Observation, Assisting, Apprenticeship: Cycles of Visual and Kinesthetic Learning in Dental Education

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Abstract: Dentists are self-selected for visual and kinesthetic learning preferences. Watching another practitioner perform treatment can be incredibly didactic, both before and after learning the procedure. This missing part of dental education has the capacity to play a tremendous role in dental education for all levels of practitioner. Dental students in their clinical years begin to realize the meaning of dentistry as a practice, a set of skills that are never perfected. Abundant evidence demonstrates that cycling between observation and practice enhances procedural learning and retention, yet this mechanism is vastly underused in dental education. Collaborative treatment paradigms, wherein the able student assists a more experienced practitioner, can create mentorship. Learning potentially esoteric information or subtle nuances of clinical acumen is facilitated by the contextual framework of the clinical environment and is strengthened by emotional attachments through interpersonal interactions. In this article, we explore the evidence surrounding mentorship and clinical observation both before and after students are given the responsibilities of patient care, which together recapitulate clinical apprenticeship. Finally, we present examples of how apprenticeship can be brought back to dental education, including evaluation of a clinical assisting program that we implemented and explanation of a hypothetical faculty-student practice partnership model.

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"There are three types of people in this world: those who do not learn from their mistakes, those who learn from their mistakes, and those who learn from the mistakes of others."
—Ancient proverb

Before the modern era of school-based dental education was launched with the founding of the Baltimore College of Dental Surgery in 1840, the common progression into clinical dental practice required long apprenticeships. Dentists learned their trade through cycles of observation and closely guided practice, which allowed those dentists who were genuinely passionate about the dental arts the opportunity to continually polish their skills. Within such a framework, each dentist was consistently engaged as student, practitioner, and teacher. While apprenticeship training was highly dependent upon the skills and quality of each individual dental mentor and the validity of each instructor's qualifications, this student observer-teacher guide relationship provided a framework of apprenticeship training that can be reapplied quite favorably today.

The advent of formalized education has standardized our dental training and methodology. This has moved dental education from an almost completely unregulated process fraught with profit-based diploma mills and licensure fraud to a system of regulated education that serves to ensure members of the public that their dental practitioner has the required amount of knowledge, skills, and experience. Yet, we may have lost something along the way in the transition to our current system of formalized dental education. The steps of a clinical procedure are made

available and often explained, but a picture is worth a thousand words and we assert that a demonstration is worth a thousandfold more.

Today, for instance, as dental students we read about the anatomical, neurological, and pharmacological fundamentals associated with local anesthetic blocks. Yet how many fewer missed inferior alveolar blocks occur when students observe experienced clinicians both before and after learning to do it themselves?

Further, we are presented with pictures and specifications for the standard G.V. Black cavity preparations. We are told to use a 56 bur. But are we ever shown how to get the non-end cutting bur to dig out a proximal box? We are told to elevate teeth, but how many students have ever watched dentists from different schools use a straight elevator? Some practitioners hold the elevator vertically so they do not slip and lance the tongue, while other dentists may have been taught to hold it horizontally so they do not slip and lance the vestibule. Also, there are dentists who prefer to cross the oral cavity to gain better access, while others avoid this technique in fear of hitting contralateral teeth. What are the proper methodologies? Go watch your favorite oral surgeon, and you will learn that for many questions there is no absolute right answer. However, within such observational shadowing you have the opportunity to see what works for an experienced practitioner who has developed expertise in the field via repetitive practice, self-assessment, and fine-tuning of technique that allows him or her to reach a consistently high level of performance.

Today, dental students are too often text-guided, self-taught, and reliant on repetitive self-practice to meet proficiency standards of clinical dental education. Preclinical and clinical work is always corrected when mistakes are recognized, but a standardized approach to demonstration, and particularly cycling between the student attempting a procedure and observing the professor perform the procedure, would set the student on the right path from the first steps, and perhaps avoid much of the need for correction. Must we reinvent the wheel with every procedure and protocol through a process that has many attributes of trial and error learning, or can the student have the opportunity to advance beyond the teacher by first learning the teacher's skills as the foundation from which to progress?

The fundamental educational process for nonclinical doctoral degrees (Ph.D., Sci.D., D.Ed., Dr.P.H., etc.) requires intense and prolonged mentor-student apprenticeships. A faculty mentor guides the student to design, implement, and analyze studies that represent novel progress in human knowledge and abilities, using the contemporary body of knowledge and the mentor's expertise as the foundation from which to begin. The intensity of the experience, which couples novel discovery with the development of the student's career and the mentor's research goals, builds emotional attachment among student, research, and mentor, which in turn motivates the student and enhances the outcome. Relationships such as those that occur between the mentor and doctoral candidate, as well as relationships among patients and practitioners, supplement didactic education by creating emotional attachments to learning.

A recent survey of dental student opinions by Victoroff and Hogan focusing on successful teaching methods provides insights into the student's perspective for development of instructional strategies.[1] One of the key and recurrent observations made by students in this study is summarized by "learning is easier after I see it." Faculty demonstrations were perceived to be essential to understanding: "They were showing us while explaining. . . . It just really clicked." Performing the procedure soon thereafter was viewed as critical to mastery. One-on-one faculty-student interactions in the simulation laboratory and clinic reportedly formed the most powerful learning experiences, which one student described as "a night and day difference." Observing senior students also helped by generating an understanding of upcoming responsibilities for junior students in the dental school clinic. An interesting point from this study is that students did not mention whether experiences in further developing newly acquired skills were important for cementing their learning, nor did they mention cycles of technical skill demonstration, as these instructional strategies do not predominate in dental education curricula.

Our skills are continually reshaped as we progress through our careers, beginning in dental school and continuing through our practice after graduation. Dental educators must take into account how our clinical experiences have succeeded in teaching us and how we actually learn the practices we render. Through advice and example, dental study clubs, colleagues, and patients all affect the way we practice. Speaking with colleagues and mentors about our cases yields insight into the thought processes that dictate our actions, but seeing is believing, and observing the techniques of other dentists catalyzes our mastery of clinical dental techniques.

It's simple but true that before you do something, it helps to see it done by someone else, and once you've carried out the task a few times yourself, you will become more proficient more quickly through continued cycles of seeing and doing. Although faculty members may demonstrate clinical techniques to students as a way to teach by example and ensure patient safety, learning is never perfectly efficient: when do we allow for the progression from safety, to proficiency, to efficiency, to mastery? After a student has performed a technique, it is seldom demonstrated by a faculty member. However, sometimes by the random chance of performing a procedure incorrectly in the dental school clinic or when waiting on a less experienced schoolmate, a student may observe a faculty member demonstrating a non-novel technique, allowing the student to learn not only how to perform a technique appropriately, but how to do it best.

