Critical Thinking Theory to Practice: Using the Expert's Thought Process as Guide for Learning and Assessment

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Abstract: Critical thinking skills are essential for the successful dentist, yet few explicit skillsets in critical thinking have been developed and published in peer-reviewed literature. The aims of this article are to 1) offer an assessable critical thinking teaching model with the expert's thought process as the outcome, learning guide, and assessment instrument and 2) offer three critical thinking skillsets following this model: for geriatric risk assessment, technology decision making, and situation analysis/reflections. For the objective component, the student demonstrates delivery of each step in the thought process. For the subjective component, the student is judged to have grasped the principles as applied to the patient or case. This article describes the framework and the results of pilot tests in which students in one year at this school used the model in the three areas, earning scores of 90% or above on the assessments. The model was thus judged to be successful for students to demonstrate critical thinking skillsets in the course settings. Students consistently delivered each step of the thought process and were nearly as consistent in grasping the principles behind each step. As more critical thinking skillsets are implemented, a reinforcing network develops.

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Critical thinking is an essential skill for the successful practice of dentistry.[1-4] Indeed, it is first on the American Dental Education Association (ADEA) Competencies for the New General Dentist.[5] The core argument for pursuing alternative models in critical thinking is the dental student's need to master the practice of critical thinking, but existing teaching methods are not objective and systematic enough to support assessment of students' critical thinking abilities in specific clinical situations.[6] In this article, we want to propose a model for doing that based on the thought process of experts.[7,8]

In our model, critical thinking entails systematically applying the expert's thought process in situations common to dentistry. As our examples will make clear, the expert's thought process requires students to apply judgment, synthesis, and creativity as they consider alternatives before arriving at a final decision. In previous considerations of this topic, we have offered critical thinking skillsets for treatment planning, search and critique of the literature, caries risk assessment, evidence-based dentistry, and behavior management.[9-15] The model is based on deriving the thought process of the expert; the thought process

derived from the expert becomes the critical thinking skillset. The terms are used interchangeably. The resulting skillset has some parallels to the scientific method. In both the scientific method and the thought process of the expert, there is a structure with each step, engaging the student in critical thinking. None of the steps allows the student to guess at a "right" answer. This guided learning then also serves as the assessment instrument.

Aside from the limited existing literature on critical thinking in dental education,[6-15] we are not aware of a tested model for objective and subjective assessment of critical thinking skillsets. Our model is a step forward for two reasons. First—and essentially—the expert's thought process becomes the desired outcome, the learning guide, and the assessment instrument. Second, in this model, the expert's thought process is systematically applied.

The aims of this article are to 1) offer an assessable critical thinking teaching model with the expert's thought process as the outcome, learning guide, and assessment instrument and 2) offer three critical thinking skillsets following this model: for geriatric risk assessment (D4 year), technology decision making (D4 year), and situation analysis/reflections (D2 year). We will argue for the value of engaging students in multiple and various critical thinking exercises. The more experience a student has applying the expert's thought process, the more prepared he or she will be to apply those critical thinking skillsets in new situations.[7]

Design of Critical Thinking Skillsets

To develop the three critical thinking skillsets described in this article, we interviewed faculty experts. The goal was to capture their thought processes succinctly enough that they could be understood and applied by the novice or advanced beginner. The novice-to-expert approach acknowledges the novice's need for structure as well as the ways in which structure can be an impediment for the expert.[16,17] The expert may go through the thought process so quickly he or she cannot articulate the discrete parts of the process.

