Integrating Critical Thinking and Evidence-Based Dentistry Across a Four-Year Dental Curriculum: A Model for Independent Learning


Abstract: Introducing critical thinking and evidence-based dentistry (EBD) content into an established dental curriculum can be a difficult and challenging process. Over the past three years, the University of Iowa College of Dentistry has developed and implemented a progressive four-year integrated critical thinking and EBD curriculum. The objective of this article is to describe the development and implementation process to make it available as a model for other dental schools contemplating introduction of critical thinking and EBD into their curricula. The newly designed curriculum built upon an existing problem-based learning foundation, which introduces critical thinking and the scientific literature in the D1 year, in order to expose students to the rationale and resources for practicing EBD in the D2 and D3 years and provide opportunities to practice critical thinking and apply the EBD five-step process in the D2, D3, and D4 years. All curricular content is online, and D3 and D4 EBD activities are integrated within existing clinical responsibilities. The curricular content, student resources, and student activities are described.

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Evidence-based practice is defined as an approach to health care that emphasizes the best available scientific evidence, clinician expertise, and patient preferences.1 The concept of basing medical practice on scientific evidence is not new; Dr. Archie Cochrane highlighted the limited evidence and use of such evidence supporting health care practice with the publication of his book *Effectiveness and Efficiency* in 1971.2,3 His subsequent activities emphasized the need for evidence-based medicine and resulted in the establishment of the Cochrane Collaboration.2 The Evidence-Based Medicine Working Group published an opinion piece identifying the need to teach evidence-based medicine in the *Journal of the American Medical Association* in 1992, while Richards and Lawrence introduced evidence-based practice to dentistry in the *British Dental Journal* in 1995.4,5

The American Dental Association (ADA) established its Center for Evidence-Based Dentistry in March 2009 to provide clinicians with access to resources and strategies for practicing evidence-based dentistry (EBD).6 In the same time frame, the American Dental Education Association’s Commission on Change and Innovation in Dental Education (ADEA CCI) called attention to the need for dental schools to teach curricular content based on EBD principles, to prepare faculty members to model EBD, and to teach students literature appraisal skills while in dental school.7 The ADEA Competencies for the New General Dentist approved by the 2008 ADEA House of Delegates included in its Critical Thinking domain a competency to evaluate and integrate research outcomes, clinical expertise, and patient values for evidence-based practice.8 About the same time, the Commission on Dental Accreditation...
members of the general public to effectively evaluate health claims. Thus, the dental clinician must be able to help patients navigate oral health resources and evaluate the content using evidence-based practice strategies.

Although the University of Iowa College of Dentistry has historically introduced students to critical thinking as well as access to and interpretation of the scientific literature, the curriculum in the past did not contain EBD language or incorporate the processes underlying evidence-based practice. Over the past three years, however, a core group of faculty members have designed and implemented a new critical thinking and EBD curriculum. The objective of this article is to describe the process by which this school incorporated the knowledge, principles, and application of critical thinking and EBD into its predoctoral curriculum. The process description is designed to serve as a model for dental schools contemplating strategies to incorporate critical thinking and EBD into their own curricula (Figure 1).

Figure 1. Overview of development of University of Iowa College of Dentistry critical thinking and EBD curriculum

Note: Appendices are available at http://myweb.uiowa.edu/tmarshall/MarshallAppendicesJDE2014.docx.
Curricular Design and Development

Developing a new curriculum is a process that must balance the present reality with an idealized future, kept in check by logistical constraints of energy, time, and money. The process is iterative and requires gathering of information, identification of outcomes, consideration of resources, and assimilation of these components into feasible approaches. The development steps we followed are outlined in Table 1.

Introspective Review

Consideration of curricular change is typically driven by an issue of concern—a recognition, for example, that something is not working, that the teaching process could be accomplished in a more efficient manner, or that new knowledge should be communicated to students. Although individual faculty members might identify needs, unless the needs are recognized by the department or college administration, comprehensive change is difficult. At the University of Iowa College of Dentistry, the faculty members charged with problem-based learning (PBL) instruction (i.e., critical thinking and reading the scientific literature) in the D1 year (authors TAM, MWF) and application of science to treatment planning and patient care in the D4 year (CSM) recognized a lack of continuity between their efforts. The emphasis on critical thinking and EBD by both the ADEA CCI and CODA Standards 2-9 and 2-21 caught the attention of the college’s administration, and with their awareness of the curriculum deficit, key EBD faculty members (TAM, CSM, MWF, CMS, NH, MCF) were encouraged to proceed with administrative support and Curriculum Committee oversight.