The barrier to learning through observation is built while we develop our skills—a product of the norm within our educational system and our egos. Our ambitions to gain experience through our own treatment of patients can confound the opportunity to observe others during the clinical years of dental school and in practice thereafter. Catching dental students in the preclinical years before they are preoccupied with their own patients is also useful, forming a very reasonable method to increase access to this type of learning. Nevertheless, continuing the development of novice clinical skill sets, or even well-developed techniques, through observation will enhance our profession, the clinical success of our treatment, and the satisfaction of our patients.

In this article, we present a model in which traditional dental education is modified by formalizing a cycle between visual observation and practice (Figure 1). We start by developing an argument for invoking this cycle in dental education from the scientific literature by interrogating the scientific bases for the utility of this approach and reviewing the utility documented for analogous types of task acquisition. We continue by exploring opportunities for applying these principles within predental extracurricular experiences, the dental school preclinical curriculum, the clinical curriculum, residency, and continuing education. We explore the concept of establishing a clinical context for the didactic dental education and assess a preclinical program motivated by this concept that we implemented. We specifically examine the use of multimedia simulations to accomplish the goal of cycling between observation and practice, noting utility bounded by a functional limit related to the importance of interpersonal interactions. Finally, we describe a hypothetical faculty-student partnership practice model invoking the principles of cycling between observation and practice in order to facilitate student education, faculty advancement, and patient satisfaction.

Cycles of Visual Observation and Practice as a Science

Educational models in other surgical fields mandate observational exposure to a procedure prior to performance thereof, as attentive watching is a commonly accepted prerequisite to skill acquisition.[2] Anecdotal evidence found in studies of observation and skill reproduction outside of dentistry can be used to explore the effect of previous and intermittent observation on clinical dental skill acquisition.

Mimicry is an often forgotten tool in learning dental skills. The possibility that motor skills progress solely through physical, hands-on practice and not through model observation has long been evaluated and refuted.[3] In particular, scaling movements of a nature similar to applications of different magnitude are vastly improved following observation as compared to written or oral instruction,[2] thereby significantly enhancing performance of the learned task over time.[4] The underlying mechanisms appear to follow control-related features of movement, showing that movement coordination is acquired through imitation of observed relative motion paths.[3] This mechanism relates operative interventions for differing caries size, root forms, canal lengths, etc.

Prior knowledge that one will need to reproduce a task enhances learning through increased concentration and innate subconscious visualization.[5] It has been demonstrated that premotor and motor neural cortices show significantly increased activity when observing tasks with the intention of subsequent reproduction, as compared to passive observation that is not associated with anticipation of performance of the same task in the immediate future.[6]

Studies in CPR training clearly demonstrate that procedural learning can easily be enhanced by initial and recurrent observational training and hands-on reinforcement of learned skills.[7] Certainly, we have hands-on reinforcement of procedural dental skills built into our educational system, but too

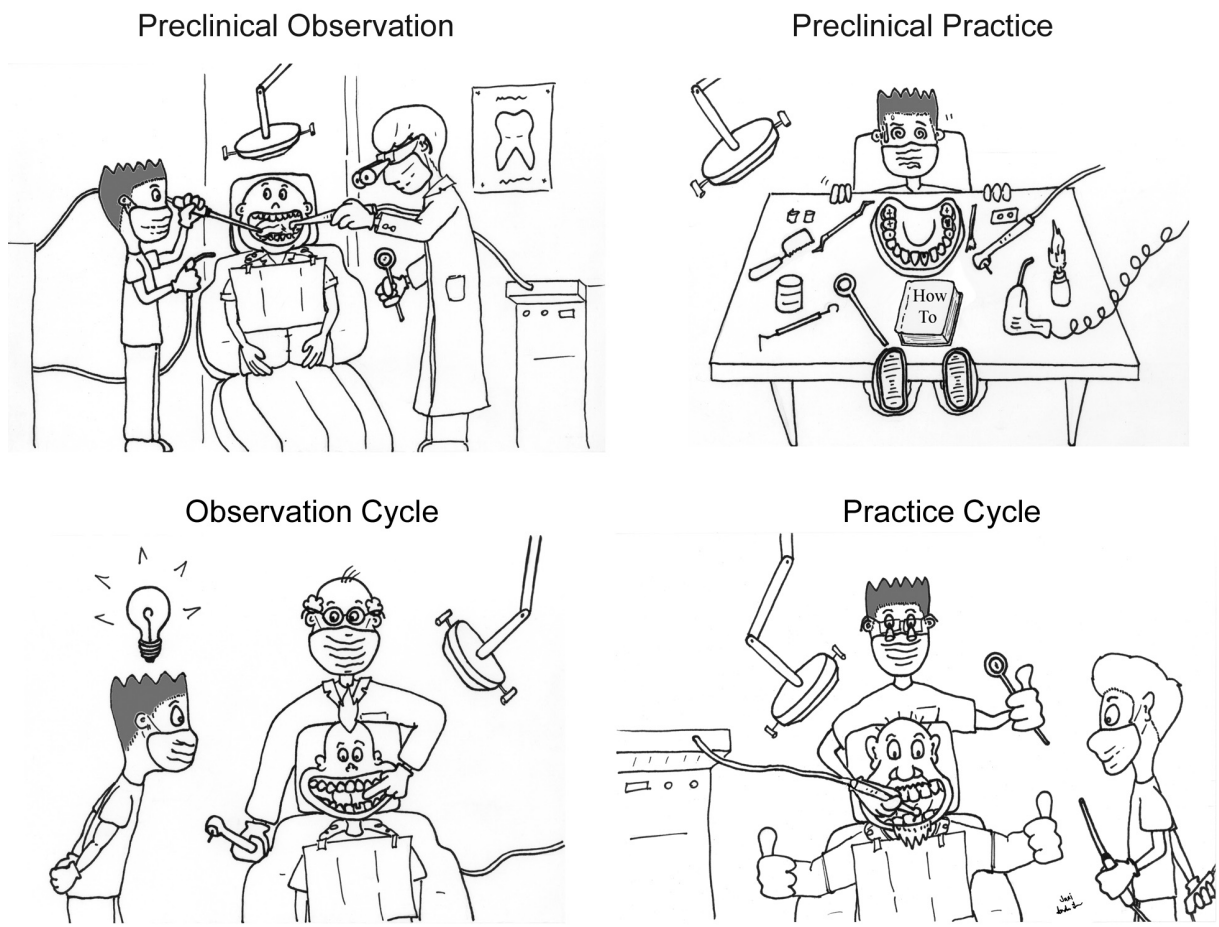

Figure 1. Depiction of dental education enhanced by cycles of visual observation and practice

Note: We render the journey of a student through the various steps towards becoming a dentist, benefited by cycles of observation and practice. In the first frame, the curious predental or preclinical dental student develops an initial understanding of clinical dentistry by watching an experienced clinician; this serves to form a conceptual framework to understand and organize the massive material communicated in the preclinical experience. In the second frame, the student has reached the simulation portion of the preclinical experience, wherein he or she attempts the previously studied and observed procedures. Although the student may understand the principles involved, he or she may stumble on a detail of application; conversely, the student may flawlessly perform the procedure but not grasp the indication for the procedure or some detail therein. In the third frame, we see that returning to the role of the observer, by watching an experienced clinical professor performing dental care, may enable clarification of the stumbling points. Cycling between observation and practice in this way instigates fine tuning of methodology and mastery of clinical acumen. Clinical mastery enables professionalism, wherein the clinician achieves the deep understanding necessary to progress the profession and, as seen in the fourth frame, to nurture the next generation of future dentists. The model supports perpetual cycling between observation and practice to drive personal mastery and develop the future of dentistry.

often we miss both prior and cyclical observation in dental training.