The education literature has a body of scholarship on the concepts of complex thought processes, interpreted here to mean critical thinking, yet with few tangible examples in which the outcome is defined, learning strategies are articulated, and assessment is performed.[1-4] These concepts are consistent with the design of this model based on the expert's thought process. The main components for the model are as follows. Interviews were conducted to help the faculty experts reflect on and relate their thought process for a given situation.[7,18-23] The goal was to articulate the expert's thought process succinctly enough for the novice to apply. The next step was to reach agreement among experts (faculty members) about the content, delivery, and assessment of skills relating to critical thinking.[7,18,22,24,25] Reaching consensus was essential because this model uses the same instrument to guide learning and to assess performance.[7,18,26-28] Finally, a consideration of alternatives, biases, and self-assessment should be included when practical.[29] The model is designed to lead a student to defensible alternatives before he or she decides on a final intervention in a given situation. This process is in keeping with the fact that experienced clinicians frequently reach different conclusions when considering treatment plans.

From 2013 through 2016, critical thinking skillsets were developed by up to four faculty members per skillset. For geriatric risk, three faculty members articulated the skillset. All three have advanced training in geriatrics as well as experience teaching the subject from three to 40 years. Each student in the course developed a PowerPoint presentation about one of his or her patients, adhering to the geriatric risk skillset. Six students presented in each session. For dental technology decision making, the members of the College Technology Committee were interviewed. The committee's ten-plus members have advanced training in various disciplines. The critical thinking exercise was implemented by four faculty members, all of whom have advanced training in dentistry and more than ten years' experience in dental education. Teams of five students each developed a PowerPoint presentation about a selected technology, adhering to the technology decision making skillset. Four teams presented at each session. For situation analysis/reflections, two faculty members were involved, one of whom has 20 years' experience including peer review in experiential learning. Students responded individually in writing to the situation analysis/reflections skillset. The skillset exercise in geriatric dentistry followed a full course in geriatric dentistry. The skillset exercise in technology decision making followed a two-hour session on the subject and is part of the course on practice management. The exercise in situation analysis/reflections is

part of the experiential learning program, including lectures on critical thinking and the problem-based learning program.

Once the skillsets were developed and introduced to students, those students were directly assessed in the act of critical thinking, using both objective and subjective measures.[7,9,12] The assessment of the student's success employing the skillsets was based on the following questions: 1) Does the student know the steps in the process and systematically apply each step to the patient or case? 2) Does the student understand the principles relevant to this patient or case? The second question is subjective, and a second, random assessment was done as part of the evaluation. The subjective component can be reduced but not eliminated. Since there is no standard format for assessing students in the act of critical thinking, the goal is consistency among the faculty. To that end, faculty members separately assessed students for each performance for geriatric risk and for technology decision making. For geriatric dentistry and technology decision making, all exercises were assessed by two faculty members. Since uniform second assessment may be logistically impractical on an ongoing basis, random second assessment is logical on an ongoing basis once the exercise is established.

The three critical thinking skillsets are shown in Figure 1. Each represents the expert's thought process for given situations. The student is assessed on the systematic application of the expert's thought process (objective) and his or her grasp of relevant principles (subjective). For geriatric risk and technology decision making, two faculty members are present at each session to complete assessments for each student performance. For situation analysis/reflections, two faculty members perform the assessments. For geriatric risk assessment, the student selects a patient he or she has worked with and, supported by a PowerPoint slide deck, presents the case following the learning guide. Student performance is then assessed using the same instrument. For technology decision making, each group of five students selects a technology and, supported by a PowerPoint slide deck, presents that technology following the learning guide. Student performance is assessed using the same instrument. For situation analysis/reflections, the student selects a personal experience and analyzes it using the learning guide with written responses. Student performance is assessed using the same instrument.

Each assessment engages the student directly while in the act of critical thinking. In one year of pilot testing the assessments at our school, for geriatric risk assessment, students had 95% success in delivering each step (objective) and 90% success in grasping the concepts (subjective). For technology decision making, students had 94% success in delivering each step (objective) and 93% success in grasping the concepts (subjective). For both exercises, inter-rater agreement among faculty members was 90% or greater for objective and subjective assessments.

