Assessing and Helping Challenging Students: Part One, Why Do Some Students Have Difficulty Learning?

William D. Hendricson, M.S., M.A.; John H. Kleffner, Ed.D.

Abstract: When students struggle with routine assignments and fall behind classmates, a busy teacher may pigeonhole them as slow, give up on them, or become frustrated from failed efforts to bring them up to speed. Well-intentioned efforts to help struggling students by providing repetitions of the same experiences may fail because the specific cause of the sub-par performance was not identified. Six potential causes of inadequate student performance can serve as a diagnostic framework to help teachers pinpoint why a student is struggling academically: 1) cognitive factors, including poorly integrated, compartmentalized information, poor metacognition that hinders the student's ability to monitor and self-correct performance, bona fide learning disabilities that require professional assessment and treatment, and sensory-perceptual difficulties that may hinder performance in certain health care disciplines; 2) ineffective study habits, which are more common among professional students than faculty realize; 3) an inadequate educational experience (unclear objectives, poorly organized instruction, absence of coaching and timely feedback) or a punitive environment in which students avoid approaching instructors for assistance; 4) distraction due to nonacademic issues such as social relationships, health of a spouse, or employment; 5) dysfunctional levels of defensiveness that hinder student-teacher communication; and 6) underlying medical conditions that may affect student attentiveness, motivation, energy, and emotional balance. The objective of this article is to help faculty recognize potential underlying causes of a student's learning problems. Strategies for helping the academically struggling student are also introduced for several of these etiologies.

Mr. Hendricson is Director, and Dr. Kleffner is former Educational Development Specialist, both at the Division of Educational Research and Development, Department of Academic Informatics Services, The University of Texas Health Science Center at San Antonio. Direct correspondence and requests for reprints to William Hendricson, Director, Division of Educational Research and Development, The University of Texas Health Science Center at San Antonio, 7703 Floyd Curl Drive, San Antonio, TX 78229-3900; 210-567-2813 phone; hendricson@uthscsa.edu.

Key words: learning, dental students, curriculum, teaching methods

Submitted for publication 9/14/01; accepted 11/15/01

Editor's Note: Part two of this study will appear in a subsequent issue of the *Journal of Dental Education.*

The article "Memory and the Brain" by Lee Robertson in this issue of the *Journal of Dental Education* reviews the neurobiology of memory, focusing on the complex physiological and chemical processes by which memories are created and the influence of various factors on memory formation including stress, sleep, drugs, and aging. Memory is the foundation of learning: without the ability to retain and retrieve information and experiences, we could not perform the tasks of daily living, or take on the responsibilities associated with our occupations. One of the profound mysteries of human life is how self-awareness and thought emerge from the movement of electrical charges from brain cell to brain cell. This electrical-to-chemical-to-electrical transmission process involves the axon of one neuron connecting to a dendrite of another neuron, a process that occurs billions of times every second. How does the miracle of thought emerge from this process? That is, how are we able to generate ideas, observations, reactions, and questions? How are we able to talk to ourselves (for example, conduct our private inner conversations)? And how are we able to communicate our thoughts to others? Another mystery, less theological in nature but just as profound for teachers, is why in any group of students a few individuals who have seemingly equivalent abilities and incentives perform less well than others or deviate so dramatically from the norms of expected behavior that they become labeled as problem students.

In a perfect world, all students would be highly motivated, energetic, enthusiastic, intellectually curious, eager to learn, and academically successful. Most students in health professions education have these desirable characteristics. However, over the course of a teaching career, faculty will encounter more than a few students who are challenging—the type of student who provokes the teacher's lament, "I spend 90 percent of my time on 10 percent of the students." The term "challenging student" refers to a student with one or more of the following characteristics:

- Has difficulty learning or performing up to expectations,
- Is distracted and does not devote full attention to academic responsibilities,
- Is difficult or unpleasant to work with; for example, has an attitude problem or is defensive, and
- Does not appear to be motivated to learn.

The senior author (Hendricson) frequently conducts workshops on teaching difficult students. The first workshop exercise asks participants to propose adjectives that describe students who are challenging and students whom teachers enjoy. Adjectives assigned to challenging students appear below on the left; on the right are words that describe learners whom teachers enjoy.

Students who are challenging or difficult	**Students whom teachers enjoy**
Lethargic, listless, lazy	Enthusiastic, energetic, eager
Disorganized (don't use time wisely)	Motivated; have inner drive
Frequently repeat the same mistakes	Learn from mistakes
No initiative (expect to be spoonfed)	Volunteer for tasks and extra work
Not punctual and ignore rules	Punctual and follow directions
Indifferent (don't appear to care; emotionless)	Put in extra time (arrive early; leave late)
Defensive (hostile when feedback is given)	Ask for feedback on their performance

We will focus here on the left hand column—the challenging student. The objective is to help dental educators understand and assess factors that may cause dysfunctional student behavior in two areas: performance (how students acquire knowledge and learn to perform skills) and attitude (the way students interact with others in the academic environment). Attitudinal issues are often intertwined with the student's performance difficulties in either a causal or reactive relationship. This article will focus on the potential causes of substandard performance by presenting a series of diagnostic questions designed to help faculty identify the underlying etiology of the learning deficiency. Strategies for helping the student with learning difficulties will also be introduced. A companion article in a subsequent issue of the *Journal of Dental Education* will review the causes of inappropriate and dysfunctional student behavior such as acute defensiveness, apathy, and belligerence; explore reasons for apparent lack of motivation among some students; and present a protocol for conducting an "educational intervention" with a challenging student.

Assessing and Diagnosing the Etiology of Challenging Student Behavior

In the authors' collective sixty years of experience in health professions education, most cases of challenging student behavior can be classified into the categories presented in Figure 1:

- **learning problems,** which are reflected in performance consistently below expectations or a sudden decline in performance by a student who has a solid academic record; and
- **attitudinal issues,** which include a variety of behavioral manifestations among students that are perplexing, frustrating, and, in extreme cases, unacceptable to faculty and disruptive to the overall learning environment.

Underlying medical conditions, including psychological problems, may contribute to substandard performance or undesirable behaviors and attitudes. The student may or may not be aware of medical problems or may attempt to obscure medical conditions, including chemical dependency, from student peers and faculty.

In relation to the attitudinal issues displayed in Figure 1, the authors have observed faculty to be particularly perplexed and frustrated by three types of behavior: acute defensiveness that hinders student-teacher communication and thus the quality of the learning experience; lack of personal motivation; and the "cocky" know-it-all attitude of students who have a high estimation of their ability, sometimes deserved and sometimes not. Defensiveness, lack of motivation, and know-it-all demeanor can be the behavioral manifestations of underlying learning deficiencies or medical problems. Defensiveness and a passive approach to learning, which are often perceived as a lack of motivation, appear to be intertwined with the student's sense of safety within the academic envi-

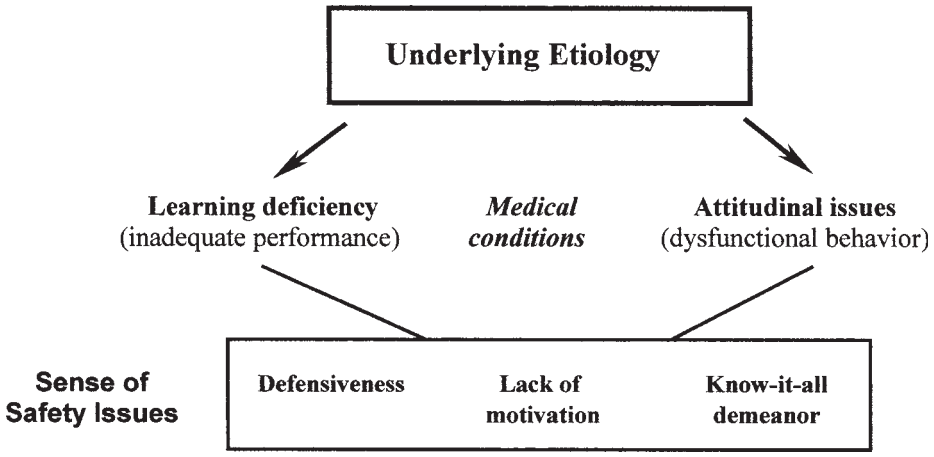


Figure 1. Categories of challenging student behavior

ronment and his or her "survival" strategy (that is, making it to graduation day).