The balance of observation and practice has been constructed through study of relative timing in naïve task acquisition: whether to have observation precede, be interspersed throughout, or follow practice, versus no observation at all. Multiple rounds of model observation preceding initial practice trials, combined with subsequent cycles of numerous practice attempts and model observation, produced better performance throughout learning, immediately following learning, and significantly after training—indicative of skill retention.[8] Our model follows directly from this argument (Figure 1).

Higher levels of experience correlate with enhanced brain activity when observing variations of a procedure, as shown in the higher cerebral activity of professional pianists when listening to an unknown song as compared to nonpianist controls. The difference lies in the fronto-parieto-temporal network,

which is known to be involved in planning and feeds into the premotor and motor cortices for activity engagement.[9] Neural interconnections mediating motor activities involved in rudimentary acquired skills are strengthened through further observation.[10]

The establishment of mirror neurons in the monkey ventral premotor cortex has revolutionized our understanding of the physiologic basis for the role of cyclical observation in action learning.[11] The origins of this concept go back two centuries, to the functional rationale that actions are intrinsically linked to perception: "Every mental representation of a movement awakens to some degree the actual movement."[12] We propose to take this concept one step further and assert that visual observation, whether mental or physical, will enhance task acquisition.

Profoundly similar cortical activity in the motor and premotor cortices are observed when performing, observing, and imagining the same physical task.[13-15] Data have been generated for observing these activities in humans.[16-21] For example, neural imaging experiments have separated responses in primary motor cortex activity when watching purposeless versus purposeful movements involving hand tools (e.g., chopsticks). Remarkably, purposeful use of these tools, analogous to operative dentistry, induced measured cortical activity levels significantly more than watching purposeless movements with the same tools.[22]

These data establish the tremendous importance and real effect of planned cycles of observation on skills acquisition, by separating and balancing the effects of observation and practice in learning and establishing a physiologic mechanism for mimicry.

Predental Clinical Experience

In our interactions with predental students, we notice they often confirm their career choice in dentistry through apprenticeship-like volunteer experiences. Many begin to enjoy dentistry for its hands-on nature. They tend to matriculate already comfortable with the clinical environment, well prepared to assist their clinical colleagues, and armed with a cognitive framework for the vast amount of information they receive during their preclinical education.

Those of us with clinical experience prior to dental school have a tendency to find the subtler concepts of preclinical education more accessible. These students also tend to be more comfortable transitioning into clinic. Involving predental students in clinical care through assisting is an effective means for reinforcing their interest in dentistry and beginning their dental education (Figure 1, "Preclinical Observation" frame).

Each of the authors of this article participated in a large amount of assisting and observing in clinical dental practice prior to entering dental school. Such experience is easily accessible by reaching out to local dentists or the local dental society; in our experience it was sufficient to open a phone book and contact a half dozen dentists within an hour in order to find someone willing to let the motivated student shadow or even assist on a regular basis. As well, community clinics are almost universally willing to train a responsible volunteer who commits to a regular schedule. The administrative and personnel barriers within the medical field that relegate excited premedical students to a hospital gift shop or developing nations simply are not observed when climbing the ladder into dental education. We believe predental students should take advantage of this trend and begin their dental education in this way.

Our experience with the response of dental school admissions personnel suggests a universal appreciation for this type of predental experience. It is no secret that clinical experience improves applicant acceptance. Why is this? Is it simply a concern for knowing what one is getting into and thereby finding truly motivated applicants, or is assisting also thought to have a substantial role in preparing us to become dentists? We believe that one's capacity for depth of observation is facilitated by previous experience.

Deeper understanding of contemporary issues in dentistry will impact students throughout dental school and long afterward by expanding the framework for knowledge learned there. A predental student who has gained an understanding of disease in disparate populations, perhaps by assisting in treatment of patients suffering from oral sequelae of a severe mental disability, systemic disease, or methamphetamine abuse, will be more driven to focus on relevant topics during dental school, thus building interest in these subjects and making caring for underserved populations part of his or her future dental career. Meanwhile, the student learns more through this interest and frame of reference.

Early exposure to clinical dentistry in and out of the dental school setting enhances future dentists' awareness of unsolved problems within dentistry. Students at this level can better form lasting connections to the plight of underserved populations

such as the working poor, the elderly, the young, new mothers, the homeless, immigrants, migrant farm workers, rural communities, battered women, and infectious disease patients. As well, they can learn to appreciate clinical manifestations that challenge contemporary treatment options, such as resorbed edentulous spaces and teeth fractured at the gingival margin. The diversity of clinical dental opportunities afforded outside the walls of our dental schools offers fantastic experiences for predental students to begin their education, which they will then bring with them into the academic environment. Students with such experiences come into dental school excited and prepared by real-world experiential learning.

Observation During the Preclinical Years

A Clinical Context for Didactic Education

Have you ever noticed how quiet most dental school lectures are? Dental students are renowned for their proficiency in memorizing vast amounts of material, and dental school lectures have been refined to a point at which most are actually very clear. However, students with no clinical context for the lectures often miss the opportunity to address many fascinating and challenging complexities of clinical care while they have access to the lecturing faculty—that's why they are "quiet" (Figure 1, "Preclinical Practice" frame). Later, when they enter clinical practice for the first time, they may be challenged to link the lecture material with its clinical application, as we conclude, anecdotally, from an informal compilation of questions asked by clinical faculty during our five years after entering clinical practice. Clinical observation experiences prior to the lectures would give students the familiarity necessary to consider these questions back when they were in the classroom where they can be easily answered.

Under the contemporary model of dental education, students spend their preclinical years learning dentistry with very little actual exposure to hands-on dentistry. How much more could students reap from lectures and reading if they were already generally familiar with the clinical practice for which they memorize the volumes of standard material?

Early clinical experience through observation or assisting creates a workable mental image of clinical dental practice, enabling students to understand the relevance of the classes they endure through their rigorous didactic course schedule (Figure 1). There has been considerable advancement in the understanding of learning with respect to context-dependent memory. Would building a patient care context during the first and second years facilitate improved retention of preclinical coursework until the time students actually apply this knowledge in treatment? A study exploring the role of reflective thinking in the first-year dental curriculum found that, through writing and interviews, active mental exploration into the clinical relevance of the current didactic experience actually enhances learning.[23] Generalizing formal education to the clinical setting at the time of the didactic education is clearly important and can be achieved through simple early clinical exposure.