Identification of the desired outcomes of new curricular content from faculty and administrative perspectives was needed first. Although key faculty members at Iowa understood strategic curricular directions and knew what was missing, they did not have clear outcomes in mind. Extensive review of the EBD literature, Practice Guidelines, interactions with private practitioners, and conversations with faculty members and experts in the area led to the identification of desired EBD outcomes. Our group determined that the desired student outcome of the D1-D4 curriculum was a graduate with the necessary skills to independently apply EBD principles to clinical practice. When faculty members were surveyed to identify EBD outcomes, the desired clinical faculty outcomes included graduating a student prepared to read and integrate scientific evidence during D3-D4 treatment planning and clinic activities. The ultimate outcome was defined as “the development of lifelong learning skills necessary to maintain a cutting-edge, evidence-based clinical practice.” Achieving this outcome necessitated development of a cohesive D1-D4 interdisciplinary curriculum that teaches EBD knowledge and fosters critical thinking, self-assessment, and professionalism.

The D1-D4 curriculum was then distilled into a logical, progressive sequence of manageable learning objectives (Figure 2). The existing D1 PBL curriculum already introduced students to critical thinking strategies and the primary literature. The new D2 curriculum was designed to expose students to the rationale and resources for EBD, while providing opportunities to develop critical thinking skills and practice EBD. The new D3 curriculum was designed to expose students to additional EBD resources, develop their critical thinking skills, and help them apply the EBD process to case patients in clinic activities. The new D4 curriculum was designed to support the maturing of critical thinking and EBD processes and move students from being beginners to minimally competent EBD practitioners.

After identification of desired outcomes, the next step in curricular development was to identify activities to support the desired outcomes. The PBL...
also respect faculty concerns and include evaluation of content resources. To introduce change, careful evaluation of the existing environment as well as exploration of different models of instruction was necessary for us to formulate revised instructional methods.

Evaluation of available resources balanced with required resources for potential instructional strategies is a significant determinant of the structure of new curricular content. At Iowa, physical space was not an issue; large lecture halls and small-group meeting rooms are available for student instruction. The university also supports multiple online resources for teaching purposes, and the libraries provide online access to scientific literature. Curricular time, however, was a significant limitation since blocks of time were not available to introduce a stand-alone EBD course. The PBL curriculum is housed in the D1 Experiential Learning course with instructional components scheduled throughout the year, which allows for integration with concurrent basic and oral science content. Since the D2 and D3 Experiential Learning courses could support yearlong integrated instruction, they were identified as the logical home for the developing EBD content. Experiential learning content was reviewed for overlap with proposed EBD content, and when overlap was identified, content was removed to create curricular time.

Change is often threatening to those affected, and change for the sake of change is usually resisted with good reason. Thus, as with any curricular curriculum introduces critical thinking concepts and seeks to develop expertise in critiquing the scientific literature. The rationale for the PBL objectives is to enable students to apply scientific findings to clinical practice, but the EBD language and process had not been integrated previously into the PBL instruction. Clinical faculty members were expecting students to read the literature and support their treatment decisions with science; however, the specific teaching strategies and faculty expectations in various departments were largely unknown. Consultation with faculty colleagues, as well as surveying faculty behaviors, supported our assumptions that faculty members used evidence to teach and expected students to use evidence—but that each instructor had his or her own way of doing so. Although consistent with evidence-based practice, individual and departmental efforts also lacked the structure and language of the EBD process. The differences between the desired outcomes and current practices defined the gaps to be filled by new curricular content. These curricular gaps included structured critical thinking activities; use of the language, principles, and processes of EBD; and opportunities for guided EBD practice.

**Background Considerations**

For existing dental schools, curricular change must occur within their present environment (i.e., the physical facilities, ongoing curricular activities, student commitments, and faculty resources); it must also respect faculty concerns and include evaluation of content resources. To introduce change, careful evaluation of the existing environment as well as exploration of different models of instruction was necessary for us to formulate revised instructional methods.