Assessing Causes of Learning Deficiency

The etiology of learning deficiencies is complex and can involve a variety of factors often acting in concert. Six factors should be considered when a student has difficulty learning. These are briefly described here and then explored in more detail below.

The first factor is **cognition.** Abnormalities can occur related to how the student acquires, processes, stores, and retrieves information. For example, students may advance to the clinical phase of the curriculum with poorly integrated knowledge because of curriculum format, teaching methods, or the student's study strategies.[1] These students may have difficulty retrieving the information needed to answer questions asked by instructors or "thinking on their feet" to cope with unexpected events that occur during patient treatment. Metacognition, which is the ability to self-assess the quality of performance and make corrections, varies considerably from person to person. People with poor metacognition cannot distinguish accuracy from error and have inflated impressions of their abilities. It is not out of the realm of possibility that an underperforming dental student may have an undiagnosed learning disability that requires professional intervention. People differ in their ability to recognize spatial relationships among objects and perceive small differences in shape, size, position, and texture. For some students, difficulties with spatial-perceptual tasks may be due to the way their brains process information received from the environment.

The second factor is **study habits.** Ineffective study methods may contribute to substandard learning. **Quality of the academic environment** is third. Sometimes the overall curriculum is so poorly conceived or implemented that learning becomes difficult even for the best students. **Student distraction** is fourth. Stressful, time-consuming, and energy-sapping events in a student's life outside school can overwhelm even highly motivated students and contribute to inadequate academic performance. Fifth is **the affective component of learning.** Learners evolve through an emotional development continuum as they progress through the stages of professional training. During this maturation process, a student's self-concept as a learner and attitudes about the task of learning change substantially. These evolving attitudes play an important role in student-teacher interactions, often by creating a wall of defensiveness that hinders communication and helps shape the teacher's perception of the student, sometimes in a negative manner. Sixth are **underlying medical problems.** If all other causes of inadequate performance are ruled out, is it possible that an underlying health problem is the catalyst for the student's academic struggles? Chemical imbalances, chronic stress, the effects of aging, and certain systemic diseases can alter the chemical

basis of memory formation and contribute to attention deficits, loss of concentration, lack of energy, mental confusion, and emotional disorders.

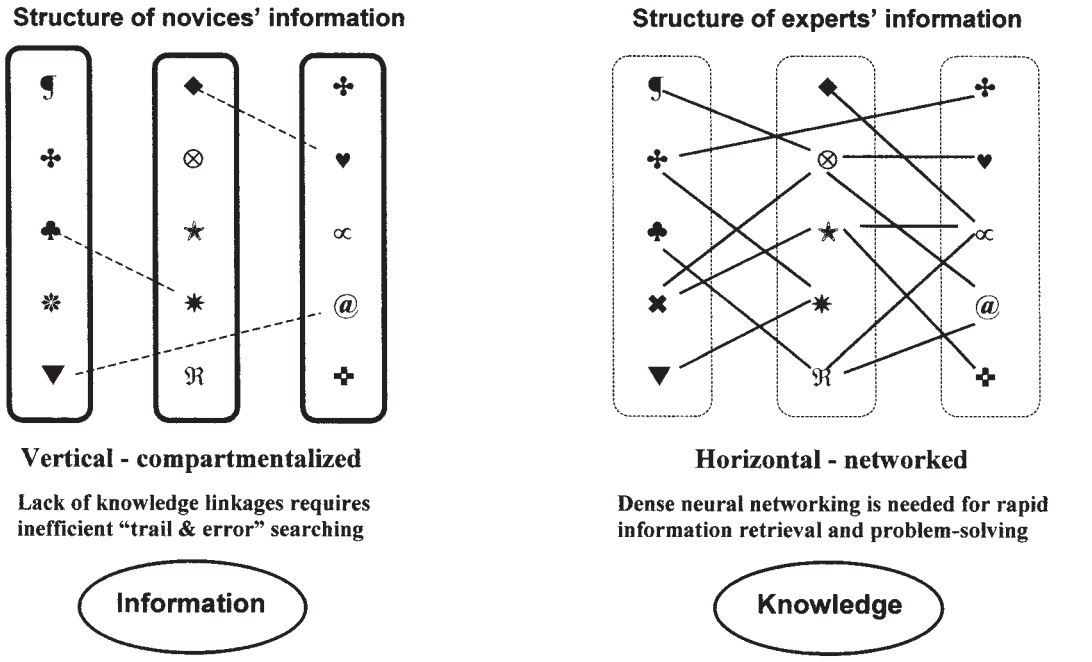
This section presents diagnostic questions for each of these six factors that may contribute to substandard learning.

Cognition: The Student's Thinking Processes

Teachers should consider the following questions when a student exhibits learning deficiencies that cannot be explained by other factors.

Does the Student Have Poorly Networked Knowledge? This question will receive the most attention because it has implications for the overall educational process. There have been dramatic breakthroughs in our understanding of brain function and the neurophysiological mechanisms of learning and memory.[2-5] A principle outcome of brain research is a better understanding of the neurophysiological mechanisms involved in the creation of knowledge networks. These neurocognitive networks *appear* to underlie many aspects of memory, pattern recognition, and decision-making.[6-7] The word "appear" in the previous sentence is emphasized because we are still several decades away from definitive answers about how expertise develops. For now, we can say that the available evidence is suggestive but not conclusive.

Figure 2 schematically represents probable differences in the way novices and experts mentally structure information they acquire from various sources and experiences. Novices' information, represented by the left panel, is vertical and compartmentalized. When confronted with a task or problem new to them, novices struggle in a trial and error manner to assemble isolated bits of information, represented by the various symbols within the columns, because they lack pre-existing networks that allow fast retrieval of pertinent information. Students may have encyclopedic information about topics introduced in the curriculum, but this information is compartmentalized and largely unlinked to other topics. To develop problem-solving ability, students must convert the largely unorganized fragments of data absorbed from textbooks and lectures into interlinked chains of networked knowledge. Knowledge is de-



Source: Hendricson WD, Cohen P. Oral health care in the 21st century: implications for dental and medical education. Acad Med 2001;76(12):1181-1206.

Figure 2. Differences between novices' and experts' mental organization of information

fined as information that individuals can explain in their own words, has recognized value and utility, and can be retrieved instantaneously to solve problems.[8-11] The conversion process of taking isolated bits of information and consolidating them into useful knowledge is the core of the constructivism theory of learning which is the prevailing educational model among cognitive psychologists today.[12] Experts (see the right panel of Figure 2) have developed networks that allow rapid retrieval of chains of knowledge relevant to solving a problem. Cognitive psychologists refer to this interlinked configuration by various names such as horizontally networked knowledge, elaborated knowledge, or spider web knowledge.[13-17]

Classic symptoms of a student with poorly integrated information include the following: long-winded, circuitous answers to questions that never get to the point; the inability to look at clinical data and recognize an obvious pattern (for example, to recognize that 2 + 2 = 4); the inability to move beyond obvious surface features when discussing a patient's problems (versus discussing important underlying etiologies); difficulty explaining relationships among patient care variables (for example, how two drugs such as coumadin and captopril might alter each other's pharmacokinetics and affect the patient's cardiac and pulmonary function); the inability to compare and contrast physiologic mechanisms (for example, the differences between hypovalemic and cardiogenic shock); and a phenomenon known as "anchoring" in which the student fails to recognize the need to change an opinion or a patient care plan when new or different information becomes available that changes the situation.[18]

We have observed three types of students who exhibit poorly integrated knowledge.

Type I students are in over their heads; they attempt to solve problems or perform tasks without adequate prerequisite learning experiences. Type II students are at a natural stage of cognitive development along the novice-to-expert continuum where a fragmented, poorly integrated knowledge base is the norm. Type III students may have unique difficulties putting it all together that extend beyond the normal struggles of the novice learner. Type I students are frequently the result of a curriculum that has inadequate assessment methods at the foundational level of the program (for example, tests that emphasize memorization of facts rather than the ability to apply information to problems), or they are individuals who did not take full advantage of learning opportunities for one or more of the reasons discussed later in this paper but manage to move ahead because of testing that measures relatively low levels of cognition function.

A number of studies have established an association between the overall structure of the curriculum, the way students study and prepare for tests, and the depth at which they learn the subject matter of courses.[19-24] An active-learning environment in which students are frequently asked to assess data, make decisions, and explain the thinking underlying their decisions appears to be our best bet for helping students build integrated knowledge.[9,11,25-26] Unfortunately, many health professions students are the products of undergraduate or preclinical curricula in which they spent hundreds of hours sitting in a lecture hall listening (perhaps) to lectures. These students arrive in the clinical environment ill-prepared to assess patient problems or even to answer questions that teachers perceive to be very easy.