ECETAP: A Clinical Mentoring Program

We at the American Dental Education Association (ADEA) local student chapter of the University of Washington School of Dentistry (UWSoD) created a program to facilitate a clinical context for preclinical education. The Early Clinical Exposure Through Assisting Program (ECETAP) teams first-year dental students with fourth years, bringing first-year students to assist in the full range of restorative, prosthodontic, and nonsurgical periodontal therapy in the undergraduate teaching clinics, where all are supervised by clinical faculty. First-year students voluntarily assist with complex tasks such as patient management, four-handed dentistry, diagnosis, treatment planning, and documentation and are introduced to the various methods by which to cut through the red tape inherent in every dental school.

Taking advantage of students' excitement about clinical exposure complements our goal of providing a contextual framework for lectures. First-year students enter dental school eagerly expecting to be involved in the practice of dentistry, but too often get their ambitions postponed until their excitement has waned. Before ECETAP, the only clinical experiences during the first two years of dental school at UWSoD were taking a few sets of full-mouth radiographs, making and delivering one set of dentures, providing ten prophylactic cleanings, and performing approximately ten patient entrance interviews—all clustered at the end of the second year. Clearly, there was great opportunity for change. With this program, beginning

students are afforded the opportunity to get involved in clinical dentistry as early as the first term.

Another advantage of the ECETAP is that the excitement and motivation of first-year students help to fill the otherwise inevitable shortage in clinical assistance in the teaching clinics. Cheap labor for the sake of education has its benefits. By gaining assistance in four-handed dentistry, the fourth-year students are also rewarded for their involvement as mentors, since treatment was reported to be more efficient than normal (particularly when the mentee returned multiple times). Note that the practitioner at the right in the "Preclinical Observation" frame of Figure 1 could be a dental student! Hypothetically, this type of approach could compensate for the occasional situation in which a clinical instructor is overburdened, in effect teaming up early clinical students with near-graduates to increase the opportunity for meaningful educational interactions.

The program is now in the midst of its fourth year. The administration requested that the program remain student-driven, and the recent transition to a third generation of student leadership has been carried out successfully. ECETAP has been presented formally and informally to various ADEA Councils and Sections, one of which motivated the assessment of its premise and success that we present here.

ECETAP Assessment

We conducted an anonymous survey of the second- through fourth-year dental students at UWSoD in an attempt to measure the success of the program in preparing students to be more comfortable handling patients and providing treatment. As well, we sought to assess the ability of clinical assisting experiences to facilitate comfort with patient care, thereby interrogating a premise of this article. We collected and evaluated a total of ninety surveys.

The survey covered ten parameters. The first four questions asked students to provide information regarding their experience with the following topics: 1) number of clinic sessions in ECETAP; 2) hours of predental clinical experience (up to ten, fifty, 100, 500, 1,000, or more hours); 3) duration of predental full-time experience (none, three months, six months, one year, two years, or more); and 4) their year in dental school. The subsequent five questions used a visual analog scale to enable more accurate appraisal of subjective response. Those questions addressed the students' perception of the following: 5) value of their preclinical exposure to patient care; 6) comfort with handling patients now; 7) comfort with providing dental treatment now; 8) comfort with handling patients when first entering clinic; and 9) comfort with providing dental treatment when first entering clinic. Finally, we provided an area for free written response. To ascertain the effect of prior clinical experience on comfort with providing care, we measured significance of differences for responses amongst groups separated by amount of clinical experience or participation in ECETAP.

Students with less clinical assisting experience prior to entering dental school (less than 100 hours) expressed greater growth in developing comfort with providing treatment after entering clinic, measured as the difference between the time of the survey and when first entering clinic ($p=0.027$, homoscedastic two-tailed student's t-test). Similar differences were found for comfort in handling patients (but only with less than 50 hours; $p=0.044$). However, no correlations were observed between experience and the magnitude of comfort reported at the time of the survey ($p=0.96$ for handling patients, $p=0.23$ for providing treatment). Additionally, while no direct gain was found for providing treatment when entering the clinic ($p=0.28$), a difference was seen for comfort in handling patients when entering the clinic ($p=0.044$).

We believe that the above data should be interpreted together as such: observational clinical experience prior to being deemed responsible for treatment aids in attaining the maximal comfort for each individual, and the learning curve decreases with length of experience. Directly, many extraneous factors influence one's self-assessment of comfort in providing care, but the difference between the initial and current reported comfort indicates how much comfort one has gained. That is, those with more experience were already closer to their personal best when first entrusted with the responsibility of patient care.

Nonetheless, after separating out the third-year students (who had been deemed responsible for patient care and had entered clinic for over a half year by the time of the survey, were the first to have the opportunity to participate in ECETAP, and were subject to a large curriculum change at UWSoD and thus are relevant to follow-up measures of future students), all measures of students' comfort in providing care to patients were significantly enhanced by having at least fifty hours of clinical experience before dental school, including comfort with handling patients now ($p=0.0033$), comfort with providing dental treatment

now (p=0.0046), comfort with handling patients when first entering clinic (p=0.024), and comfort with providing dental treatment when first entering clinic (p=0.019; Figure 2).

We also sought to measure the effect of prior clinical experience on the perceived value of observational experiences in dental education. Students with at least 500 hours of assisting experience clearly expressed higher appreciation for the value of this assisting as a learning mechanism than those with less experience (p=0.023). This trend continues for students with at least 1,000 hours of assisting experience (p=0.0062), again suggesting awareness and agreement with this approach. As well, there was a nonsignificant tendency for this value to increase as students gained perspective on clinical education by progressing through dental school.

In general, we found estimated hours of clinical assisting experience to be a better indicator of developed understanding and comfort providing care than estimated amount of full-time assisting. However, one difference for full-time experience was notable: the nine respondents with two or more years of full-time involvement in clinical dentistry prior to entering dental school reported higher comfort with handling patients upon entering clinic as compared to all others (p=0.029).

