Guiding Dental Student Learning and Assessing Performance in Critical Thinking With Analysis of Emerging Strategies


Abstract: Patient-centered care involves an inseparable set of knowledge, abilities, and professional traits on the part of the health care provider. For practical reasons, health professions education is segmented into disciplines or domains like knowledge, technical skills, and critical thinking, and the culture of dental education is weighted toward knowledge and technical skills. Critical thinking, however, has become a growing presence in dental curricula. To guide student learning and assess performance in critical thinking, guidelines have been developed over the past several decades in the educational literature. Prominent among these guidelines are the following: engage the student in multiple situations/exercises reflecting critical thinking; for each exercise, emulate the intended activity for validity; gain agreement of faculty members across disciplines and curriculum years on the learning construct, application, and performance assessment protocol for reliability; and use the same instrument to guide learning and assess performance. The purposes of this article are 1) to offer a set of concepts from the education literature potentially helpful to guide program design or corroborate existing programs in dental education; 2) to offer an implementation model consolidating these concepts as a guide for program design and execution; 3) to cite specific examples of exercises and programs in critical thinking in the dental education literature analyzed against these concepts; and 4) to discuss opportunities and challenges in guiding student learning and assessing performance in critical thinking for dentistry.

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Concepts regarding learning outcomes and program strategies in critical thinking have developed across the educational environment in the last decade. In dental education, the American Dental Education Association (ADEA)’s Competencies for the New General Dentist, adopted in 2008, place critical thinking at the top of the list. Teaching knowledge and technical skills and measuring performance in these areas are necessary but not sufficient for the dentist now graduating to be considered competent. The dental education literature is sparse in dealing with principles of teaching, learning, and assessment of complex thought processes such as critical thinking skills, and performance assessment remains a major challenge. However, an extensive body of scholarship has been developed in the education literature over the past decades that has significant potential for application to dental education. Some of these concepts may seem self-evident but have taken several decades to substantiate. The potential for using these concepts to guide program design and substantiate practices in dental education seems considerable.

In many dental schools, problem-based learning (PBL) has been a key instrument in raising the culture of critical thinking and in changing the social context to group or team learning and problem-solving. However, a widely accepted set of assessment instruments to accompany student learning has not been established. Published descriptions of well-conceived and well-structured programs to guide critical thinking in dental education are growing in number. These descriptions often tell us “what” is being done in specific programs and exercises. Some
also provide insight into “how” specific programs were developed and executed. However, an investigation of commonalities in foundational principles, instructional strategies, and assessments among these programs and exercises has not been attempted. Such an analysis has the potential to provide an opportunity for transferability among dental schools and promote greater consistency in dental education.

After reviewing definitions of critical thinking, the first purpose of this article is to offer a set of concepts from the educational literature that will be potentially helpful to dental educators and policymakers. These include operational definitions; principles in developing exercises, programs, and assessments; increasing the effectiveness of instruction as measured by performance assessments; and coordinating these activities in dental curricula across years and disciplines. In addition, this article will offer a schematic/translational model consolidating these concepts from the education literature as a guide for implementation; cite specific examples of exercises and programs in critical thinking analyzed against these considerations; and discuss the opportunities and challenges in guiding dental student learning and assessing performance in critical thinking.

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### Defining Critical Thinking

Understanding critical thinking is complicated by a lack of consensus on an operational definition. One definition is “the art of analyzing one’s thought process with the intent to improve it.”7 The “art” component puts critical thinking on a different footing from knowledge and technical skills and a dental education culture that generally emphasizes and values elements that are “scientific.” Critical thinking draws from the gestalt of complex thought processes going beyond disciplines, curriculum years, and stage of development. The whole of cognitive, moral, and emotional development can be summarized by the breadth of the perspectives the person can take.8

Critical thinking is defined in the ADEA Competencies for the New General Dentist as “the process of assimilating and analyzing information; this encompasses an interest in finding new solutions, a curiosity with an ability to admit to a lack of understanding, a willingness to examine beliefs and assumptions and to search for evidence to support these beliefs and assumptions, and the ability to distinguish between fact and opinion” (p. 894).1 The University of Iowa College of Dentistry, drawing on Paul and Elder’s definition,7 defines critical thinking as a strategy for evaluating one’s own thought processes. One of the objectives of critical thinking is to identify strengths and weaknesses in one’s thought processes and to develop ways to address the weaknesses. The goal of critical thinking is to achieve a higher level of thinking, a level in which one recognizes one’s own biases, honestly perceives all sides of an issue, identifies needed information, and pursues the best possible alternative for the given situation. Critical thinking provides the basis for self-assessment.