The traditional smokestack or "silo" curriculum has been the prevailing model for the health professions education for decades.[27-28] In this type of curriculum, each discipline operates autonomous mini-curricula, educating students independently with minimal cross-fertilization among disciplines. Structurally, the silo curriculum is organized much like the left side of Figure 2. The student graduates and is assumed to be competent when all courses in each of the discipline-based silos are passed. However, there is growing discontent with this model. The Institute of Medicine-National Academy of Science report *To Err Is Human: Building a Safer Health Care System* examined the reasons for patient care errors that contribute to approximately 75,000 deaths and several hundred thousand near-misses annually within health care facilities.[29] Numerous contributing factors were identified including three educational causes: 1) reliance on silo curricula and passive, sponge-learning during training produces entry-level practitioners with poor knowledge integration, poor vigilance for errors, and inadequate coping skills when problems occur; 2) entry-level practitioners lack training in information management systems and thus rely on memorization on the job; and 3) there is a lack of opportunity to practice problem-solving during training and on the job.

Given the reliance on silo curricula in health professions education, clinical teachers should anticipate that many students will struggle with problem-solving tasks. Research indicates that one of the

most effective strategies to help students develop the mental muscle needed for problem-solving—as well as one of the easiest and least resource-intensive to implement—is to create a learning environment in which instructors make it a goal to frequently ask questions that help students "connect the dots."[30-32] Connect-the-dot questions provide students with opportunities to think about and verbalize their understanding of the relationships between isolated bits of information acquired throughout the curriculum. Responding to connect-the-dot questions, which requires students to pull together information acquired from different sources, has been shown to be a powerful technique for building deeper understanding of concepts and principles. The students' process of building personal meaning by articulating their understanding and interpretation of information in their own words may be the most critical step in the process of learning.[11,13,33] Connect-the-dot questions include: *decision questions* (What do you think we should do for this patient?), *why questions* (Why do you think this is our best option?), *how questions* (How can we perform that procedure given the patient's condition?), *what-if questions* (What should we do if the patient cannot tolerate the splint?), and *dig deeper questions* (That's a good idea, but can you think of any other dietary plans we can recommend for this patient?). These types of questions require students to assemble their explanations from different information compartments and thus have been linked to higher levels of comprehension.[33-36]

The cognitive tasks involved in assessing the intent of a decision question (for example, what should we do next for this patient and why?), mentally selecting information pertinent to the query, linking this information to construct an answer, verbalizing (or writing) the answer, offering a supportive rationale for the decision, and answering follow-up questions to further clarify, modify, or justify the response can help learners start to make sense of the mass of information they have absorbed in the curriculum.[11] Through repetitions of similar cognitive events (such as frequently answering connect-the-dots questions), neuronal linkages are established and a memory of the response to a particular situation or question becomes more deeply ingrained, thus increasing the potential for prompt retrieval in the future.[37] As described in the Robertson article, it appears that neuron-to-neuron connections are strengthened by repetition of experience. Repetition produces coordinated activation of a network of neuronal connections; the more repetition, the easier it is for the same neuronal pathway to reactivate in subsequent situations. The process of making it easier for neuronal pathways to reactivate may be the basis for how memories are created.[38] Students who struggle with rudimentary problem-solving tasks appear to particularly benefit from frequent participation in very focused problem-solving conferences in which teachers use the questioning techniques previously described to help learners practice answering questions and then provide specific feedback to help students compare and contrast their responses to an ideal response.[39-40]

We must add one note of caution. In our careers, we have observed countless health professions faculty unfairly label students as substandard learners before they have even begun the lengthy process of creating these knowledge networks. Faculty expectations, particularly early in the clinical phase of training, are often skewed too high. Novice learners may be expected to assess patient problems and reach decisions just as quickly as experienced faculty, which is an unreasonable and inappropriate expectation. To help faculty guard against the unreasonable-expectation phenomenon in medical education, Pangaro et al. developed the R-I-M-E model and a variation of this model adapted for dental education appears in Figure 3.[41] This model identifies desirable levels of performance that can be expected of learners as they progress through the educational continuum (**r**eporter, **i**nterpreter, **m**anager, **e**ducator). The level of performance appropriate and expected for students at each of the four levels of training is identified in the text. The sentence in bold at the conclusion of each skill-level description indicates level-appropriate assessment criteria for students at that particular phase of the curriculum. For example, assessment of students at the reporter level (an early phase of clinical training) should measure the completeness and accuracy of the students' data collection (by history-taking and patient examination) and the clarity and accuracy of their verbal and written reports about the patient's health. Students at this ground floor level should not be assessed on their ability to make diagnostic decisions about patient care that is appropriate only for learners on subsequent rungs of the ladder. This model is used in faculty development sessions and clinical orientations to remind faculty of the expectations that are appropriate for learners at each stage of development as they proceed through training.

Reporter = Student is expected to accurately gather and clearly communicate the clinical facts abo patients. Mastery of the reporter phase requires fundamental patient interviewing and examination skills, interpersonal skills, and verbal/written communication skills. **At thi stage of development, the completeness and accuracy of the students' data collection (by history-taking and patient examination) and the clarity and accuracy of their verbal and written reports about the patient's health are important assessment criteria**

Interpreter = Student is expected to prioritize among patient problems, to interpret this data in order construct a differential diagnosis, and to order follow-up tests that will help confirm or rule-out diagnoses. **Ability to explain and justify diagnostic interpretations is an importa assessment criteria at this stage of learner development.**

Manager = Student is expected to choose among therapeutic options to tailor and implement a treatment plan for the patient's unique circumstance, to coordinate the efforts of other health professionals, and to be able to provide patient education. **Ability to make correc and timely decisions about patient care and ability to choose and perform appropriate treatment are important assessment criteria at this stage of development.**

Educator = Student is expected to assist learners at lower levels in the RIME continuum in their development and be able to share his or her knowledge and educate other members of t health care team. **The effectiveness of the trainee's teaching activities is an important assessment criteria at this stage of development.**

Adapted for dental education from Pangaro's R-I-M-E model.
Source: Pangaro L. A new vocabulary and other innovations for improving descriptive in-train evaluations. Acad Med 1999;74:1203-7.

Figure 3. A clinical development continuum for setting level-appropriate expectations for learner performance

Does the Student Have Poor Metacognition?
Some people who have poorly developed skills or limited knowledge are simply oblivious to their incompetence. In any group of professional students, some individuals will fall into a category that has been labeled "unskilled and unaware of it."[42-44] Unskilled and unaware students often reach erroneous conclusions, perform tasks ineptly, reach amazingly wrongheaded decisions, and repeatedly make unfortunate choices in their academic lives (as well as in their nonacademic lives), but are remarkably unaware of their incompetence. In fact, these individuals often have very high, although inaccurate, estimates of their abilities and are very confident, if not arrogant.[45] As Charles Darwin once observed, "Ignorance more frequently begets confidence than does knowledge."[46]

Unskilled and unaware students have poorly developed metacognition, which is the brain's self-assessment process that analyzes what we say and do (it allows us, for example, to think about what we're doing) and distinguishes correct from incorrect actions and decisions. People with well-developed metacognition constantly self-correct and fine-tune their behavior and actions. This self-monitoring process allows people to make an appropriate assessment of their capabilities and to display a level of confidence that corresponds to actual ability.[47-48] Students with poorly developed metacognition blunder from one error to the next, but have the mistaken impression that they are doing just fine. Researchers in neuroscience and cognition believe that poor metacognition is a fundamental component of incompetence.