Free responses relating directly to ECETAP revealed widely similar impressions of appreciation for the program and the underlying concept: "Assisting during 1st year, and even more so during 2nd year," said one student, "helped relate our [preclinical] coursework to patient care and gave us students a better idea—and a head start—on how to treat patients." The conceptual framework created by the clinical exposure was clearly recognized by many students and hopefully will aid in long-term retention and clinical acumen. Also, multiple respondents

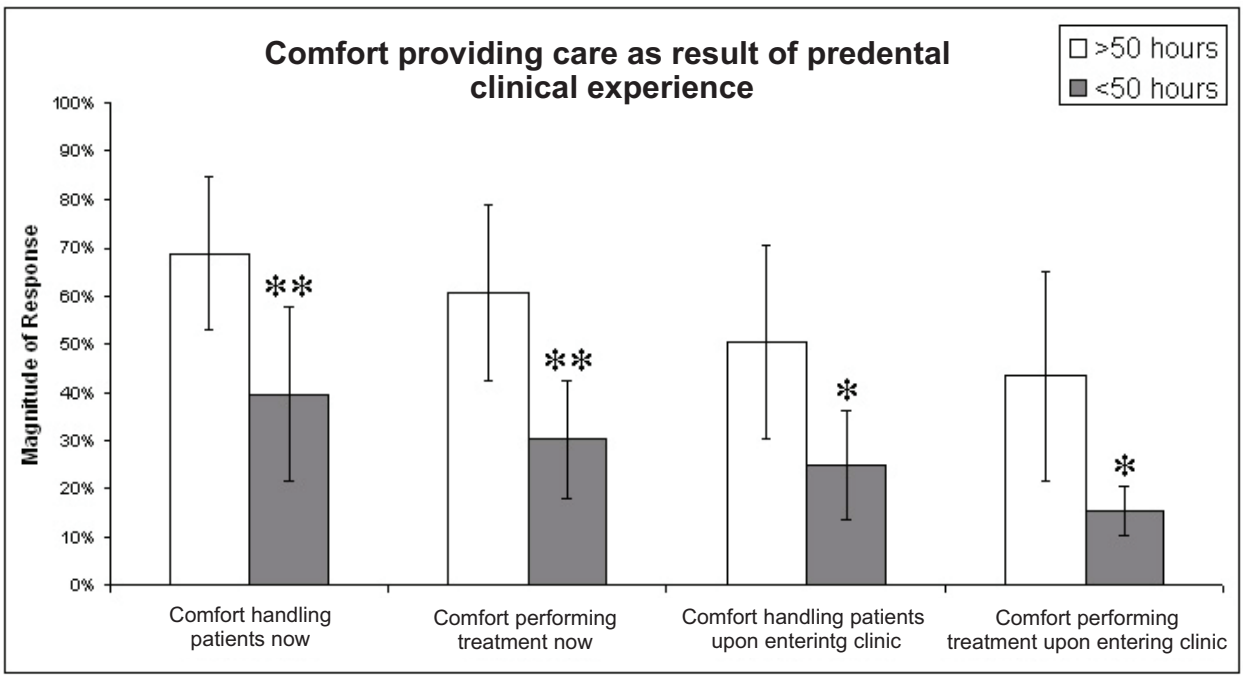

Figure 2. Students' responses suggesting that predental clinical observational experiences enhance comfort in performing treatment and handling patients during dental school

Note: Responses to an anonymous survey of third-year dental students at the University of Washington School of Dentistry indicate that students with more than fifty hours of clinical assisting experience prior to dental school have significantly greater comfort in providing dental care at the time of the survey (**=p<0.005; homoscedastic two-tailed student's t-test) and upon first entering clinic (*=p<0.05), as compared to those with less than fifty hours of predental clinical experience. Responses were significantly different for all four questions of clinical comfort: comfort with handling patients now (p=0.0033), comfort with providing dental treatment now (p=0.0046), comfort with handling patients when first entering clinic (p=0.024), and comfort with providing dental treatment when first entering clinic (p=0.019). Responses were measured on a visual analog scale.

specifically mentioned that this activity made them more comfortable in knowing they will soon be responsible for treatment. "Incorporating us as 1st and 2nd years into clinic was a great way for [us] to gain comfort in the clinical setting," said one. "Before this I didn't really know what the dentist was doing; now I know more than I imagined in my classes, plus where things are/how they work in the clinical settings." Students appeared cognitively aware of the learning mechanisms taking place, directly stating that they, as one put it, "feel better able to plan ahead, prepare, and understand" what will be expected of them upon entry into clinic, as compared to those who did not participate.

Beyond the informal appreciation for the program expressed to us by various participating preclinical and senior students, a clear trend emerged for respondents with less clinical assisting experience to participate more in ECETAP. The median reported hours of clinical experience prior to entering dental school was greater than 100 hours for nonparticipants and less than fifty hours for ECETAP participants.

Involvement in ECETAP correlated to lower levels of change in comfort performing treatment between the time of entering the clinic and the time of the survey ($p=0.027$; Figure 3a), meaning that these students were more likely to feel as comfortable when they enter the clinic as they did at the time of the survey, when they had accumulated more experience. As well, ECETAP students expressed significantly higher comfort in handling patients at the time of the survey ($p=0.016$; Figure 3a). Finally, the value of clinical assisting experience expressed by students who went through ECETAP was higher than those who did not ($p=0.0092$; Figure 3a).

The participants attended a mean of only 3.5 ECETAP clinic sessions and had a median less than fifty hours of previous experience, yet the significant trends across survey respondents are only reproduced for nonparticipants when separating responses by those with over 100 hours of experience ($p=0.013$, $p=0.029$, and $p=0.025$, respectively; Figure 3b). This outcome emphasizes the great potential of observing clinical treatment while acquiring the skills and knowledge of providing treatment: we reproduced the effect of more than 100 hours before dental school with less than ten hours in dental school.

In sum, clinical assisting experience prior to performing clinical procedures, both before (predental) and during dental school (through ECETAP), correlated significantly to higher levels of comfort performing treatment and handling patients upon entering clinic, higher levels of comfort performing treatment after being in the clinic for a while (at the time of the survey), and a higher sense of value for clinical assisting experiences in dental school (Figure 1).

Other Clinical Mentoring Programs

Similar programs to ECETAP at UWSoD exist in other dental schools with slightly different approaches. Some involve more continuous and gradual incorporation into clinical practice. The vertically integrated clinic format of such programs as that of the University of Michigan School of Dentistry (UMSoD) enables an integrated system of education for their clinics through their curriculum.[24] Every student is connected to one student in each of the other classes, and time is allotted for students to attend clinic throughout all four years (personal communication, UMSoD Office of Admissions). Many schools have cross-class mentoring programs, but the common experience of student representatives (e.g., American Student Dental Association, ADEA Council of Students, National Student Research Group) we have heard is that these are often used solely to recycle study materials, as opposed to creating meaningful clinical mentorships that would drive skill acquisition. Once interclass connections are brought into the clinical environment, many doors for applying and interpreting didactic learning are opened.

One can imagine that integration of these mentoring programs into the core curriculum would result in more consistent patient care, a collaborative learning environment, and fewer students falling through the cracks. Specifically, progressive incorporation of clinical observation may facilitate learning for both preclinical and clinical students (Figure 1).