Several words and phrases in these definitions highlight what is distinctive about critical thinking: “analyzing information,” “finding new [alternative] solutions,” “curiosity,” “one recognizes [systematically] one’s own biases,” “perceives all sides of an issue,” and “basis for self-assessment.” In these definitions, critical thinking reflects complex thought processes gained from diverse learning experiences.9–11 At its core, critical thinking demands that the learner ask questions in order to reflect, doubt, inquire, challenge, investigate, and create. This skill is fundamentally different from the skills used in acquiring knowledge of science and technical procedures and requires instructional approaches that are also fundamentally different.12,14

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### Concepts to Guide Student Learning and Assess Performance

#### Cultivating Critical Thinking

Critical thinking is the first domain in the ADEA Competencies for the New General Dentist.1 In the near future, dental education programs must not only teach these skills but demonstrate by accountable assessments that students have achieved competence in this area. To provide assistance in that process, concepts from the education literature hold promise for general background and guidance in program implementation. As will be shown in a subsequent section, several programs in dental education now use some of these concepts, but without
synthesizing them or in referencing this body of scholarship.

A central theme of this educational literature is to put the student into multiple situations reflecting critical thinking. For each situation (exercise), a next step is to emulate the intended activity. If the intent is to assess writing, the idea is to have the students write rather than tell how they write. If the intent is to have the students solve math problems, have the students solve math problems rather than ask how they do it. If the intent is to treatment plan, have the students treatment plan rather than tell how they do it. An exercise in critical thinking begins with a learning construct that emulates the concepts and tasks of the intended activity. The intended effect of instruction can be viewed as the learning construct defined as an idea or theory containing various conceptual elements, typically one considered to be subjective.

The construct should be defined by specific and measurable learning outcomes or objectives and by evaluative criteria to guide the instructor, student, and grader. A common example in dental education is treatment planning (other examples will be referenced later). Validity is increased with fidelity to the mapping and attachment of inferences to the target behavior. Validity is also increased with directness, meaningfulness, fairness, usefulness, and transparency for the learning construct. Directness may be self-evident and means translation of the thought process with an accurate articulation in words, lists, or steps of the thought process. Meaningful and effective assessment is preceded by and predicated on a learning construct that emulates the intended activity.

The development of the learning construct, curriculum, and performance assessments requires agreement among qualified experts (in our case, faculty members) across disciplines and curriculum years. Faculty agreement will center on content of the learning construct, application to the patient or case, and method of assessment. Reproducibility and reliability are enhanced with expanded agreement across disciplines and across curriculum years. The learning construct also serves as the guide for performance assessment. Instructional programs in critical thinking should have enough tasks to reflect the desired activity, be concise enough for practical use, and aggregate across multiple instances.

Exercises and programs challenge students to address biases, self-assess, and consider multiple perspectives to frame and resolve problems (for example, differential diagnoses and therapeutic alternatives). Progressive approaches may get students outside their comfort zone. The assessments are generally standardized or observational by one or more graders. Institutions must develop performance evaluations that are valid, i.e., the result of the evaluation method truly measures attainment of competence.

Assessing Critical Thinking

Guiding student learning and assessing performance are interlocked because the way we test shapes the learning environment we create. Performance assessments have objective and subjective components. The objective component involves knowledge of and rigorous application of the learning construct. The subjective component involves the determination by faculty members concerning the performance level achieved. Because values shape the criteria by which we evaluate the outcomes of our decisions, a subjective component will be part of the process. The subjective component separates critical thinking assessment from knowledge measurement, which is objective.