Unskilled and unaware students who overestimate their capabilities and are overly confident can be challenging to teach. Research has shown that these individuals 1) rarely receive feedback that might help them develop an accurate view of reality, 2) do not learn from feedback unless it is very precise and frequent, and 3) do not learn by observing how other people function.[49-50] It is unreasonable to expect that these students will fine-tune their performance by simply observing clinical teachers as they interact

with patients. However, there is evidence that conducting debriefings with these students in which their decisions are carefully analyzed and compared to an ideal will help them develop metacognitive skills.[40,44]

Does the Student Have an Undiagnosed Learning Disability? Students in demanding professional training programs are unlikely to have an undiagnosed learning disability, but it should not be automatically ruled out. Often, students can cope with a learning disability at lower academic levels, only to fall apart upon entry into a professional program that requires extensive reading or careful attention to written instructions in laboratory manuals. Classic signs of a potential learning disability among late adolescents and adults include: 1) difficulty reading aloud, 2) difficulty comprehending the meaning of written material, 3) difficulty completing written tests on time, 4) failure to follow written instructions, 5) difficulty comprehending diagrams and flow charts, and 6) difficulty expressing thoughts and ideas in written form.[51] None of these problems, alone, is diagnostic for a learning disorder, but it should raise your index of suspicion if it occurs in combination with other signs of substandard performance. Notably, there is a trend in the research literature—which is not conclusive but still frequently reported—of an association between a certain style of cognitive processing (reviewed in the next section of this paper) and a learning disability, particularly in curricula emphasizing perceptual and motor skills.[39]

If you have concerns about a student, alert the academic dean or program director by phone or in person. Teachers should not communicate a guess or hunch about a student's possible learning disability in a memo or email message that can become a public record or verbally in a public forum. Your responsibility is to alert the program director and allow the university to follow up with a professional assessment.

Does the Student Have Difficulties with Perceptual Tasks or Motor Skills? Research by psychologists and neurophysiologists over the past fifty years demonstrates that human beings mentally process information and use visual, tactile, and auditory cues from their environment in dramatically different ways. These different types of information-processing apparently influence how individuals attempt to structure the environment in which they work or learn, how much they trust their own judgment versus the opinions of others, and how well they can perform certain tasks that require visual, spatial, and tactile perception.[52-55] Although more research is needed, a person's unique way of processing sensory stimuli may also influence his or her creativity, for example, the ability to think outside the box and see ways of doing things other people do not see. A person's unique style of cognitive functioning also appears to influence the amount of guidance and structure desired when learning.

Much of the information-processing research is based on the field dependent-field independent construct of cognitive function.[52,56] This model was proposed at the time of the Korean War (1950-53) to explain why some experienced World War II fighter pilots could maneuver the new and faster jet fighters and why others who had been successful in slower, propeller-driven aircraft had difficulty in jets. In fact, there were so many crashes in the early phases of training that the military sought the help of cognitive psychologists to determine why skilled pilots could not safely fly the new generation of jet planes. A series of cognitive tests was developed that involved such tasks as tracing images when they can be observed only by an inverted image in a mirror, stacking objects of various sizes and shapes, discerning geometric figures embedded within a larger and more complex image, and determining body position in space when subjects are physically rotated through various positions in a darkened room in which they can see only a rod within a square frame.

This battery of brain function tests identified two distinct ways in which the pilots processed information received from their senses. One group was determined to be field dependent (FD) because they relied heavily on their external environment (instruments, geographic landmarks, and the horizon) to make maneuvering decisions. When flying their aircraft at supersonic speeds (roughly twice as fast as the earlier propeller-driven planes), FD pilots did not have time to look around and locate the horizon, find geographic landmarks, or take more than a quick glance at their instruments. Without these external cues, many FD pilots could not determine if they were right side up or upside down, or whether their aircraft was gaining altitude or diving toward the earth. The other group of pilots was determined to be field independent (FI) because they had their own internal sense of direction and body position and thus did not rely extensively on external cues to make decisions. FI pilots could make the transition from the propeller-driven plane to the jet fighter because they did not need constant visual contact with the

horizon or the landscape below and did not rely heavily on instrument readings to make decisions.

There have been over 500 investigations of field dependence-independence (FDI) and how it influences personality variables (including mental health pathologies), academic performance, and athletic and musical tasks, as well as FDI's relationship to physiological mechanisms such as motion sickness. These studies indicate that our unique way of processing information from the surrounding environment influences how we prefer to learn, how adept we are at certain fine motor visual-spatial-perceptual tasks, and how we interact with others in school or work environments. Tinajero et al. provide a comprehensive review of research based on the field independence and field dependence construct.[56]

Students who have difficulty learning psychomotor tasks (such as administering an intravenous injection) that require eye-to-hand coordination and ability to interpret tactile and visual stimuli may not be deficient because they have not studied or practiced. It may have something to do with the way they are "seeing and feeling" the object or, in fact, not seeing and feeling it. Notably, several studies have found that students with sub-par performance in motor skills training tend to have a field dependent orientation.[57] As demonstrated in research pertinent to dental education, primarily conducted by Feil, Guenzel, and Knight,[58-66] as well as other investigations of psychomotor learning, all students and particularly those who struggle with motor skills benefit from a well-organized instructional process that has the following characteristics introduced in the following sequence: 1) students can clearly see and analyze the desired end product; 2) students practice visualizing and/or drawing the desired end product; 3) students have opportunities to compare and contrast the desired outcome to examples of outcomes that are not acceptable; 4) students can observe the performance of the task by an expert practitioner who explains movements and procedures as they are executed; 5) during time-outs in the instructor's demonstration, students can ask questions and request repeat demonstrations of components of the task; 6) students are actively coached during several initial attempts to perform the task; 7) students receive prompt comparison of how their work corresponds to the ideal outcome; 8) students are asked to analyze their work products and identify reasons for discrepancies from the ideal; 9) instructors provide specific advice about how to improve performance; and 10) students have ample opportunities to refine their performance.[33,67-70] Research on the learning of procedural skills indicates that students who struggle with tasks requiring eye-to-hand coordination and perceptual accuracy (such as judging depth, width, angle, and separation distance) benefit from a precise application of these steps.[33]

The three most significant factors in the learning of procedural tasks are the quality of the initial instructor demonstrations, the quality and promptness of feedback, and the total amount of time the student devotes to learning the task. Instructors who employ the teaching steps identified above and who supplement demonstrations with illustrations, even hand-drawn sketches, and three-dimensional models produce better learning than instructors who do not.[70-73] Prompt feedback and access to information about the results of a task are the techniques most likely to improve the performance of learners, particularly those who struggle with the skill.[58,70,74] Supplemental practice on a task after criterion levels are achieved enhances long-term retention. Fifty percent overlearning is appropriate, but overlearning reaches a point of diminishing return. If it takes a dental student four attempts, for example, to master a particular type of restorative procedure, two more practice trials will enhance skill retention. However, additional trials may not improve performance.[72,75-76]

Additional Factors That May Cause Inadequate Performance

In addition to cognition issues, a number of additional factors can contribute to substandard student learning. When instructors are trying to pinpoint the reasons students are struggling, they should therefore ask themselves the following questions related to study habits, educational experience, distractions, the student's self-concept, and possible underlying medical problems.

Does the Student Have Effective Study Habits? It is unlikely that a large number of students will reach an advanced level of professional training with poor study habits. However, we routinely encounter students who have sufficient native intelligence to get by with ineffective study methods for much of their academic career, but who struggle when they run into conceptually difficult material. Figure 4 reviews the characteristic study habits of high-achiev-

	High-Achieving Learners	Underachieving Learners
Environment	Quiet & isolated from others Well-illuminated reading surface Prefer to sit upright at desk	Background sound (music, TV) May prefer dim lighting Seek comfort; read in bed or lying on sofa
Emotional	Set priorities & stick to them Take responsibility for problems Allocate time to finish tasks Sacrifice social life	Don't stick to study plans; get distracted Blame others or circumstances Underestimate time needed to study Unwilling to sacrifice social time
Social	Willing to be "alone" Self-reliant Network with other good students (in the loop)	Need ongoing peer contact/stimulation Make decisions in conjunction with peers Associate with poor students or nonstudents Often are "loners" (out of student loop)
Physical	Rely on multiple senses Study without activity breaks Mentally alert in afternoon & pm	Primarily tactile/kinetic Highly mobile (can't sit still; fidgety) Difficulty studying during mid-day
Psychological	Both concrete & abstract Good impulse control Confident; receptive to critique High expectations	Primarily concrete thinkers Poor impulse control Defensive; avoid feedback Low expectations
Methods	Tend to be active learners: * Self-quizzing while reading * Write notes in class & review * Ask questions during class * Keep up with assigned reading	Overly passive or overly independent: * Dysfunctional study groups (too social) * Inefficient study time (distractions) * Read passively (no notes or self-quizzing)
Summary	**Persistent; grind it out** **Good impulse control** **Active learning** **Network = other good students** **Isolated study**	**Low impulse control; easily distracted** **Kinetic; need physical activity** **Conflict between social & academic** **Network = poor students or nonstudents** **Distracting study environment**

Figure 4. Characteristic study habits of high-achieving and underachieving students

ing and underachieving students. It is important to note that this figure presents general characteristics. Students who are high achievers may not exactly match the profile, and students who are underachievers may employ some of the desirable study methods. However, a large body of research supports the conclusion that the study methods of high-achieving and underachieving university students are often strikingly different.[20,22-23,77-79]

High-achieving students, for example, tend to be persistent and schedule a specific time block every day for reading and review. Underachievers rarely block out time for study and are easily distracted, often succumbing to social opportunities or diversionary activities like talking to friends on the phone or taking a break to watch television. High-achieving students are more likely to use active learning strategies such as writing detailed notes in class, reviewing class notes daily, interacting frequently with instructors, and self-quizzing. In contrast, underachieving students tend to approach their studies in a more passive manner. Finally, high-achieving students more often than not study in a quiet location, whereas students who are underachievers may prefer background sound from a radio or CD player and often study in high-traffic areas where they are likely to encounter people who might stop and talk.

