A Model for Critical Thinking Measurement of Dental Student Performance


Abstract: The educational application of critical thinking has increased in the last twenty years with programs like problem-based learning. Performance measurement related to the dental student’s capacity for critical thinking remains elusive, however. This article offers a model now in use to measure critical thinking applied to patient assessment and treatment planning across the four years of the dental school curriculum and across clinical disciplines. Two elements of the model are described: 1) a critical thinking measurement “cell,” and 2) a list of minimally essential steps in critical thinking for patient assessment and treatment planning. Issues pertaining to this model are discussed: adaptations on the path from novice to expert, the role of subjective measurement, variations supportive of the model, and the correlation of individual and institutional assessment. The critical thinking measurement cell consists of interacting performance tasks and measures. The student identifies the step in the process (for example, chief complaint) with objective measurement; the student then applies the step to a patient or case with subjective measurement; the faculty member then combines the objective and subjective measurements into an evaluation on progress toward competence. The activities in the cell are then repeated until all the steps in the process have been addressed. A next task is to determine consistency across the four years and across clinical disciplines.

Dr. Johnsen is Dean; Dr. Finkelstein is Professor, Department of Oral Pathology, Radiology, and Medicine; Dr. Marshall is Assistant Professor, Department of Preventive and Community Dentistry; and Dr. Chalkley is Associate Dean for Students and Curriculum—all at the University of Iowa College of Dentistry. Direct correspondence to Dr. David C. Johnsen, College of Dentistry, University of Iowa, 100 Dental Science Building, Iowa City, IA 52242-1010; 319-335-7145 phone; david-johnsen@uiowa.edu.

Key words: critical thinking measurement model, treatment planning, dental education

Critical thinking and its measurement are gaining attention as dental education attempts to better define student educational outcomes and respective measures.\textsuperscript{1-7} For this discussion, we define critical thinking as the art of analyzing and evaluating thinking with a view to improving it.\textsuperscript{8,9} Programs like problem-based learning (PBL) and case-based seminars have created an environment conducive to the cultivation of critical thinking.\textsuperscript{10,11} Many facets of critical thinking have been articulated. A barrier to the measurement of critical thinking is the limited availability of models or constructs to measure this ability. Since the process of critical thinking is complex, it seems logical that some segmentation of critical thinking will occur as concepts for measurement evolve. The purpose of this article is to present a model now being used to measure dental student critical thinking abilities in patient assessment and treatment planning across the four years of the curriculum and across clinical disciplines. The model is now used when the student assesses the patient (or case) and develops a treatment plan as well as when the student presents to faculty members or peers. We will present elements for the model, examples, adaptations from novice to expert, the role of subjective measurement, and variations supportive of the model and correlation of individual and institutional assessment.

Elements of a Model for Measuring Critical Thinking

The two elements of the model now in use are 1) a repeating set or “cell” of minimal actions measured in critical thinking as shown in Figure 1, and 2) an agreed upon set of minimally essential steps in the critical thinking process applied to patient assessment and treatment planning as shown in Figure 2.\textsuperscript{12,13} The critical thinking measurement cell reflects the smallest set of interdependent actions from which some assessment of critical thinking can be made. The cell is repeated, creating a framework for more general assessments of student thinking abilities. The cell has only five components, making it practical for widespread use.
The critical thinking measurement cell has two dimensions, as shown in Figure 1. One dimension is demonstration of the critical thinking process by the student, and the second dimension is the faculty member’s objective and then subjective measurement of the student’s performance. Student demonstration of the steps in the critical thinking process is accomplished with the identification of a step (in the critical thinking process), followed by application of each step to an individual patient. Measurement of the student’s performance is accomplished with the objective measurement of the student’s identification of the step in the process, followed by the subjective measurement of the student’s application of the step to an individual patient.