Teachers learn by teaching. When upperclassmen are placed into the role of the teacher mentoring an underclassman, their knowledge is reaffirmed through response to inquiry and instinctual responsibility. As well, the teaching role mandates communication on multiple levels, serving as an exercise in communicating diagnostic and procedural details in logically relevant lay terminology, which translates well into patient care (Figure 1, "Observation Cycle" frame). The student mentors undoubtedly have the prior awareness that they may be questioned by the mentee, and therefore will likely study to refine their pragmatic understanding of clinical principles. In turn, the mentors get feedback from faculty guidance, mentee response, and their own satisfaction. Expo-

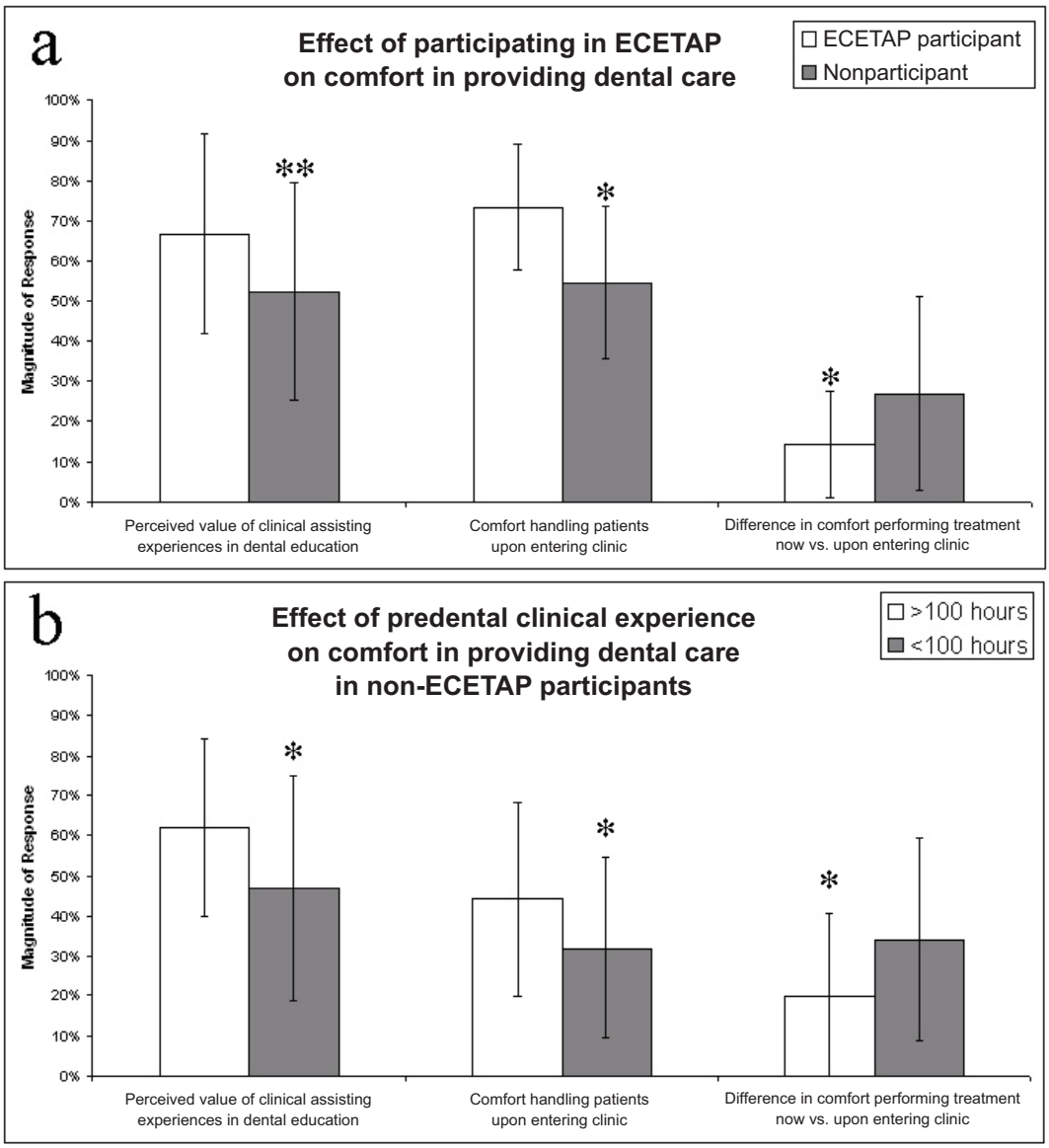

Figure 3. Students' responses suggesting that the Early Clinical Exposure Through Assisting Program (ECETAP) enhances comfort in treating patients, in a manner similar to a large amount of predental clinical experience

Note: To understand whether ECETAP helps students to become more comfortable in providing clinical treatment, we compared participants' to nonparticipants' responses from an anonymous survey of second- through fourth-year dental students at the University of Washington School of Dentistry. Responses were measured on a visual analog scale (*=$p<0.05$; homoscedastic two-tailed student's t-test). We found that a) students who participated in an average of 3.5 ECETAP sessions (2.5 hours each) had significantly higher confidence in providing care when entering clinic compared to nonparticipants ($p=0.016$), which was parallel to that of b) nonparticipants who had greater than 100 hours of clinical assisting experience prior to dental school compared to those who had less than 100 hours of clinical assisting experience ($p=0.029$). ECETAP participants had more closely achieved their end stage confidence (represented as the time of the survey) upon first entering the clinic, whereas nonparticipants had more ground to make up ($p=0.027$). Again, a parallel relationship was observed for nonparticipants with more than 100 hours of predental clinical experience as compared to those with less ($p=0.013$). We believe these relationships indicate that prior observational experiences lower the learning curve for becoming comfortable as an oral health care provider. Finally, the ethical value of clinical assisting experience in dental education expressed by students who went through ECETAP or had substantial previous experience was higher than those who did not ($p=0.0092$ and $p=0.025$ respectively). This outcome emphasizes the great potential of observing clinical treatment while acquiring the skills and knowledge of providing treatment: we reproduced the effect of more than 100 hours before dental school with less than ten hours in dental school.

sure to this clinical teaching role (assuming some positive experiences) may also motivate students to consider a career in academic dentistry, a field we need to nurture.[25]

In a clinical mentoring situation, both students become engaged in cycles of acquiring and demonstrating knowledge, which catalyzes skill acquisition. Publishing assessments of early clinical immersion programs may influence dental schools to integrate such programs into their curricula. We encourage schools experimenting with their curricula in such ways to evaluate them and publish the results.

Multimedia in Preclinical, Advanced, and Continuing Dental Education

The advent of multimedia preclinical simulation laboratories opens the possibility to learning through observation, but the expensive audiovisual aspects of these facilities are too commonly left to collect dust. Continuing education programs take advantage of these opportunities efficiently, but what about our dental curriculum? Regrettably, in our experiences, our school's state-of-the-art system was only used once to demonstrate waxing up teeth and once for preparing composite veneers.