Are You Providing a Quality Educational Experience? As the saying goes, "We have met the enemy, and he is us." This is a hard pill for teachers to swallow, but the sad truth is that substandard student performance is frequently associated with a substandard educational experience. When confronted with a consistent pattern of inadequate performance by more than a few students, the educational environment needs to be assessed. There are well-recognized ingredients for good practice in higher education programs,[80-82] and the characteristics of quality teaching in the patient care environment of health care facilities have been identified in several literature reviews.[83-88]

Although countless questions can be asked to assess the learning environment, the authors have found the following items to be useful. Several "no" responses may be a red flag for a potentially substandard learning environment.

For all types of instruction:

- Do teachers communicate clear learning objectives to the student?
- Do students know how they will be evaluated and are the evaluation methods suitable to measure student attainment of course/rotation objectives?
- Is coursework well organized and presented in a stimulating manner that includes variety, fun, opportunities for frequent student interaction, including peer teaching, and frequent student-teacher contact both inside and outside of class?
- Is coursework structured so that students have opportunities to promptly use new information and employ active learning strategies such as analysis of cases or research projects?

For clinical rotations and preceptorships:

- Do students routinely receive coaching and suggestions before they encounter patients, or are students basically left to their own devices?
- Are students routinely observed while they interact with patients?
- Are instructors enthusiastic, available, and approachable, so that students are not afraid to request help or ask questions?
- Do instructors routinely give constructive feedback to students and reserve time in their schedules to meet with students to review progress?
- Do students have ample opportunity to observe clinicians' providing patient care and to ask questions about techniques the students observed?

Figure 5 presents eleven teaching strategies that teachers can use to enhance learning. The authors consider the research support for these strategies to be extremely strong: each item has been found consistently effective over decades of research in numerous educational settings with many different kinds of learners. As a review of educational quality in your teaching program, readers are encouraged to check [□] those methods you use frequently when working with students and mark methods with an "X" that are frequently employed by other instructors in your teaching program.

Is the Student Unusually Distracted? Students who are present in body but not in spirit or who seem easily distracted from routine tasks often have so much going on in their nonacademic lives that they cannot fully attend to the school component. Key symptoms of dysfunctional nonacademic distraction include forgetfulness, excessive amount of time on the phone or away from the clinical facility during work hours, sudden requests for time off, moodiness, concentration errors, unproductive time (daydreaming), dramatic changes in demeanor, sudden decline in performance, and unexplained tardiness or absences.

Faculty who sense such distractions should ask themselves two questions. First, what do I know about student's personal/domestic situation? Many variables can become time- and energy-consuming distractions for the student, diverting attention away from the academic program. Financial concerns, domestic conflict with a spouse, outside employment, or the health of a spouse, children, or parents can become major sources of distraction. Students tend to be close-mouthed about these issues, and faculty often do not think of the students' "other life." Exploring nonacademic issues can be tricky and should be approached with caution. However, if the student's level of distraction is such that his or her performance is unsatisfactory (especially if it has declined dramatically) or, in clinical education, if the overall functioning of the facility is affected, then it is your responsibility to share your concerns with the student.

The second question to ask is: is the student maintaining a lifestyle conducive to learning? Student readiness to learn can be dramatically influenced by lifestyle variables including diet, sleep (or lack thereof), caffeine consumption, alcohol consumption, and level of physical activity. A number of studies have documented an increase in drug use among postsecondary students over the past decade including several studies of health professions students.[89-92] The most frequently consumed drug in all studies

Educational Quality Assessment:

[✓] Check methods you use frequently when working with students now
{×} Mark methods other teachers in your academic program use frequently

[ ] **Give students learning objectives stated in the form of end-of-course expectations** { }

Example: *At the end of this course, you will be expected to perform the following tasks . . .*

[ ] **Provide opportunities for students to actively and quickly use "new" information** { }

- Ask students to explain their understanding of newly received information
- Ask students to draw and explain concepts and techniques with flow charts or diagrams
- Conduct activities in which students use new information within one day to explore a problem

[ ] **Give just in time (JIT) corrective feedback** { }

- Provide immediate corrective advice during and after performance
- When errors or problems occur, feedback includes a prescriptive "how to correct" message
- Ask student to self-identify errors and problems after completion of the task

[ ] **Provide priming just before task performance** { }

- Priming = Prompts, reminders, and alerts (e.g., watch out for this)
- Priority questions = *What is the most important information we need from Mr. Reynolds?*
- Anticipation questions = *If Mrs. Jones cannot tolerate that test, what are our options?*

[ ] **Activate learner emotions** { }

- Allow students to participate in challenging events that require hands-on learning
- Provide opportunities for students to pursue a high priority personal interest
- Provide novelty and variety: surprise, unexpected events, controversy, fun
- Ask students to self-assess performance and identify corrections that are needed

[ ] **Encourage students to mentally or physically rehearse for performance** { }

- Mental (self-quizzing; visualization of task; re-copying notes taken in class)
- Physical (slow-time walk-throughs; visualization; review videotapes of past performance)
- Test prep: mock tests; in-class reviews with practice questions; student-led study groups

[ ] **Give students opportunities for multisensory interaction with subject matter** { }

Provide students with opportunities to learn by various methods: read, listen, see, touch, manipulate, observe experts in action and by DOING: discuss (explain verbally), ask questions, use information in a patient care task, evaluate performance of another person

[ ] **Allow students to make decisions** { }

- Ask students to make decisions and see the results of their decisions
- Ask students to analyze why decisions were correct or incorrect

[ ] **Give students opportunities to do peer teaching (i.e., students teach students)** { }

- Collaborative learning (student-directed groups)
- Assign students to research and teach a topic
- Students proctor in labs and clinic

[ ] **Learners actively "encode" during lecture classes** { }

- Examples of encoding:

  → Writing notes during class
  → Reproducing "test notes" after class
  → Diagramming (mapping) the relationship between concepts
  → Explaining concepts "in their own words"during class (answering questions)

[ ] **Ask students to compare and contrast** { }

- Examples: Ask students to

  → Distinguish between correct and incorrect definitions or explanations of concepts
  → Recognize appropriate and inappropriate technique
  → Compare and contrast the advantages/disadvantages of treatment approaches
  → Compare treatment outcomes (recognize satisfactory and not satisfactory outcomes)
  → Contrast (identify) differences among theories

Figure 5. Methods and activities that teachers can use to enhance learning

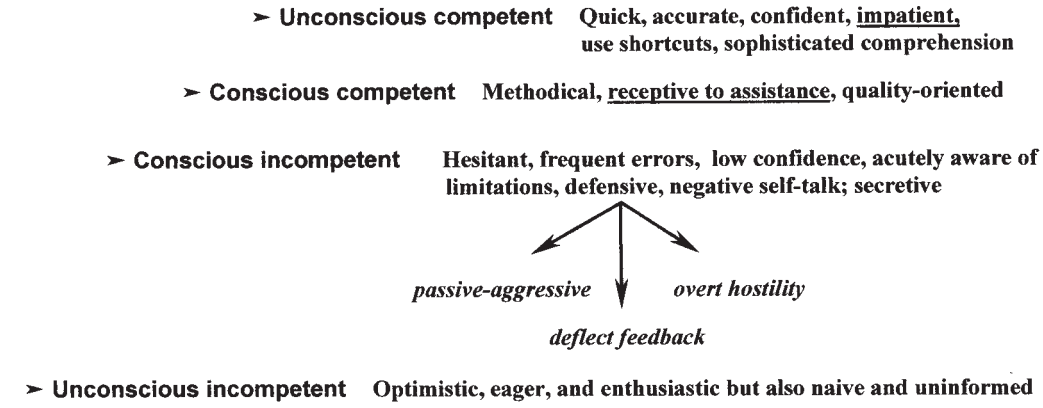
is alcohol, with more than 50 percent of students reporting at least weekly alcohol consumption and 10-20 percent of students reporting daily alcohol consumption. Alcohol consumption has been associated with inefficient study habits, poor academic performance, and an increase in the number of physical assaults by students.[90] Unfortunately, the academic rigors of dental school leave little time for physical exercise, so many students drift into a couch potato routine in their limited free time. Declining physical condition, a fatty, fast-food diet, associated weight gain, and lack of sleep are ingredients for low energy and lethargic behavior.

