaguely defined at the onset, or not defined at all. To avoid this, a broadly based faculty committee should create guiding principles for the predoctoral curriculum prior to commencing the remodeling effort. These guiding principles should describe the characteristics of an ideal or "gold standard" curriculum which can serve as outcome measures to evaluate the success of the remodeling. These principles should be communicated to the faculty for discussion, modification and eventual approval by appropriate faculty governance groups, and endorsement by the chairs of the school's academic departments, again, for emphasis, *before* starting curriculum review.
4. School administrators who launch curriculum reform should articulate the goals of the voyage they are asking faculty to make. Is the outcome to repair specific problems (e.g., pothole filling), to conduct a comprehensive review of the entire program (e.g., the executive physical), or to create a new curriculum without active review of the current program (e.g., the ground-zero approach)? Conflicts occur when the scope of remodeling is not consistent with the expectations of school administrators.
5. Bloom and Magill observed that the discipline-based structure of health professions educational institutions is a direct descendent of the organizational structure of the German research university as it emerged in the latter half of the nineteenth century[100,108] (e.g., curriculum follows the organizational chart). In 1870, subdividing university resources along purely disciplinary lines made sense because cross-disciplinary research was not even a consideration given the dim awareness of biological mechanisms underlying human health and disease, virtual ignorance of bacteriology and virology, and the unsophisticated technology available to investigate biological questions. However, as dentistry and dental education enters the twenty-first century, does the organizational structure of the nineteenth-century German research university still provide the most appropriate environment for oral health research and for educating oral health care professionals? Academic administrators will need to address this critical question as part of the curriculum reform process.
6. A special issue of *Academic Medicine* reviewed the preliminary outcomes of the Robert Wood Johnson curriculum innovation project and provided observations about the process and politics of curriculum reform.[72,75,87] We selected ten "lessons learned" from that project that are pertinent to the task at hand for dental education:
   - How did change begin at these schools? It began with a vision articulated by a small group.
   - Those who envisioned innovations were not always the best people to win consensus.
   - Implementing a well-integrated curriculum requires strong leadership and overcoming departmental barriers.
   - Leaders played an important role by assuring incentives and rewards for faculty members involved in the change process.
   - Successful leadership strategically bypasses challenges. Pockets of resistance from faculty members and departments related to the innovation are often best addressed at a later date when the innovation has been institutionalized and the resistance isolated.
   - Consistently, changes were most successful when they reflected broad-based ownership of the innovations. Most schools used several strategies to attract broader faculty ownership and greater creative input—case discussions, forums, symposia, demonstrations of learning methods, and ongoing dialogue about education.
   - All programs found students helpful to the change process; because students experienced the entire curriculum, their thoughtful feedback and suggestions were invaluable.
   - The educational development of faculty members is an essential ingredient in significant curriculum reform.
   - Authority, accountability, and allocation of resources for education sometimes became confused when a traditional departmentally controlled curriculum became interdisciplinary.
   - Attempts to centralize the budget for education led to resistance among chairs who were accustomed to flexible use of funds that had been earmarked for education.

We'll conclude with a reminder from the sixteenth century:

> There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things—because the innovator has for enemies all those who have done well under the old conditions . . . but only lukewarm defenders in those who may do well under the new.
>
> —Niccolo Machiavelli, *The Prince*[109]

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Supporting Teaching and Learning in Schools Level 3 will introduce you to the role and responsibilities of a teaching assistant. Modules on child development and the safeguarding of young people will teach you the best care for children and adolescents, whilst units on school organisation and professional relationships will offer you insight into policies and procedures of the school environment. Along with this, the study of teaching strategies, assessment planning and learning techniques will prepare you for the everyday classroom routine. By the end of this teaching assistant course, you wi