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Change is often threatening to those affected, and change for the sake of change is usually resisted with good reason. Thus, as with any curricular
change, it was necessary to include all potential players and to be transparent in the planning process. Although key faculty members (TAM, CSM, MWF) designing the curriculum were invested in the process, we recognized our biases and considered it very important to identify and address a wide range of faculty concerns. We did not know whether our fellow faculty members had the interest and/or knowledge base to implement curricular content associated with critical thinking and EBD. We were pleased that our faculty survey results suggested that most respondents were interested in EBD, supportive of the process, and used evidence to teach in their specialty. However, we were not surprised to find that many of them did not feel comfortable with EBD language and process and that they considered time and resources to be major limitations to EBD implementation. As key faculty members, we also recognized our own knowledge deficits. To address our limitations, two of us (TAM, CSM) attended the ADA/Forsyth Course on Evidence-Based Dentistry, hosted an ADA Evidence Reviewer Program for the college’s faculty, and presented EBD content at departmental and collegiate retreats. In addition, faculty knowledge gaps were considered when we designed curricular content that incorporated student EBD activities into ongoing clinical activities in order to minimize the burden on faculty members.

Identification of content resources (textbooks, videos, online tutorials) and development of supplemental course materials occurred simultaneously with building the structure of the curriculum. As faculty members developing the curriculum but cognizant that we were not EBD experts, initially we did not feel competent to develop our own resources, so we spent time evaluating published content resources to guide student learning. Unlike foundation knowledge committed to memory or clinical skills practiced until proficiency is achieved, critical thinking and evidence-based practice are processes that develop over a lifetime. Since evidence-based practice in the field of dentistry is relatively new and dynamic, we wondered whether the ideal resource truly existed. After perusal of available texts and tutorials on critical thinking and EBD, we concluded that online resources developed by content experts would support content instruction, evolve with refinement of the EBD process, and be readily available to students and interested faculty, both now and in the future. We perceived a unique opportunity with these resources to encourage professionalism and introduce lifelong learning concepts.

Three key points identified during our background evaluation were thus instrumental in developing the EBD curriculum. The first—a limitation of open curricular time—defined the structure of the new curriculum. The second—faculty members’ interest in and support for EBD coupled with their knowledge, time, and energy constraints—encouraged us to create opportunities for faculty education and shaped the mechanism for incorporating EBD into clinical activities. Finally, a realistic acknowledgment of our own time and EBD knowledge limitations resulted in a self-directed learning format modeling lifelong learning behaviors.

Feasibility

In curricular change, the feasibility question—simply defined as what’s a realistic or logical possibility or is achievable in the given circumstances—must always be addressed. The rationale for curricular change as well as the desired outcomes must be clearly and openly communicated and be deemed important by invested parties. Multiple strategies for ways to fill the identified gaps should be identified and critiqued. Objective identification of barriers, strengths, and weaknesses of each proposed strategy must be balanced to develop the best fit for the situation. While anything might be feasible, reasonable consideration of faculty burden (perceived or real) is necessary in order to minimize resistance and facilitate acceptance of proposed changes.

In our situation, the answers to our feasibility questions led us to conclude that the most feasible strategy was to develop a relatively flexible online curriculum that could be integrated into existing clinical activities. As a result, all critical thinking and EBD curricular content is online, with assignments submitted and evaluated online. Defined but flexible deadlines are provided to support student autonomy when scheduling extracurricular activities (e.g., board exams, national meetings, research) and life events (e.g., weddings, babies), while encouraging development of independent learning and professionalism.

Curricular Content and Logistics

Identification of desired curricular outcomes and a mechanism by which to achieve those outcomes was our first step in developing new cur-
rricular content. Next, the content to be included and the tools and activities to communicate content and evaluate student efforts had to be identified and assimilated into a cohesive, logical structure (Table 2). Although this process of curricular design can be reduced to logical steps, in reality the process is cyclical and reiterative with multiple steps occurring simultaneously.