The three skillsets are in keeping with our observations regarding critical thinking and its application over 20 years. The value of emulating the expert's thought process, gaining agreement of faculty members on respective skillsets, and using the same instrument to guide learning and to assess performance are common themes of both our informal observations over two decades and the more structured designs of the process described here that we implemented from 2013 to 2016. These ideas can now be employed to design additional critical thinking skillsets. Critical thinking is one aspirational characteristic for graduates.[30] The others are knowledge, technical, ethics, practice management, social responsibility, and ability to function in a collegial professional setting.

Critical thinking is an indispensable skill for graduates. Despite this fact, there are no previous examples of critical thinking skillsets based on the thought process of the expert and with a tested assessment model that follows the expert's thought process. As a result, we argue that the model presented here represents a substantive step forward.

Relevance and Utility of These Critical Thinking Skillsets

Geriatric Risk Assessment

Geriatric risk assessment for Rapid Oral Health Deterioration (ROHD) is needed due to the potential for the rapid deterioration of oral health with comorbidities usually associated with age.[31] More individuals are retaining their natural dentition through an advanced age. Many of these individuals develop risk factors such as dementia, stroke, Parkinson's disease, or dry mouth from multiple medications. There is a great and significant opportunity to anticipate this risk while the person remains a patient in a general practice before he or she enters a care facility.

Geriatric risk learning guide and performance assessment instrument

STEPS IN THE THOUGHT PROCESS
Do we have the data?
General health conditions
Social support
Oral conditions
What data are important?
What will happen if I do nothing?
What is the patient risk? **1.** Risk factors for ROHD have not presented. **2.** Risk factors XYZ are presenting for ROHD **3.** Beginning ROHD with immediate risk for further ROHD **4** ROHD has happened – What risk factors led to ROHD?
What treatment alternatives can be done?
Specific interventions with rationale
Communication plan for Pt or caregiver
Self-assess

Technology decision-making learning guide and performance assessment instrument

Identified Technology: _____
Learning Guide
Health Benefit
Evidence: a. PICO b. Quality c. Depth
Technology Characteristics a. Stage of development b. Longevity c. Utility d. Acceptance e. Safety; Risks f. Quality g. Initial disruption
Training a. Duration b. Difficulty c. Clarity
Financial considerations a. Cost/benefit b. Cost for access
Company characteristics a. Reliability b. Service contract
Process a. Alternatives b. Biases c. Self-assessment

Situation analysis/reflection critical thinking learning guide and performance assessment instrument

Component
Event
Event description
Emotional response
Problem posed
Analyses
Player's assumptions Biases Point of view Information base or components shaping event Potential modification of components Outcome of modifying components if appropriate
Differences between player's assumptions Biases Point of view Information base
Ability to view situation from a different perspective
Alternative actions and implications
Discussion of desirability of modified components on final outcome

Figure 1. Critical thinking skillsets for geriatric risk assessment, technology decision making, and situation analysis/reflections

The expert's thought process for interpreting and applying these factors to a geriatric patient is strikingly similar to that reported for dental caries risk.[12] The level of risk is determined from a combination of risk factors and disease progression: low risk/little disease; high risk/little disease; high risk/rapid deterioration; high risk/deterioration occurred (Figure 1). The risk assessment approach to disease progression adds the dimension of time to the process. The assessment might now be said to be a moving picture rather than a static snap shot. To observe this approach in action, six PowerPoint presentations were prepared and presented by students during each session. Students could then gain insights from the other presentations. Delivery of each skillset was invariably followed by rich discussion. Adjustments were made between year one and year two. When asked, "Does this skillset make you a better dentist?," all students reported a 4 or 5 on a scale from 1=strongly disagree to 5=strongly agree.

Dental Technology Decision Making

Decision making about the use of technology is a skillset that practitioners will use throughout their careers and will affect their ability to meet advancing standards of care. For this skillset, four presentations were completed by students in each session. Students could thus take in the decision making process for three additional technologies.

The skillset was found to be applicable for any of the technologies assessed. These included rotary endodontics, electric/air handpieces, digital photography, electronic health records, electric toothbrushes, whitening materials, obturation systems, air abrasion, apex locators, digital dentistry for fixed and removable restorations, implant systems, implant planning software, cancer detection technology, orthodontic alignment systems, lasers for soft and hard tissues, local anesthesia options, and others.