What Is the Student's Self-Concept and How Does This Affect Student-Teacher Interactions? The amygdala plays a crucial role in the creation of memories associated witih emotional arousal. Not surprisingly, heightened emotional arousal has been associated with increased learning.[11,33] As a consequence of this research and the recognition that students' attitudes play a profound role in how they approach learning tasks, measurement of the emotional sophistication of college and professional students has become a hot topic in recent years.[93]

A number of instruments have been developed to assess emotional intelligence, which is defined as the ability to monitor one's own emotions and the emotions of others and to use this information to guide thinking and actions.[94] It is important for health professions educators to understand that learners travel along an emotional development continuum, which in many ways parallels the development of competence as they progress through the curriculum and through the stages of professional development.[10,95] A student's self-concept as a learner evolves dramatically through predictable phases as they grow from novice status when they enter professional school to a competent entry-level professional at the time of graduation.

The self-concept continuum depicted in Figure 6 illustrates how students see themselves at various stages of the competency development process. Students matriculate as unconscious incompetents who are excited to be entering professional training, optimistic about their performance, but naive about the rigors of the training and unaware of their limitations. In other words, they don't know what they don't know. The unconscious incompetent stage is the natural entry point of competency development and is different from the unskilled and unaware student discussed earlier. The unskilled and unaware student lacks the ability to self-monitor, which prevents the student from recognizing substandard performance and making corrections.

At some point in the first year of the curriculum, the learner's self-concept shifts dramatically to conscious incompetent, which is the most characteristic stage of the novice learner. Students are now acutely aware of their limitations and realize that the road to competence will be long and arduous. Negative self-talk can dominate the novice learner's inner conversations. This produces an undue focus on perceived deficiencies, which in turn stimulates efforts to hide these weaknesses from instructors, thus hin-



Source: Hendricson WD, Kleffner JH. Curricular and instructional implications of competency-based dental education. J Dent Educ 1998;62:183-96.

Figure 6. Evolution of learner self-concept during progression from novice to expert status

dering the learning process. Students at this point of the continuum are defensive, which may manifest itself in passive-aggressive behavior (often incorrectly perceived by faculty as apathy or lack of motivation) or overt hostility (perceived correctly as a bad attitude). Teachers may view students in the conscious incompetent stage as frustrating and difficult to teach. Indeed, conscious incompetents may be secretive and attempt to minimize interaction with teachers.

At this stage, students hesitant to deviate from rules and guidelines, and are reluctant to make their own decisions for fear of making errors. They have little patience for abstractions or alternatives, desiring instead precise directions from instructors, such as "Just tell me what to do!" Instructors who understand the etiology of such defensiveness can be particularly helpful to the novice student with a fragile conscious incompetent mind-set by providing encouragement, practical suggestions consistent with the student's skill level, extensive hands-on but nonjudgmental assistance, and praise for accomplishments, even partial successes. Students in professional school may spend the bulk of the curriculum in the conscious incompetent phase.

Students slowly evolve with repetitive practice and instructor coaching into conscious competents. Students at this level perform somewhat mechanically by the numbers because they must think carefully about everything they do (thus the conscious competent label). During the conscious competent phase, students drop their defensive shields and actively seek assistance from teachers. They worry less about what others think of their performance, focusing instead on the quality of the work they perform for the patient. Work performance is not as fluid and effortless as the expert practitioner, but the conscious competent can, with adequate time and limited distractions, perform the tasks expected of the unsupervised entry-level practitioner.

Expert practitioners are known as unconscious competents because they routinely perform the tasks of their profession at a high level of quality and efficiency without expending a great deal of brainpower. Over the years, expert practitioners have hardwired needed knowledge and skills into their brains and, consequently, do not overtly think about each step in a task, a level of intellectual development called automaticity by cognitive psychologists.[96] Unconscious competents can take mental short-cuts because they can automatically recognize important cues when studying a problem and quickly leap to a solution with a high probability of success. The length of time and amount of experience required to reach an unconscious competent, expert status have been the subject of speculation, with estimates ranging from ten to fifteen years.[26,97]

The self-concept continuum has significant implications for teachers. The primary communication dyad in health professions education is a teacher who is an expert and an unconscious competent, interacting with a student who is a conscious incompetent. A review of the words and phrases below that describe each of these individuals underscores the potential for misunderstanding and conflict when unconscious competents and conscious incompetents attempt to work together. In some ways, this expert-novice dyad is like mixing oil and water.

Unconscious competent (teacher/expert)	**Conscious incompetent (student/novice)**
Quick; uses mental short-cuts (automaticity)	Hesitant
Accurate	Frequent errors
Confident	Low confidence; acutely aware of limitations
Impatient	Defensive; secretive; seeks to hide weaknesses

Because of their quickness and accuracy and the confidence that results from frequent success, experts tend to expect everyone to perform at a similar high level of proficiency and become impatient with a student's less-developed skills. A student's slow and hesitant approach to a task, frequent errors, and defensiveness may lead the teacher to conclude that the student is dim-witted or hopelessly incompetent. In reality, the student may be demonstrating an appropriate level of skill for his or her training level. However, many teachers lose sight of what is level-appropriate performance and focus on the student's deficiencies. This further reinforces the student's conscious incompetent self-concept, fostering more defensiveness by the student and more frustration by the teacher and sending the relationship into a downward spiral.

The P-E-T model presented in Figure 7 (**P**rime, **P**artition and **P**raise, **E**mpathy, **T**each) was developed by the authors for use in faculty development workshops. It is intended to remind teachers of strategies that can be employed to reduce the prototypical de-

fensive posture of the conscious incompetent learner. Strategies included in P-E-T are derived from comprehensive reviews of the literature on clinical teaching, supervision in the health care professions, and Baron's review of strategies to minimize defensiveness.[84,87,98-100] These strategies are likely to benefit all students, but we believe they are particularly useful for students who are struggling.

The components of the model are as follows. Before students undertake a task, prime (prepare) them by reminding them of key elements of the task and alerting them to possible problems. Ask students how they will deal with problems that may arise. Novice learners often are more successful if an entire task is subdivided into manageable components; thus, it is advisable to allow students to build from success by assigning manageable tasks early in the rotation and then expand the scope of responsibilities. Praise for successful completion of tasks is essential early in the learning curve and sends a signal that you are not a malignant instructor on the prowl for opportunities to criticize errors. Getting down off the pedestal of perfection and sharing examples of problems you encountered when you were a student is an effective door-opener for student-teacher communication. Make it clear to the student that you recognize that professional training is a developmental continuum and that mistakes will occur, especially early in the learning curve. As discussed previously (Pangaro's R-I-M-E Model), an on-target assessment of the student's level of training is critical to successful teaching in the clinical environment.

Finally, the "T" in P-E-T stands for "teach." Amazingly, the most common criticism we hear from dental students about their clinical education is that many instructors only give suggestions after the procedure is completed or wait until the student's work has gone so far off course that instructor interven-

P	**Prime**	Before students undertake a task, prime (prepare) them by coaching through the key elements of the task and alerting them to possible problems. Ask students how they will deal with problems that may arise.
	Partition	Allow students to build from success by assigning manageable tasks early in the rotation and then expand the scope of responsibilities.
	Praise	Ample doses of praise for tasks performed well are essential. Words of encouragement when problems are encountered are also essential.
E	**Empathy**	Share your problems from when you were a student, including stories about errors you made and how you improved your performance. Make it clear that you know that professional training is a developmental continuum and that mistakes will occur, especially early in the learning curve.
	Expectations	Your coaching and feedback will be more on target and you can avoid unreasonable expectations (usually, too high) by investigating what students can and cannot do at this level of training.
T	**Teach**	Coach actively with demonstrations, rehearsals, and helpful feedback.
	Help	Focus on helping the student learn, rather than evaluating performance. Help the student identify skills that need work and special interests he or she wants to pursue. Create opportunities for students to work on these skills and interests.
	Model	Show the importance of self-critique by requesting feedback from your peers while the student is watching and self-assess your own performance while the student is listening.