Content Identification

The fundamental gaps identified at Iowa were the absence of structured critical thinking activities, EBD concept knowledge, and EBD practice. We first considered critical thinking expectations: should they be separate from or integrated with EBD activities? During PBL instruction, students are given a lecture that defines and outlines the principles of critical thinking using Paul and Elder’s model, but they do not have opportunities to apply the concepts. We (TAM, CMS, MCF) decided that reflection and critique of peer, patient, and faculty experiences using elements from Paul and Elder’s model would encourage the development of critical thinking skills. We (TAM, CMS) also recognized that sincere critique of negative experiences, particularly involving peers and faculty, required complete freedom to voice honest feelings. Therefore, we separated structured critical thinking activities from EBD activities: the critical thinking exercises are housed in a Reflections track of D2 and D3 Experiential Learning courses and are completely confidential. Reflection including self-evaluation is also incorporated into advanced EBD activities.

Other gaps to be addressed by the new curriculum were the deficit in EBD language, principles, and strategies for practice. From PBL, the students were familiar with some but not all of the fundamental EBD concepts (e.g., PICO questions, research design, five-step process, critical appraisal). After evaluating available online resources, we selected individual components from different tutorials (e.g., PICO from Duke University/University of North Carolina’s tutorial; critical appraisal from the Centre for Evidence-Based Medicine tutorial) for either review or introduction of EBD concepts. Our rationale for selecting multiple tutorials was to expose students to a variety of approaches so they could determine which approach worked best for them. We also identified readings from both lay and professional literature to reinforce or introduce supporting knowledge (e.g., statistics), EBD principles, and the rationale for practicing EBD. Finally, we designed theoretical and clinic-based assignments for the students to practice the five-step EBD process.

Content Sequence

These EBD activities are housed in a separate EBD track of the D2 and D3 Experiential Learning courses. Although the courses are discrete, the key faculty members (TAM, CSM) viewed the curriculum as a continuum, beginning with PBL in the D1 year and ending with didactic and clinical demonstration in the D4 year. Thus, course boundaries were perceived to be artificial, and the content was ordered based on a logical progression and distributed based on perceived workload and concurrent experiences across D2 and D3 years. Fundamental EBD concepts (Elements) were emphasized early, while professional literature (Readings) and the EBD five-step process (Exercises) were more evenly distributed. Professional readings that presented overlapping yet differing perspectives or arguments were spaced throughout the curriculum. The five-step exercises were staged to incorporate new sources of information (e.g., critical summaries, clinical recommendations) after the source was introduced as an Element. Although students are in clinic throughout the D2 year, we recognized that individual patient experiences might not be conducive to a five-step exercise, and students were given the option of basing it on a clinic, lecture, or personal situation. During the D3 year, students historically have been expected to present cases with supporting science in several of their rotations. The five-step exercise is now used to present the science in three of the rotations (Pediatrics, Endodontics, Periodontics), and the written exercises are concurrently submitted online for the EBD track. A fourth rotation (Operative) elected to develop a team-based activity to apply the five-step exercise to a patient case.
Student Activities and Evaluation Strategies

At that point in developing the curriculum, we had identified critical thinking activities (Reflections), tools to communicate EBD concepts (Elements), arguments to support the rationale for EBD (Readings), and opportunities to practice EBD (Exercises). We considered critical thinking and evidence-based practice to be processes to be learned, rather than testable knowledge, and we considered thinking and professionalism to be multifaceted, not discrete measurable units. Our process of defining outcomes for each component, how we expected students to achieve the outcome, and the type of outcome (knowledge or process) resulted in different evaluation strategies for each type of activity.

For the Reflections track, we (TAM, CMS) wanted students to develop a critical thinking process that could mature over time. We developed an assignment template outlining a process for critical thinking and prompts for Reflection topics. For evaluation purposes, we developed a grid consistent with the assignment template. (Template and grid are available at http://myweb.uiowa.edu/tmarshall/MarshallAppendicesJDE2014.docx.) Recognizing that judging thoughts is not appropriate, our evaluation emphasizes process completion, with additional points for deeper or more mature thinking. We decided to use a five-point Likert scale, with a 3 equivalent to 90 percent, in order to de-emphasize grades.