Situation Analysis/Reflections

The skillset for situation analysis/reflections was the most challenging of the three exercises to describe, but it may be the most powerful because it can apply to situations well beyond dentistry. Indeed, the skillset itself was established with concepts from outside the health sciences.[32-34]

The situation analysis/reflection exercise differs from the geriatrics and technology exercises in that responses are written. These written responses give the faculty member insight into the student's personal background, values, biases, and mechanisms of introspection.[17] It must be noted that student privacy is a potential issue because student responses can be intensely personal.

Situation analysis and reflection are essential since almost all situations encountered by the dentist are different from the ideal. Helping practitioners to adapt to clinical situations requires a general skillset that can be adjusted for technical procedures, treatment decisions, and patient behaviors. Although the concepts applied in this exercise are contemporary, they can be traced back to philosopher David Hume: thinking starts with doubt, reflection is at the heart of scholarship, and one's ethics come more from feelings than reasoning.[32-34] Incorporating reflection and self-explanation prompts into instruction has been shown to improve student problem-solving according to Singer et al.: "Students have attitudes, beliefs, and expectations about learning that can influence their behavior and performance in courses. In addition, differences in metacognitive ability translate into differences in students' learning outcomes. Students who are more metacognitive are better students overall."[6] The exercise in situation analysis/reflection condenses concepts from experts inside and outside dentistry for application to clinical dentistry.

Discussion

While the guiding concepts are the same for the three skillsets, the formats can be customized. Geriatric risk can apply to any part of health care. Dental technology decision making can apply to any part of science. Situation analysis/reflections can apply to any part of one's personal or professional life. The guiding concepts may well be applicable beyond these three examples and potentially beyond the previously described skillsets in caries risk, treatment planning, literature search, and evidence-based dentistry.[9-14] The models we have suggested provide a basis for further research.

Several aspects of critical thinking are worth discussing to place these results in context. Respected experts in the field think critically and analytically and may not be able to articulate how: rather, they just do it. One can use exercises that teach openness to alternatives, the suspension of judgment, and decision making in the face of some ambiguity. Although critical thinking does not lend itself easily to structure, without it, complex learning becomes

a random, even mysterious, event. The purpose of this model is to offer structure to critical thinking exercises common in dentistry.

Challenges remain. Explicit critical thinking skillsets do not fit neatly into courses, disciplines, and curriculum years—a significant challenge in a culture deeply entrenched in courses and disciplines. Singer et al. went on to state, "Discipline-Based Educational Research should measure a wider range of outcomes and should explore relationships among different types of outcomes. Better instruments are needed to measure a variety of outcomes. In addition, faculty instructional practices in science and engineering have not been systematically documented."[6]

The intended outcome is for students to be able to consistently reproduce the expert's thought process. Once the expert's thought process is derived and experts agree on it, the learning framework and assessment instrument become self-evident. However, a question remains regarding the degree of structure needed to get the student started while not stifling freedom in thinking.

The educational model presented here has some limitations. The level of precision in performance assessment is sufficient to establish a basic level of competence but not sufficient to rank students. The institution is charged with overcoming this limitation. If the mission is for all students to establish competent performance, it is congruous with the model. If the mission is to rank students, it is less so. While the objective component of assessment approaches maturity, the subjective component is a work in progress. Thus, faculty calibration should also be included with any critical thinking assessment strategies. Another limitation of the model is a situation involving an irreversible (surgical) procedure. In the event of an emergency, it is necessary to understand who makes the decisions during the procedure and for all others to immediately abide by those decisions. This model is congruous with the activity before and after the irreversible (surgical) procedure, but refinements are needed for application during the procedure.