The subjective component also separates critical thinking assessment to some extent from technical skills with criteria based on measurements. For example, in a treatment planning exercise, a question could be “Does the student have a grasp of basic principles in applying to this patient?” This question can be applied to assess performance of individual items in the learning construct (analytical) or the entire learning construct (holistic) and can be assessed as yes/no or 1 through 5 (or A through F) on an ordinal scale without quantified intervals. This question can be transferred to any subject area in dentistry. A separate assessment rubric can also be used. While faculty/grader calibration in technical procedures relies on measurement and is largely visual, critical thinking skills center on ideas. While it may well be impractical for multiple faculty members to assess every exercise, random assessment/evaluation by more than one faculty member improves fairness and ultimately increases consistency and reliability.

Assessment effectiveness is associated with the number of qualified faculty member/graders following an agreed-upon construct/learning set and assessment rubric in arriving at the same judgment on performance level. Reliability is agreement among qualified faculty member/graders in the students’ attainment of predetermined performance levels (including entry-level competence). So for the above
example in treatment planning, the more faculty members who arrive at similar judgments on student performance, the greater the reliability and effectiveness of the assessment. This process is also different from measurement of knowledge or technical procedures, in which it is possible for a single faculty member or department to develop a program and measure performance. In both cases, calibration of judges and quality assurance are important.

Assessments in critical thinking are not designed to rank students. A single high-stakes assessment of critical thinking is limited in gaining a definitive assessment of abilities. Institutional assessments declaring a student to have achieved entry-level competence in critical thinking will likely involve multiple exercises across disciplines and curriculum years with regular or at least random assessment by more than one faculty member.

Critical thinking skills cross disciplinary lines, while knowledge and technical skills tend to be discipline-based. Institutional coordination is a key element in developing a curriculum that sequentially and progressively builds and supports effective instruction in critical thinking. Examples include patient assessment, treatment planning, self-assessment, searching and critiquing the scientific literature, evidence-based practice, ethics, appointment management, incorporation of technology, and synthesis of main components of care.

Implementation Model to Guide Student Learning and Assess Performance

This section includes a summary of concepts from the educational literature that can be used for implementation in dental education. The model is shown in the three panels of Figure 1.

The first row of the model (panel 1.1) shows a process for guiding learning and measuring performance to gain knowledge. In this process, it is possible for one faculty member (or more) to select facts, deliver the facts (lecture, website, etc.), administer a multiple-choice test, and derive a score. Achievement of acceptable scores in multiple disciplines can determine overall competence for a knowledge core in dentistry. The process is additive for respective disciplines with a separate process for each discipline.

The second row of the model (panel 1.2) shows a single faculty member (or more) defining an outcome for some aspect of critical thinking. A learning construct is then developed to guide learning and assess performance. The student then performs the steps in the construct (for example, treatment planning), and the faculty member assesses a level of performance. Assessment can be by a single question or by an assessment rubric. As will be described in a later section, several examples in dental education follow this version of the model but do not refer to the education literature. The experiences cited in the subsequent section portray a series of rich experiences of individual exercises for students.

Themes from the education literature support the concept that valid, reliable assessment for thinking and judgment increases with agreement on a definition, sound teaching, and repetition across disciplines and curriculum years. This formative approach also brings the benefit of consistency for students. A central theme is to put the student into multiple situations that reflect critical thinking in dentistry, thus bringing increased validity, reliability, and comparability to the learning process and to the assessment.

For any/each of these situations (for example, treatment planning) a learning construct is developed to include steps in that process. In addition to steps for that specific situation/process, additional steps can apply to any of the above situations—for example, seeking alternatives, addressing biases, and self-assessment. The more direct, transparent, applicable, and useable the construct is, the greater the validity. The same construct is used to guide learning and as a guide for performance assessment. For increased reliability, experts (faculty members) across disciplines and curriculum years gain consensus on the content of the learning construct, the application of each step in the patient/case/literature piece, and the assessment mechanism. Knowledge of the steps and systematic application of each step can be assessed objectively. Assessment of the student’s grasp of individual principles as applied to the respective case will be subjective. Reliability increases with independent agreement of calibrated faculty members on the student’s grasp of principles as applied to the patient/case. A single question or assessment rubric can be used to answer that central question. Assessment will be exact enough to determine a general level of performance (which could be called competence) and not exact enough to rank students. Thus, validity, reliability, and comparability (as well as consistency from the student perspective) are increased with a common approach applied to multiple situations.
involving critical thinking, across disciplines and curriculum years. Assessment is thus predicated on sound teaching.