Figure 7. The P–E–T model (Prime, Partition & Praise, Empathy, Teach) for helping conscious incompetent students

tion is required. Reviews of clinical teaching effectiveness consistently indicate that the teachers perceived to be the most helpful by learners take a proactive coaching role before, during, and after patient appointments using demonstrations, reminders, rehearsals, prompting questions, and nonjudgmental feedback to guide the student's learning.[84,87,88] These exemplary teachers primarily focus on helping students develop skill and learn how to correct mistakes, rather than evaluating performance.

Is There an Underlying Medical Problem That Should Be Considered? Lee Robertson's article in this issue, "Memory and the Brain," provides an excellent review of the complex cellular and molecular mechanisms that control memory formation. Abnormal brain chemistry, induced by high levels of stress, hormonal imbalances, thyroid dysfunction, other systemic diseases such as hypertension, and insufficient sleep, can contribute to attention disorders, concentration difficulties, and affective (emotional) abnormalities that may impair the brain's capacity to create memories and thus interfere with a person's capacity for learning. For example, stress appears to have a particularly adverse effect on the hippocampus, which is centrally involved in memory formation.[101] Loss of sleep, thyroid dysfunction, and alcohol can also impair normal hippocampal function. The scope of abnormalities at the cellular and molecular level as well as dysfunctions in the brain structures involved in memory creation are too complex to address here, but are mentioned because teachers should include chemical and physiological abnormalities in their index of suspicion when other causes of substandard learning have been ruled out. If you have well-founded reasons to be concerned about a student's health, contact the academic dean at your school by telephone and share your observations. Again, do not communicate unconfirmed hunches about student performance or behavior in a memo or email.

Summary: Potential Causes of Learning Deficiency

When a student inexplicably struggles with routine assignments and falls behind classmates, busy teachers who are juggling patient care, educational, research, and even administrative responsibilities might be tempted to either pigeonhole the student as slow or hopeless, give up on the student, or grow frustrated from failed efforts to bring the student up to speed. Well-intentioned efforts to rehabilitate a struggling student by providing more repetitions or more time in a clinical environment may fail because the specific cause of the subpar performance was not clearly identified.

Simply "throwing more education at the student" may not be the answer. Rather, six potential causes of inadequate student performance can serve as a diagnostic framework to help teachers more clearly pinpoint why a student is struggling academically: 1) cognitive factors including poorly integrated, compartmentalized information, poor metacognition which hinders the student's ability to accurately monitor and self-correct performance, learning disabilities which require professional referral, and sensory-perceptual difficulties which may hinder performance in certain health care disciplines; 2) ineffective study habits which, from our experience, are more common among professional students than most faculty realize; 3) an inadequate educational experience including substandard curriculum quality (unclear objectives, poorly organized instruction, lack of opportunity to practice problem-solving, absence of coaching and feedback) or a punitive environment in which students are hesitant to approach instructors for assistance; 4) a high level of student distraction due to nonacademic issues including social relationships, employment obligations, and worry over health and financial issues; 5) student defensiveness and hesitancy to interact with faculty during the conscious incompetent stage of learning; and 6) underlying, and perhaps undetected, medical etiologies which may affect student attentiveness, concentration, and emotional balance.

REFERENCES

1. Norman GR, Schmidt HG. The psychological basis of problem-based learning: a review of the evidence. Acad Med 1992;67:557-65.
2. Harrier RJ, Siegel BV, et al. Regional glucose metabolic changes after learning a complex visual-spatial/motor task: a positron emission tomographic study. Brain Research 1992;570:134-43.
3. Cabezza R, Nyberg L. Imaging cognition II: an empirical review of 275 PET and fMRI studies. J Cognitive Neuroscience 2000;12:1-47.
4. McGaugh JL. Memory: a century of consolidation. Science 2000;287:248-51.
5. Rolls ET. Memory systems in the brain. Annu Rev Psychol 2000;1:599-630.

6. Eichenbaum H, Cahill LF, Gluck MA, et al. Learning and memory: systems analysis. In: Zigmond MJ, Bloom FE, Landis SC, Roberts JL, Squire LR, eds. Fundamental neuroscience. San Diego: Academic Press, 1999.
7. Nyberg L, Persson J, Habib R, Tulving E, et al. Large scale neurocognitive networks underlying episodic memory. J Cognitive Neuroscience 2000;12:163-73.
8. Horton DL, Mills CB. Human learning and memory. Ann Rev Psychol 1984;35:361-94.
9. Regehr G, Norman GR. Issues in cognitive psychology: implications for professional education. Acad Med 1996;71:988-1001.
10. Hendricson WD, Kleffner JH. Curricular and instructional implications of competency-based dental education. J Dent Educ 1998;62:183-96.
11. Bransford JD, Brown AL, Cocking RR, eds. How people learn: brain, mind, experience and school. Washington, DC: National Academy Press, 1999.
12. Whitman N. Review of constructivism: understanding and using a relatively new theory. Fam Med 1993;25:517-21.
13. Anderson J. Cognitive psychology and its implications. New York: Springer-Verlag, 1985.
14. Bordage G, Lemieux M. Semantic structures and diagnostic thinking of novices and experts. Acad Med 1991;66:S70-S72.
15. Caine RN. Making connections: teaching and the human brain. Menlo Park: Addison Wesley, 1991.
16. Bordage G. Elaborated knowledge: a key to diagnostic thinking. Acad Med 1994;69:883-5.
17. Jensen E. Teaching with the brain in mind. Alexandria, VA: ASCD Press, 1998.
18. Voytovich AE, Rippey RM, Suffredini A. Premature conclusions in diagnostic reasoning. J Med Educ 1985;60:302-7.
19. Hendricson WD, Berlocher WC, Herbert RJ. A four-year longitudinal study of dental student learning styles. J Dent Educ 1987;51:175-81.
20. Brown G. Studies of student learning: implications for medical teaching. Med Teacher 1983;5:52-6.
21. Coles C. Differences between conventional and problem-based curricula in their students' approaches to studying. Med Educ 1985;19:308-9.
22. Newble DI, Clarke RM. The approaches to learning of students in a traditional and an innovative problem-based medical school. Med Educ 1986;20:267-73.
23. Martenson D. Students' approaches to studying in four medical schools. Med Educ 1986;20:532-4.
24. Arnold L, Feighny KM. Students' general learning approaches and performance in medical school: a longitudinal study. Acad Med 1995;70:715-22.
25. Ericsson KA, Kampe RT, et al. The role of deliberate practice in the acquisition of expert performance. Psychol Rev 1993;100:363-406.
26. Ericsson KA. Expert performance: its structure and acquisition. Am Psychol 1994;49:725-47.
27. Hendricson W, Cohen P. Future directions in dental school curriculum, teaching and learning. In: Leadership for the future: the dental school in the university. Washington, DC: Center for Educational Policy and Research, American Association of Dental Schools, 1999.
28. Hendricson WD, Cohen P. Oral health care in the 21st century: implications for dental and medical education. Acad Med 2001;76(12):In press.
29. Institute of Medicine, Division of Health Care Services. To err is human: building a safer health system. Quality of health care in America. Washington, DC: National Academy of Science, 2000.
30. Katona G. Organizing and memorizing. New York: Columbia University Press, 1940.
31. Ross BH, Kennedy PT. Generalizing from the use of earlier examples in problem solving. J Exp Psychol Learn Mem Cognit 1990;16:42-55.
32. Kurfiss JG. Critical thinking: theory, research, practice and possibilities. ASHE ERIC Higher Education Report Number 2. Washington, DC: Association for the Study of Higher Education, 1988.
33. Druckman D, Bjork AR, eds. In the mind's eye: enhancing human performance. Washington, DC: National Academy Press, 1991.
34. Gall MD. The use of questions in teaching. Rev Educ Res 1970;40:707-21.
35. Redfield DL, Rousseau EW. A meta-analysis of experimental research on teacher questioning behavior. Rev Educ Res 1981;51:237-45.
36. Connell KJ, Bordage G, Chang RW, et al. Measuring the promotion of thinking during precepting encounters in outpatient settings. Acad Med 1999;74(suppl):S10-S12.
37. Cohen NJ, Ryan J, Hunt C, Romine L, et al. Hippocampal system and declarative (relational) memory: summarizing the data from functional neuroimaging studies. Hippocampus 1999;9:83-98.
38. Martin SJ, Grimwood PD, Morris RG. Synaptic plasticity and memory: an evaluation of the hypothesis. Annu Rev Neurosci 2000;23:649-711.
39. Blackman S, Goldstein KM. Cognitive styles and learning disabilities. J Learn Disabilities 1982;15:106-15.
40. McPherson SL, Thomas JR. Relation of knowledge and performance in boys' tennis: age and expertise. J Exp Child Psych 1989;48:190-211.
41. Pangaro L. A new vocabulary and other innovations for improving descriptive in-training evaluations. Acad Med 1999;74:1203-7.
42. Moreland R, Miller J, Laucka F. Academic achievement and self-evaluations of academic performance. J Educ Psych 1981;73:335-44.
43. Sinkavich FJ. Performance and meta memory: do students know what they don't know? Instruct Psych 1995;22:77-87.
44. Kruger J, Dunning D. Unskilled and unaware of it: how difficulties in recognizing one's own incompetence lead to inflated self-assessments. J Personality and Social Psych 1999;77:1121-34.
45. Weinstein ND, Lachendro E. Egocentrism as a source of unrealistic optimism. Personality and Social Psych Bulletin 1982;8:195-200.
46. Darwin C. The descent of man. London: John Murray, 1871.
47. Everson HT, Tobias S. The ability to estimate knowledge and performance in college: a metacognitive analysis. Instruct Science 1998;26:65-79.