We (TAM, NH) assumed that we needed confirmation that students completed the Element and Reading assignments and that simply assigning activities would not ensure completion. Looking at the purpose of each assignment led to our categorization of Element activities (i.e., resources that communicated a process to be learned) and Reading activities (i.e., resources that provided a professional perspective or shared content knowledge). For each Element, we designed an activity to complement the process to be learned. For all Readings, students were asked to read and respond to the article using a standardized format. These assignments were deemed low key and were evaluated on a pass/fail basis since our primary objectives were to share resources for practicing EBD, encourage lifelong learning, and support professional development. Therefore, completion generally constitutes passing. (Copies of all resources discussed in this section and examples of exercises are available at http://myweb.uiowa.edu/tmarshall/MarshallAppendicesJDE2014.docx.)

The five-step EBD process reflects the integration of patient preferences, clinician experience, and science-based evidence. Thorough completion of the five-step process takes time, yet should be automatic in clinical practice. A solid understanding of the scientific literature is essential for applying science-based evidence. We designed Exercises based on the five-step process; expectation levels for these exercises evolve in the D2-D4 years. We recognize that reading and critiquing the primary literature is difficult, but we consider critiquing the literature to be a necessary skill to practice EBD. Therefore, students are expected to use a primary article as a source of evidence for all Exercises in the D2 and D3 years. During the D2 year, students are expected to critique the primary article using a lengthy, formative process introduced during PBL. As students progress through the D2 year, they are asked to use a critical summary and/or clinical recommendation as an additional source of information. Criteria for critiquing these sources are provided to students. During the D3 year, students are expected to use two resources as evidence for their Exercise and are encouraged to critique their primary article using critical appraisal worksheets for efficiency. Additional emphasis is placed on selection of the best available evidence for the PICO question during the D3 year. Completion of the five-step process is central to EBD, can be judged correct or incorrect, and presents an opportunity for a continuum of learning. The Exercises are considered higher stakes than the Elements and Readings, so they are graded on a 100-point scale using criteria based on the assignment expectations.

The five-step EBD process is formally incorporated into treatment planning and clinic activities (CSM) in the D4 year. The treatment planning activities include didactic content (e.g., case presentations) and integrated clinical application of the five-step process. Students supplement clinical decisions on the floor using the five-step process. In addition, they submit two written reflections for patients with major restorative needs whom they have comprehensively managed. The written reflection challenges students to construct meaning out of educational experiences in the comprehensive management of patients and illustrates the impact of these experiences on their professional growth.

Content Engagement and Retention

The decision to practice critical thinking and EBD is dependent on an individual practitioner’s
Curriculum Evaluation

Ongoing evaluation of new and existing curricula is desirable to improve education. We have actively and frequently sought student and faculty feedback and have made changes in response to student suggestions. For example, D2 students requested multiple small-group sessions—specifically asking that a comprehensive summary activity be replaced with an opportunity to share their EBD Exercises since they missed the peer learning associated with PBL. Small-group sessions were therefore scheduled to present EBD exercises as a prelude to D3 presentations since the D2 schedule does not allow for additional small-group activities. Students also requested fewer critical thinking Reflections, and we compromised somewhere between what we thought was optimal and what students suggested was a reasonable workload. In addition, students have requested a reordering of EBD Readings; they feel that they would have benefitted from having specific readings earlier in the curriculum. These changes have not yet been made since, in some cases, the content is strategically placed to reinforce specific concepts, while in others the content was newly published. As course faculty, we recognize that the EBD content will evolve and that periodic replacement and reordering of the Elements and Readings will be necessary to keep the curriculum fresh and relevant.

In addition to informal feedback, formal evaluation of student EBD knowledge and performance and of faculty perceptions of student performance following implementation of the new curriculum is necessary to confirm changes in student behaviors. We are currently in the second year of curriculum implementation, and evaluation of curricular effectiveness is ongoing.

Conclusion

Development of new curricular content requires identification of educational objectives and desired student outcomes, both integrated with institutional logistics. Implementation of new curricular content necessitates collaboration, patience, flexibility, and ongoing assessment. At the University of Iowa, we designed an integrated critical thinking and EBD curriculum to model independent learning and emphasize accessible online resources, efficient strategies for practicing EBD, and the rationalization of lifelong learning skills necessary to maintain a cutting edge, evidence-based clinical practice dictated by the University of Iowa's educational objectives and institutional logistics.
for EBD. This curriculum will prepare graduates to maintain a cutting-edge, evidence-based clinical practice.

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REFERENCES