Dental school groups, such as our local ADEA student chapter, have started to create videos of experienced students waxing up teeth and cutting cavity preparations. Expert practitioners such as Gordon Christianson (www.pccdental.com), Clifford Ruddell (www.endoruddle.com), and Richard Tucker (www.rvtucker.org) have developed instructional videos as well. These efforts are tremendous steps in a positive direction, but not a complete solution. Can we ask questions of a video? Many of the cases shown in videos are more ideal than those seen in dental school or community clinics. They often do not elucidate the subtle intricacies of the human interactions in dentistry—for example, treatment planning, patient management, and balancing complex medical histories. Nonetheless, videos of expert demonstration can be an indispensable complement to traditional preclinical education.

Incorporating technology into preclinical technique learning also increases the opportunity for feedback and observing, while decreasing the need for precious faculty time. A study on the ability of virtual reality versus traditional preclinical simulation teaching methods to teach operative dentistry found that faculty time decreased fivefold while maintaining performance quality.[26]

While multimedia can have potentially enormous utility in dental education, it cannot completely substitute real mentorship. Emotional ties and nonverbal feedback (e.g., body language) during in-person interactions build knowledge more deeply than artificial simulations can. In fact, stronger motor cortex activity is observed in people observing movements in others in person than through a video display.[27] However, proper use of video instruction should be embraced by clinical departments to free instructor time and energy for these important in-person interactions.[28]

Most professions have reciprocal peer observation inherent to their structures, such as courtroom law, multiple practitioner surgeries, the stock exchange business, and, of course, all professional sports. But we as dentists are seldom afforded the opportunity to watch each other at work, particularly after graduation when our skill set is deemed clinically acceptable. The opportunity to observe others in action and learn from their performance is all too often absent in dental school as well.

Dentistry is unique even among the health professions in that dental students rarely see their instructors providing patient care. In medicine, naturopathic medicine, traditional Chinese medicine, nursing, pharmacy, veterinary medicine, and other allied health disciplines, clinical education occurs in patient care facilities where faculty serve dual roles as care providers and educators. Students in these disciplines assist the instructor and other members of the health care team in completion of patient care tasks, providing opportunities for continual observation, mentoring, and apprenticeship-type training.[28] What might a model similar to this look like between undergraduate dental students in their clinical years and the attending faculty supervising student patient care?

Some continuing dental education institutes are utilizing progressive strategies for teaching clinical procedures. These institutes demonstrate a profound understanding of contemporary progress in educational methodology and are leading by example. The slogan of the Interdisciplinary Dental Education Academy of San Mateo, CA (www.ideausa.net), for example, exemplifies the simplicity of the apprenticeship model of education: "Hear it. See it. Do it." This institute incorporates multiple day cycles of lecture, clinical demonstration (via live

video feed from the adjacent room) with streamlined accessibility for questions to the practitioners, and a clinical simulation lab in which all individuals have the ability to pause and rewind any part of a video of the filmed procedure. An environment with at most sixteen students and more than one instructor further facilitates individual interaction.

Undergraduate dental schools have the capacity to model this type of education in our simulation labs by teaming video with lecture and reproduction, and we challenge them to do so. The oft-missed keys to learning in dental schools are the ability to watch the demonstration while performing it (e.g., individual access to play and rewind), simple cycles of observation and practice, and being instructed both before and after attempting the procedure.

After completion of dental school, we have access to specialty programs and continuing dental education. Many of these higher levels of education employ an apprenticeship model. There are a small handful of students per instructor. The residents or graduate students often observe and assist the instructor during procedures. There are prior and/or subsequent detailed question and answer sessions. Perhaps we can take the next step in predoctoral education by developing a paired faculty and undergraduate student apprenticeship model to help fill the void in clinical observation, enhancing student proficiency by taking the faculty out of the role of referee and using them instead as shining examples of knowledgeable and capable clinicians.

Undergraduate Dental Faculty-Student Partnership Practice Model

Clinical dental students generally have the chance to observe a master clinician at work only in brief rotations within a traditional chain of command practice such as hospital oral surgery or perhaps when something goes awry during a predoctoral clinic procedure. Active collaboration with a supervisory clinician, cherished within the attending-based model built upon a hierarchy of care providers with differing levels of skill and responsibility (attending/faculty doctor, three to four layers of residents, and senior and junior clinical students), is absent in undergraduate dental school education. This lapse in presenting clinical skills in a real-life, observational context limits the acquisition of clinical mastery for future dentists.

As an analogy, it would be quite difficult to master the skills of a great chef from only reading a recipe book. Preparing meals in concert with the head chef allows the two-way observation, feedback, and unspoken communication so important to learning procedural skills like sports, martial arts, and cooking.

Why is faculty practice not a part of predoctoral education? Imagine a simple paradigm shift from one day per week in faculty practice and another two in the predoctoral clinics to two days per week in a faculty practice heavily involving students. Multiple students serve the role of advanced assistants, who not only set up and clean up, but watch the professor at work and deliver a full range of care at the guidance of the professor. Junior students prepare patients and assess medical histories, senior students anesthetize and isolate, and the professor delivers operative treatment, perhaps with a microscope camera for all to observe, with freedom of appropriately timed questions and further discussion. Roles and responsibilities are progressively titrated to the individual student until nearing graduation when the advanced trainee has risen to mentor junior students (Figure 1, "Observation Cycle" and "Practice Cycle" frames). Traditional predoctoral clinics are also maintained, with the idea that cycling between more and less independent practice enhances responsibility and preparedness for independent practice (Table 1).

This faculty-student partnership practice model supports continuity in clinical development of full-time faculty practitioners, who otherwise can become too burdened with teaching duties for their skills to develop in the same way as that of their colleagues engaged in full-time clinical practice. Combining teaching duties and clinical work in this way also allows faculty members more time for academic enterprises, a consuming responsibility that is growing along with the advancement from traditional practice based on expert opinion to evidence-based practice. As well, this team approach is better suited to teaching the subtler sides of oral health care, such as patient interactions that generate trust and comfort.