To walk through the two dimensions of the measurement cell, the student is first expected to articulate the step in the process—for example, the

---

Figure 1. Schematic showing the model for measurement of critical thinking abilities

*Note:* Two cells of interrelated activities and measures are shown. A cell is applied to each step in the process of patient assessment and treatment planning shown in Figure 2.
Treatment Planning Process for Patient Care

**INFORMATION GATHERING**
1. Chief Complaint and Patient Goals
2. Medical, Dental, Psychosocial Histories
3. Clinical Examination
4. Radiographic Examination
5. Diagnostic Aids
6. Consultation/Referral

**EVALUATION OF FINDINGS**

**PROBLEM LIST**

**DIAGNOSES**

**TREATMENT OBJECTIVES**

**PATIENT MODIFIERS**

**DENTIST MODIFIERS**

**TREATMENT PLAN(S)**
- Systemic Phase
- Acute/Emergency Phase
- Disease Control Phase/Prevention
- Rehabilitation Phase
- Maintenance/Monitoring/Prevention
- Sequence of Treatment

**PATIENT PRESENTATION**
- Treatment Plan
- Prognosis
- Behavior Guidance
- Informed Consent

**RE-EVALUATION/MODIFICATIONS**

**TREATMENT**

**MAINTENANCE/MONITORING/PREVENTION**

Figure 2. List of minimally essential steps in patient assessment and treatment planning

Note: The list is applied to cases and patients across the four years and across disciplines.
chief complaint. The student either articulates the step (chief complaint) or does not, and the faculty member objectively measures the performance. The student then applies the step to the particular patient, and the faculty member subjectively measures the student's performance. For example, for chief complaint, the student is expected to verbally describe the chief complaint as well as its significance to the faculty member and seek evidence from the literature that applies to the patient's conditions where applicable. While the faculty member's measurement of the student's attainment of this step in the critical thinking process is subjective, it is highly focused and systematically repeated in every interaction with dental students across the four years and across clinical disciplines. The rationale for this sequence is that, for the student to demonstrate judgment in applying his or her analysis to any step, the student must first know that the step exists. The model is also suitable for self-assessment of student performance.

The number of facets involved in assessing the student’s performance in applying even one step of critical thinking to a patient is large. Some faculty members consciously assess facets such as accuracy, clarity, precision, relevance, depth, breadth, logic, significance, and fairness in making this subjective measurement. Not all faculty members systematically consider each of these facets in making the subjective measure of the student’s application of a step to the patient. We accept that the complexity of the subjective measure may preclude complete capture of all the inputs by the student and faculty member.

To complete the measurement cell, the faculty member then combines the objective and subjective measures into an evaluation of the student’s performance of the critical thinking step, incorporating consideration for the student’s level of development (year in school).

To continue the demonstration and measurement of the critical thinking process, the entire critical thinking measurement cell is repeated for each step outlined in Figure 2. The process is repeated until all steps of patient assessment and treatment planning are completed. Both the critical thinking measurement cell and the list of minimally essential steps in patient assessment and treatment planning can be used across the four years and across clinical disciplines. Variations for respective disciplines will be also discussed subsequently. The systematic repetition of all the actions in the measurement cell gives a framework of the planning process. Systematic repetition of this chain of cells allows institutional inference of critical thinking abilities in patient care and can be used as a framework for assessing additional characteristics about students.

Examples of the Model

Example #1 is from a first-year course, Critical Thinking: Tools and Concepts, which includes a problem-based learning (PBL) patient exercise. In this example, the process is emphasized, with the specific case serving as the vehicle to demonstrate the process. There are two sessions for each case. The course also includes a definition of critical thinking, research article critique skills, the model shown in Figure 2, elements of thought (and application), universal intellectual standards, and essential intellectual traits. A case is presented to a group of students. Each student is provided with a medical and dental history, summary of the clinical exam, and photographs and radiographs of the patient. Student performance is measured on the student's demonstration of the patient assessment and planning process, with less emphasis on clinical judgment. In applying the steps in Figure 2 to the case, most of the information gathered by students will be from the scientific and professional literature. For the specific case, students identify alternative assessments of the case and differential diagnoses. Students also systematically describe their methods and sources in seeking information, clinical gaps, and learning issues. The student group then divides the task list developed during the session. Students return for a second session to complete the case assessment. For articles brought by students relative to the case, students are asked to analyze the research design, the more important data, conclusions, assumptions, limitations for that article, and pertinence to the case.