A list of experiences in dentistry reflecting critical thinking is shown in the bottom part of Figure 1 (panel 1.3). One approach can be used for essentially all of the common applications in dentistry shown in panel 1.2, thus increasing the comparability and breadth of perspectives the person can take. Each example crosses disciplines and curriculum years. The more different the situation, the more likely the student will be able to adapt to other situations calling for critical thinking.

A side benefit of the approach is that it is highly compatible with a formative philosophy. Schools are using some of these concepts with the potential

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**Figure 1. Implementation model to guide student learning and assess performance**

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for increased collaboration across disciplines and curriculum years. The approach described here is in stark contrast to a schematic to deliver and assess knowledge that can be done on a disciplinary basis and involves a score. To cross disciplines and curriculum years, implementation of this scenario is more likely to occur in a school through cultural evolution than by prescriptive directive.

**Dental Education Programs to Guide Student Learning and Assess Performance**

To examine the above concepts in critical thinking in emerging dental education programs, we constructed a grid (Table 1) showing concepts for critical thinking from the education literature on the horizontal axis and descriptions of dental education programs in critical thinking on the vertical axis. The descriptions are in selected articles published in the *Journal of Dental Education* from 2007 to 2011. These programs/exercises showed a learning construct to guide critical thinking skills. A learning construct was interpreted as an idea or theory containing various conceptual elements in the form of a list or set with one or more elements considered to be subjective. Our investigation analyzed these exercises/programs relative to the presence or absence of the following concepts, described above: 1) emulating the intended activity; 2) agreement among faculty experts on the learning construct, application, and assessment mechanism; 3) using the same instrument to guide learning and assess performance; 4) random evaluation by more than one faculty member; 5) transferability across disciplines; and 6) incorporating key elements from the definition of critical thinking (seeks alternatives, addresses biases, self-assessment).

We constructed the grid to facilitate comparisons, establish commonalities, and determine if elements of a best practice model could be identified. Two of the articles selected have a learning construct and report results but do not assess performance. These articles are included because both include important concepts to guide student learning and begin a process of assessment. Two of us reviewed each of the articles included in the analysis. There were fewer than five differences, and those were reconciled.

Since we are not aware of this approach being used before, the list is extensive but not intended to be complete. If this approach shows promise, it can be expanded. While each of the articles selected had a clearly defined and fulfilled purpose, not all addressed the items analyzed in this study. Thus, a designation of NP (not present) in the table is not intended as a criticism or a deficiency. Beyond our selection bias, there may also be a publication selection bias, and therefore, it is not possible to know to what extent these thoughtful, well-designed examples represent the current state of dental education.

While the programs analyzed differ in appearance, as no one program is arranged like any of the others, the similarities are significant. First, these programs shared several characteristics that are congruent with concepts from the education literature. Associations included the following: 1) emulating the intended activity; 2) agreement among faculty experts on the learning construct, application, and assessment rubric; 3) using the same tool (e.g., evaluative criteria) to guide learning and for assessment evaluation; and 4) transferability (across disciplines). Second, while these programs use concepts from the education literature, little or no reference is made to this extensive body of scholarship. The opportunity to use this body of scholarship to guide program design and substantiate practices in dental education will be developed subsequently. Third, the programs sampled here fit the “critical thinking, short version” in panel 1.2 of the implementation model (Figure 1). Program development was by one or a group of faculty members working in a discipline or program area. None of the examples use all of the core concepts presented in the “extended version” of critical thinking in the third and fourth rows of the implementation model. The programs sampled demonstrate models that are highly transferable but are presently limited to a discipline or course. Of additional interest is the last column because a basic definition of critical thinking includes seeking alternatives, addressing biases, and conducting self-assessment. The articles sampled may imply these elements, but do not explicitly address them.