As additional skillsets are developed, a synergy occurs, and the network becomes reinforced (Figure 2). If the same model is used for teaching multiple skillsets, it will become easier to implement each new skillset and adapt to it. Additional skillsets now in progress include application of situation analysis/reflections to the clinic situation, interprofessional practice, and ethics.

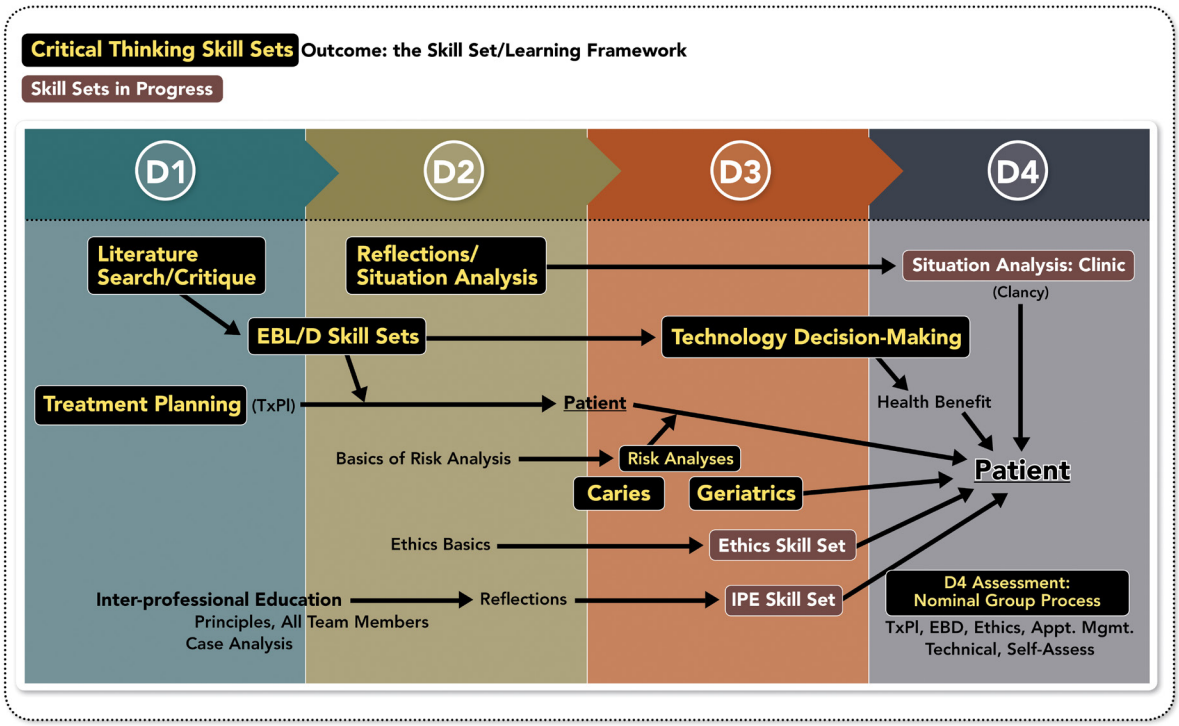

Figure 2. Development of synergy among critical thinking skillsets

Conclusion

We have presented a critical thinking model for learning and assessment, designed starting with deriving the expert's thought process succinctly enough to guide the novice/beginner to defensible alternatives and then to a preferred intervention. The expert's thought process becomes the critical thinking skillset, becoming the desired outcome, the learning guide, and the assessment instrument. Assessment is both objective and subjective. Each year of application of the model at our dental school saw improvement in student performance. Implementation of this model is dependent on a culture of inquiry, basic concepts in critical thinking, and continuity across disciplines and curriculum years. Development of new skillsets in critical thinking accelerates as more skillsets are added and connectivity and synergy occur. The end result for the graduating student is a set of succinct, interconnected critical thinking skillsets applicable in the daily practice of dentistry—and, arguably, well beyond. These focused critical thinking skillsets reveal concepts that can be used to lay the foundation for more unifying skillsets in critical thinking.

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Disclosure

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