The contemporary model of dental education is student-based practice and billing. Placing the faculty back into the driver's seat of clinical teaching and patient care has the potential to create more revenue for the school and for faculty members through enhanced efficiency, higher patient satisfaction (and thus higher return rates), increased numbers of patients moving through the clinic, and possibly from increased rates

Table 1. Characteristics and potential benefits of the faculty-student partnership practice model

For the Patient	For the Student	For the Faculty Member	For the School
• Dental school faculty stay directly involved with treatment and monitor patient outcomes (rather than students' productivity), so patients receive better care. • The treatment for each patient progresses more rapidly, so more treatment can be accomplished for each patient in each session, due to teamwork. • Patients are more likely to be made aware of etiology, diagnosis, procedure, and mechanisms of the methodologies, which form a common motivation for coming to dental schools for treatment.	• The experience creates a contextual learning framework for didactic coursework during preclinical years. • Students learn by the example of faculty, rather than other students. • Students learn from each others' mistakes. • The dental faculty member directly shows students how to perform any or all steps of treatment, including taking turns doing work. • Students gain perspective on long-term treatment plans by more rapid progress in treatment. • Students cycle through learning, watching, and doing.	• Faculty members who stay actively involved in more treatment will continue to improve their own skills and potentially receive higher compensation. • By being directly involved in treatment, the faculty member has better insight into how to gauge each individual student's skills and can adjust the balance of what tasks are trusted to each student accordingly. • Patient preparation is handled in a chain of command fashion, allowing the attending faculty member to progressively, efficiently sequence through treatment of multiple patients.	• The improved reputation of the quality and diversity of care in the school's dental clinics and faculty compensation opportunities have the potential to motivate more dentists to go into academia. • Schools can support more faculty positions because of more income generated from clinical operations. • Faculty members and junior and senior students are simultaneously involved in caring for each patient in a team environment with each functioning at his or her level of experience and skill. • A better approach to half-time positions.

because of the faculty members' more active involvement in the planning and delivery of care.

This model of institutional practice is inherently cheaper to run than private practice because students are the assistants: i.e., you don't pay the assistants, they pay you. Although it would presumably be necessary to keep full-time assistants, fewer would be needed. Students can prepare and work up patients to a further extent than can dental assistants, so doctor time with patients can be quicker. Finally, large-scale practice offers centralized processing of everything from sterilization to administrative personnel and discounted bulk ordering. The cost and time efficiency can keep faculty treatment rates low, which is so important to dental school patient populations.

Dental schools often struggle to stay afloat financially because their in-house clinical operations are so expensive to run, and schools have difficulty offering competitive wages relative to those of private specialty practice owners. However, this comparison may be mistaken because the motivation and leadership that spur independence, and the devotion to clinical excellence that creates lucrative financial opportunities for practice-owner dentists, are actually properly sought in the academic environment.[25] Contemporary faculty compensation packages, including benefits such as retirement plans and health care, can be seen as reasonable because they are favorably comparable to those of practitioners who do not own their practice.[25] Although Bertolami has argued that academic dentistry may not be in so much of a faculty shortage as often publicized,[25] increasing the motivation for dentists to become faculty members cannot but help the cause of quality education, a battle aided by increased income. This new model of education would simultaneously improve the quality of clinical education and enable dental schools to provide better incentives for highly motivated faculty.

Another hypothetical approach similar to the faculty-student partnership practice model was evaluated by Bailit et al. as having the potential to bring a viable shift of $14 million in increased revenue for an average-sized dental school.[29] While assumptions in the model might seem optimistic, incorporating our suggestion of using lower-level students as assistants or preparers will further improve efficiency and generate long-term revenue to help reduce the current deficits of our teaching clinics. While the faculty shortage may have been overestimated, the aftershocks of the economic crash have shown that the financial plight of dental schools was underestimated; accordingly, this type of paradigm change has been heralded as necessary just to keep dental schools open.[30]

If this model were adopted, the best-trained and most-qualified young clinical practitioners (many of whom desire careers in dental education but fail to

seek academic jobs) would have a career option to both practice and teach while spending up to half their time continuing to develop their clinical skills. Such a situation would be markedly competitive compared to less mentally stimulating private practice. The success of such an educational model would hopefully lead back to the universal acceptance that the best practitioners in the land were practicing in the dental schools. Imagine the increased patient flow that would be attracted to dental schools. If dental schools adopted a faculty-student partnership practice model, they could become the equivalent of the nation's best teaching hospitals: the best place for a quadruple bypass surgery or, in this case, full arch restorations (Table 1).

A poignant downside to this model is the possible increased need for faculty time. Use of student and faculty resources would have to be carefully balanced to develop a team approach allowing students to both efficiently prepare patients and have time to observe treatment. The prospect of fundamental changes in faculty compensation and clinic time would presumably motivate more dentists to enter academia. Increasing half-time faculty positions in relation to this model should be investigated.

We believe this model can be implemented in a manner that would improve dental education, enhance patient care, increase dental school revenues, and reglorify the diminishing allure of a career in academic dentistry. It is our position that the benefits derived from a clinical education model built upon the characteristics outlined here can have a substantial impact on the dental education system and overall quality of patient care. Nonetheless, a large concerted effort of pilot study and careful assessment will be required to work out the details of implementation. Truly, it would take major efforts from multiple schools to change or simply add to the paradigm in such a way. We offer this to the dental education community as a challenge, referencing for motivation the argument for an educational model enabling cycles of observation and practice we have built within this work.

Conclusions

Education can be divided into visual, auditory, and kinesthetic modalities[31] and is best conferred by cycling through all three modalities.[8] Reversion is a valued tool for solidification of learning, exemplified by common practice in reviewing tests after they have been returned and punishment for examination failure. Some aspects of these concepts are implicit in clinical treatment in the dental school setting, but it is surprising that they are generally not explicitly exploited in dental education as they could be easily transferred via clinical observation and assisting (Figure 1).

The opportunity for students to observe and assist before the clinical years of dental school can foster a smoother transition to clinic, enhance learning retention, and improve clinician-patient interactions. Students would spend more time with patients, which would ease the transition from working on manikins to live patients. We found in our study that over fifty hours of predental clinical observational experiences significantly enhance comfort in performing treatment and handling patients during dental school (Figure 2). Further, we established that the ECETAP at our school reproduces the increased comfort in handling patients observed for those with over 100 hours of predental clinical exposure with less than ten hours of time in dental school (Figure 3). We also evaluated whether these experiences provide a framework for learning procedural skills, showing that students with significant preclinical observing experiences more rapidly reach their full comfort level in providing treatment (Figure 3).

Students' serving as mentors for underclassmen also provides an experience in guiding assistants (important in clinical practice) and allows upperclassmen to function in the role of dental educators, which may whet their appetite for a career in academic dentistry at some point in their career. The opportunity to observe other practitioners, both faculty and more experienced students, after entering clinic is a crucial but vastly underutilized strategy for bettering students' clinical acumen.

Prospects for simulation technology to substitute for some facets of mentorship in procedural learning have been documented, and these applications hold promise.[25] While there may never be a substitute for the direct interpersonal interactions found in clinical assisting,[26] technological advancements such as high resolution edited video can free instructor time for substantive interpersonal mentoring.

We challenge all dental schools to implement and assess these models with the mission of improving dental education. Implementing clinical observational mentorship will improve the practice of future clinicians and has the potential to make careers in dental academia more desirable. Clinical mentorship as designed in the faculty-student partnership practice model and others described in this

article can increase the standard of care by building a strong foundation of proper methodologies early on in clinical training, placing the master skills of the mentor as the framework for the forming skills of the mentee, and properly setting the stage for innovative improvement in dental skill and ability.

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