Example #2 is from the third-year periodontics course, with an exercise that follows the schematic for critical thinking measurement and the treatment planning process in Figures 1 and 2. The exercise involves small groups, with each student presenting one of his or her assigned patients using a PowerPoint format. The student lists each step in the treatment planning process in Figure 2 and then applies the step to the patient. The student is thus objectively measured for using each step and then subjectively measured on his or her ability to apply the step to that patient. Discussion and questions by fellow students and faculty members can occur at any point in the process. Inclusion of literature is expected where
appropriate in the presentation. In the periodontics clinic, students also follow the steps in the treatment planning process in Figure 2 and are measured as shown in Figure 1. The expectation is for the student to use each step in the treatment planning process and to show progress toward competence in clinical judgment.

Example #3 is from the third-year oral surgery clerkship. Students present patients just prior to treatment as a means of pretreatment review. The faculty member expects the student to name a step in the treatment planning process (with objective measurement), followed immediately with application of the step to the patient (with subjective measurement). This faculty member will not allow the student to proceed until the student articulates the step—for example, chief complaint. To illustrate a different step in the process, treatment objectives must be articulated by the student, and the faculty member will not allow the student to proceed unless that step is named. Once named, the student is expected to apply the treatment objectives to the patient. The faculty member thus performs both an objective measure of the student’s ability to name the steps and a subjective measure in the student’s ability to apply the steps to that patient.

Example #4 is from the fourth-year comprehensive care course, with an exercise to prepare a patient for the clinic. Students first take an objective test listing the steps in the treatment planning process in Figure 2. The list of steps is objectively measured. Students then join a small student group to present the patient. The student applies each step to the patient with the expectation of developing a definitive diagnosis and definitive treatment option or options. The student is thus measured in two steps as shown in Figure 1. Students also systematically provide self-assessment.

These four examples show consistency in use of the essential elements in critical thinking measurement (Figure 1) and minimally essential steps in patient assessment and treatment planning (Figure 2). The examples also begin to show the many reinforcing variations across the four years, across clinical disciplines, and with individual faculty members. Each of our ten departments has some variation, but all still use the essential elements of objective and subjective measurement as well as the steps in treatment planning.

In each example, variability does not disrupt the use of the measurement cell nor the use of all the steps in patient assessment and treatment planning. Individual and institutional assessment can thus be achieved.

Issues Pertaining to the Model

Adaptations of the Model on the Path from Novice to Expert

Adaptations are inevitable even though application of the model is intended to be implemented by all faculty members across the four years and across clinical disciplines. The most significant adaptation is the acceleration in the student’s ability to apply the model over the four years. As novices, many freshmen will apply the model in a structured, lockstep fashion, “by the book,” so to speak. Novices are not expected to distinguish relevant from irrelevant information. Novices also can have low tolerance for ambiguity, can quickly close out the decision making process, and can have limited interconnections within their knowledge base. Awareness of these potential problems can be overcome by the use of prototypical cases.

By the senior year, the student may have internalized much of the process and will perform the process without overt prompting as an ingrained, natural component of behavior—on “automatic pilot.” The student still uses all the steps in the measurement cell and uses all the steps in the process of patient assessment and treatment planning, but may no longer consciously articulate all the steps.

Faculty members have long internalized the steps in the process with extensive experience and countless repetitions of pattern recognition. This internalized skill is a key cognitive component underlying expertise among health care providers with diagnostic and treatment planning responsibilities. Nonetheless, faculty members agree that all the steps are important in assessing the student’s ability to critically assess patients and then treatment plan. The agreement was reached in a series of discussions over about three years to establish a list of minimally essential steps for our college, but starting with a framework outlined by Stefanac. Perhaps the weakest part of the model over the four years is the progressive tendency to bundle or combine the formal articulation of two or more of the steps and respective measures, particularly if one step is of lesser significance to that patient.
The Role of Subjective Measurement

The inclusion of subjective measures in this model is consistent with the scientific method in which a step is identified and then applied. Subjective measures also run deep in educational outcomes assessment in liberal arts.\(^{17}\) The power of subjective measurement in this model rests on its being highly focused on each step and its systematic repetition across four years and across clinical disciplines. The model is also dependent on systematic subjective measurement following objective measurement. A disciplined combination of objective and then subjective measurement seems essential for credibility in assessing critical thinking abilities in patient assessment and treatment planning. Success in assessing critical thinking at the institutional level will depend on systematic use of both the repeating critical thinking measurement cell and acceptance of a common list of minimally essential steps in the critical thinking process.