**Promise and Challenge**

Emerging programs in dental education demonstrate commonalities of elements and concepts found in the education literature on critical thinking: emulating the intended activity for validity; gaining agreement of faculty members in program design, application, and assessment protocol for reliability;
Table 1. Analysis of programs to guide student learning and assess performance for complex thought processes

<table>
<thead>
<tr>
<th>Article</th>
<th>Program Description</th>
<th>Emulates intended activity; validity with directness, usefulness, transparency</th>
<th>Reliability with agreement of experts on 1) learning construct, 2) application to case, 3) assessment mechanic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Johnsen et al., 2009¹</td>
<td>Treatment planning across disciplines and curriculum years</td>
<td>Yes</td>
<td>1) yes 2) yes 3) yes</td>
</tr>
<tr>
<td>Lipp, 2008 and 2010²-³</td>
<td>Malocclusion assessment</td>
<td>Yes</td>
<td>1) yes 2) yes 3) yes</td>
</tr>
<tr>
<td>Marshall et al., 2011⁴</td>
<td>Literature search and critique, part of PBL</td>
<td>Yes</td>
<td>1) yes 2) yes 3) yes</td>
</tr>
<tr>
<td>Cho et al., 2010⁶</td>
<td>Self-assessment: principles/mechanics of tooth preparation</td>
<td>Yes</td>
<td>1) yes 2) yes 3) NP</td>
</tr>
<tr>
<td>Callis et al., 2010⁥</td>
<td>Basic science problem-solving on physical assessment</td>
<td>Yes</td>
<td>1) yes 2) yes 3) yes</td>
</tr>
<tr>
<td>Allareddy et al., 2011⁷</td>
<td>PBL: demonstrate knowledge acquisition, problem-solving, interpersonal development</td>
<td>Yes</td>
<td>1) yes 2) yes 3) yes</td>
</tr>
<tr>
<td>Licari et al., 2008⁸</td>
<td>Patient assessment and treatment planning assessment rubric</td>
<td>Yes</td>
<td>1) yes 2) yes 3) yes</td>
</tr>
<tr>
<td>Schwartz et al., 2009⁹</td>
<td>Analysis of content of ethics oaths</td>
<td>Yes</td>
<td>1) yes, ADA 5 Principles on Ethics 2) yes</td>
</tr>
<tr>
<td>Berg et al., 2010¹⁰</td>
<td>Self-assessment-patient assessment/treatment planning on rotations</td>
<td>Yes</td>
<td>1) yes 2) yes 3) yes</td>
</tr>
<tr>
<td>Hendricson et al., 2011¹¹</td>
<td>Rated student knowledge, attitudes, confidence accessing evidence (EBD)</td>
<td>Assesses student ability to apply principles</td>
<td>1) yes 2) yes 3) yes</td>
</tr>
<tr>
<td>Mould et al., 2011¹²</td>
<td>Self-assessments: time management and technical procedures</td>
<td>Yes</td>
<td>1) yes 2) yes</td>
</tr>
</tbody>
</table>

Note: Selected concepts from the education literature are on the horizontal axis. Samples of dental education programs with learning constructs published in the *Journal of Dental Education* are listed on the vertical axis. Program characteristics and design are assessed for each program.

NP=not presented in article

Sources:
<table>
<thead>
<tr>
<th>Program Description</th>
<th>Learning guide identical to performance assessment instrument</th>
<th>Random assessment by more than one faculty member</th>
<th>1) Cross-discipline or 2) transferable</th>
<th>From critical thinking definitions: 1) alternatives, 2) addresses biases, 3) self-assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Yes</td>
<td>1) yes</td>
<td>1) NP 2) NP 3) yes</td>
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<tr>
<td>Yes</td>
<td>NP</td>
<td>1) NP 2) yes</td>
<td>NP</td>
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<tr>
<td>Yes</td>
<td>Yes; value added</td>
<td>1) NP 2) yes</td>
<td>NP</td>
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<td>Yes</td>
<td>Yes</td>
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<td>Yes</td>
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<tr>
<td>Yes</td>
<td>NP</td>
<td>1) NP 2) yes</td>
<td>1) yes 2) yes 3) NP</td>
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<tr>
<td>Not intended for assessment</td>
<td>NP</td>
<td>1) NP 2) yes</td>
<td>1) yes 2) NP 3) yes</td>
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<tr>
<td>Yes</td>
<td>NP</td>
<td>1) NP 2) yes</td>
<td>1) NP 2) NP 3) yes</td>
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<td>NP</td>
<td>Yes</td>
<td>1) yes 2) yes</td>
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<tr>
<td>Not intended for assessment</td>
<td>NP</td>
<td>1) NP 2) yes</td>
<td>1) NP 2) NP 3) yes</td>
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</tbody>
</table>

and using the same instrument to guide learning, for performance assessment, etc. While working in one discipline or program area offers a rich experience for students, validity, reliability, and comparability can be increased by engaging them in multiple situations reflecting critical thinking and by involving faculty members across disciplines and curriculum years in gaining agreement on content and assessment methods.

The number of different kinds of exercises in critical thinking found so far in dental education is not large. In addition, these concepts apply to an array of complex thought processes: searching and critiquing the scientific literature, patient assessment, treatment planning, self-assessment, evidence-based practice, ethics, integration of technology into practice, synthesis of central components of care, appointment management, etc. Therefore, it seems like an opportunity to gain some consensus on these exercises since they can apply to any clinical discipline.

Critical thinking is not discipline-specific and is not knowledge-specific; rather, it is a complex higher order thought process that involves reflection, doubt, inquiry, curiosity, and challenge. Fundamentally, it seems to be the ability to ask questions and to discover or create solutions that are reasonable and defensible. The programs reviewed have a strong formative orientation and include elements from definitions of critical thinking: analyzing information, finding new/alternative solutions, and perceiving several sides of an issue. These exercises also reflect curiosity, recognizing one’s biases, and reinforce self-assessment. Critical thinking expands thought, while seeking a “right” answer contracts thought with an important reconciliation for dental educators.

Performance assessments in critical thinking face the same paradox as does the mission of predoctoral dental education versus the grading system is widely used: every graduate is expected to attain entry-level competence, yet the grading system is designed to rank students. Even though entry-level competence can be reliably determined, the subjective component may cause unease, especially when students are ranked, which is another difference from knowledge.

This paradox poses a challenge for dental education.

Crossing curriculum years concerns the developmental transformation of the learner from novice towards competence. Guiding student learning and assessing performance will likely be more structured for the novice. The same extensive and effective structure for the novice may be a hindrance at a more advanced level. If the novice-to-expert concepts are integrated into the program design, however, the programs can be enhanced.

The opportunity to take a schoolwide approach in guiding student learning and assessing performance would result in increased soundness in methodology and clarity for students. Assuming a schoolwide approach is used, a leadership structure has not been addressed here. Should it be entirely faculty-driven, for instance, or a combination of mostly faculty-driven with some administrative facilitation to keep the process moving across disciplines and across years of the curriculum?

While it is beyond the scope of this article to determine the penetration of the education literature in the health sciences, it seems that a concise prototype to guide learning and assess performance has not become widespread. Three topics are beyond the scope of this article. One is the notion of consolidating scores on multiple-choice knowledge-based exams and the performance assessments for complex thought processes to give each important learning component its due weight. One opportunity will be to develop mechanisms to consider and weigh knowledge/technical skill and critical thinking in the same field, for example in a table. A second is the use of multiple-choice or other objective exams to gain insight into cognitive abilities. Related to that is defining the limits of precision in assessing performance with complex thought processes. A third is the matter of training faculty members since the cultural shift may be as great a challenge as the methodology. Each of these topics is an important discussion for future study.

Conclusions

While this article offers a simplified view of a highly complex topic, it may begin to build a bridge between dental education and potentially effective tools from the education literature. These tools can guide dental student learning and performance assessment for complex thought processes and may require some adjustment in the culture of dental education. A first step is to recognize the fundamental differences between teaching and measuring knowledge for technical skills and guiding student learning and performing assessment for complex thought processes across disciplines and curriculum years.

Momentum is building for making critical thinking more central in dental education. Ideas of-
ferred here have the potential to add to the structural foundations for this educational and cultural shift. We close with this thought: “thinking starts with doubt.”

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