Variations Supportive of the Model

Faculty members want latitude to apply variations. Many variations can be accommodated, usually enriching the experience and without disrupting the principles of critical thinking. Success in the accommodation of variations will depend on acceptance of both the critical thinking measurement cell and the minimally essential steps in the process shown in Figures 1 and 2. Some examples of variations are given that still deliver the two essential elements in this model for critical thinking assessment.

A common variation is in the kinds of scores for subjective measurement of the student’s ability to apply a step to the individual patient/case. Some faculty members in our school assign a score based on a 1 to 5 scale with definitions of each number. Others record a plus/minus. The number of variations in kinds of assignments is almost as great as the number of courses now conducting critical thinking exercises in patient assessment and treatment planning. We submit that the scoring system is of less importance for institutional assessment of critical thinking, so long as the principles of the measurement cell and the systematic use of minimal essential steps in the process are used as shown in Figures 1 and 2. We accept that there is room for debate on these points. The model seems well suited for assessment of student progress toward competence. The model is less suited to rank students.

Another kind of variation is among disciplines. For example, oral surgery may emphasize physiologic stress of a procedure, bleeding control, infection prevention, pain management, etc.; prosthodontics may emphasize occlusion implications of treatment, sequencing, materials, etc.; pediatric dentistry may emphasize behavior management, carries risk assessment, etc.; PBL calls for an extensive literature search first for patient assessment and then for treatment planning. In each case, the critical thinking measurement cell in Figure 1 and minimally essential steps in Figure 2 are followed. These variations are thus accommodated, enhancing the exercises.

The institution has a significant volume of student measures demonstrating critical thinking abilities gathered systematically throughout the curriculum and within each clinical discipline. We submit that the institution can then infer student competence in the elements of critical thinking in patient assessment and treatment planning. The evidence is limited to date that inferred competence can be concluded based on repetitive subjective measures in cultivation and assessment of critical thinking in dentistry.

Assumptions and Collateral Assessment of Student Performance

The credibility of this model for measurement of critical thinking is based on use of the scientific method with a parallel process applied to patient assessment and treatment planning. The scientific method is based on the agreed list of essential steps and then the articulation of each step to the research question. Because experts can vary in their opinion on the “right” treatment plan for a specific patient, the main goal is for the student to develop a sound process, with a part of the process designed to develop one or more reasonable treatment plan options.

The environmental context of this model for measurement of critical thinking has consistent characteristics in our college. First is measurement in small groups or one-on-one. The lecture has not been a setting for implementing this model. Second, the small-group setting brings in peer interaction as well as self-assessments as formative elements. Third, repeated student interactions result in professional familiarity with students and are a common characteristic in the environment for the model described. One intent is to support a culture of critical thinking and to provide a framework for students’ interactions with their instructors.
It is beyond the scope of this article to assess overall abilities on inquisitiveness, open-mindedness, flexibility, overall judgment, asking relevant questions, etc. It does seem worth contemplating whether these important abilities can be assessed in the absence of structured models or frameworks as the one in this article or other structured frameworks. Models such as this one could be built upon to gain more meaningful assessments of these important abilities. A next task is to follow students longitudinally and to determine the level of reproducibility across clinical disciplines.

Acknowledgments

Faculty members who were interviewed did much to nurture our culture and fulfill the principles discussed in this article: Professors Georgia Johnson, Bill Synan, Rick Walton, and Vince Williams. Also, thanks and acknowledgment to more than thirty full-time faculty members who facilitated our PBL, CBL, and clinical seminars.

REFERENCES