48. Maki RH, Jonas D, Kallod M. The relationship between comprehension and metacomprehension ability. Psychonomic Bulletin & Review 1994;1:126-9.
49. Tesser A, Rosen S. The reluctance to transmit bad news. In: Berkowitz L, ed. Advances in experimental psychology, vol. 8. New York: Academic Press, 1975.
50. Gilbert DT, Giesler RB, Morris KE. When comparisons arise. J Personality Social Psych 1995;69:227-36.
51. Welford AT. Skilled performance. Glenview, IL: Scott Foresman, 1976.
52. Witkin HA, Goodenough DR, Oltman PK. Role of field dependent and field independent cognitive styles in academic evolution: a longitudinal study. J Educ Psych 1977;69:197-211.
53. Wilson S, Suddick RP, Shay JS, Hustmyer FE. Correlations of scores on embedded figures and mirror tracing with preclinical technique grades and PMAT scores of dental students. Perceptual Motor Skills 1981;53:31-5.
54. Suddick RP, Yancey JM, Devine S, Wilson S. Field dependence-independence and dental students' clinical performance. J Dent Educ 1982;46:227-32.
55. Suddick RP, Yancey JM, Wilson S. Mirror-tracing and embedded figures tests as predictors of dental students' performance. J Dent Educ 1983;47:149-54.
56. Tinajero C, Paramo M, Cadaveira F, Rodriguez-Holguin S. Field dependence-independence and brain organization: the confluence of two different ways of describing general forms of cognitive functioning? a theoretical review. Perceptual Motor Skills 1993;77:787-802.
57. Huang J, Chao L. Field dependence versus field independence of students with and without learning disabilities. Perceptual Motor Skills 2000;90:343-6.
58. Feil P, Reed T, Hart JK. Continuous knowledge of results and psychomotor skill acquisition. J Dent Educ 1986;50:300-3.
59. Feil P, Reed T. The effect of knowledge of the desired outcome on dental motor performance. J Dent Educ 1988;52:198-201.
60. Feil P, Reed T, Hart JK. The transfer effect of leadup activities. J Dent Educ 1990;54:609-11.
61. Feil P, Reed TR, McMillen SD, Killip JW, Purk JH. An experimental evaluation of the effectiveness and efficiency of the leadup activity. J Dent Educ 1991;55:560-4.
62. Feil P. An assessment of the application of psychomotor learning theory constructs in preclinical laboratory instruction. J Dent Educ 1992;56:176-82.
63. Killip JW, Feil P, McMillen S. Effect of planning the desired outcome on the quality of tooth preparation. J Dent Educ 1993;57:804-6.
64. Knight GW, Guenzel PJ. Design and validation of mirror skills instruction. J Dent Educ 1994;58:752-61.
65. Feil PH, Guenzel PJ, Knight GW, Geistfeld R. Designing preclinical instruction for psychomotor skills (I)—theoretical foundations of motor skill performance and their applications to dental education. J Dent Educ 1994;58:806-12.
66. Knight GW, Guenzel PJ, Feil P. Using questions to facilitate motor skill acquisition. J Dent Educ 1997;61:56-65.
67. Fischman MG, Christina RW, Vercruyssen MJ. Retention and transfer of motor skills: a review for the practitioner. Quest 1982;33:181-94.
68. Hagman JD, Rose AM. Retention of military skills: a review. Human Factors 1983;25:199-213.
69. Johnson P. The acquisition of skill. In: Smyth MM, Wing AM, eds. The psychology of human movement. London: Academic Press, 1984.
70. Schmidt RA. Summary: knowledge of results of skill acquisition—support for the guidance hypothesis. J Exp Psych: Learn Mem Cognit 1989;15:352-9.
71. Smith E, Goodman L. Understanding instructions: the role of explanatory material. Cognition and Instruction 1984;1:359-96.
72. Schendel JD, Hagman JD. On sustaining procedural skills over a prolonged retention interval. J Applied Psychol 1982;67:605-10.
73. Kieras DE, Boviar S. The role of mental modeling in learning how to operate a devise. Cog Science 1984;8:255-73.
74. Davis DA, Thomson MA, et al. Evidence for the effectiveness of CME: a review of 50 randomized controlled trials. JAMA 1992;268:1111-7.
75. Melnick MJ. Effects of overlearning on the retention of a gross motor skill. Research Quarterly 1971;42:60-9.
76. Loftus GR. Evaluating forgetting curves. J Exper Psychol: Learn Mem Cognit 1985;11:397-406.
77. Price GE, Dunn K, Dunn R. Learning style inventory/productivity environmental preference survey, 2nd ed. Lawrence: University of Kansas, 1982.
78. Duckwall J, Arnold L, Hayes J. Approaches to learning by undergraduate students: a longitudinal study. Research High Educ 1991;32:1-13.
79. Meyer J, Dunne T. Study approaches of nursing students: effects of an extended clinical context. Med Educ 1991;25:497-516.
80. Chickering AW, Gamson ZF. Seven principles for good practice in undergraduate education. AAHE Bulletin 1987;39:3-7.
81. Sorcinelli MD. Research findings on the seven principles. New Directions Teach Learn 1991;47:13-25.
82. Curry L, Wergin J, eds. Educating professionals: responding to new expectations for competence and accountability. San Francisco: Jossey-Bass, 1993.
83. Romberg E. A factor analysis of students' ratings of clinical teaching. J Dent Educ 1984;48:258-62.
84. Irby DM. Teaching and learning in ambulatory care settings: a thematic review of the literature. Acad Med 1995;70:898-931.
85. Speer AJ, Elnicki DM. Assessing the quality of teaching. Am J Med 1999;106:381-4.
86. Wright SM, Kern DE, Kolodner K. Attributes of excellent physician role models. N Eng J Med 1998;339:1986-93.
87. Milne D, James I. A systematic review of effective cognitive-behavioural supervision. Br J Clin Psychol 2000;39(Pt 2):111-27.
88. Heidenreich C, Lye P, Simpson D, Lourich M. The search for effective and efficient ambulatory teaching methods through the literature. Pediatrics 2000;105:231-7.
89. Smart RG, Ogbourne AC. Drinking and heavy drinking by students in 18 countries. Drug Alcohol Dependence 2000;60:315-8.
90. Newbury-Birch D, White M, Kamali F. Factors influencing alcohol and illicit drug use among medical students. Drug Alcohol Dependence 2000;59:125-30.

91. McCartan BE, Sadlier D, O'Mullane DM. Smoking habits and attitudes of Irish dental students. J Irish Dent Assoc 2000;39:26-9.
92. Ashton CH, Kamali F. Personality, lifestyles, alcohol and drug consumption in a sample of British medical students. Med Educ 1995;29:187-92.
93. Salovey P, Mayer JD, Goldman SL, Turvey D, et al. Emotional attention, clarity and repair: exploring emotional intelligence using the Trait Meta-Mood Scale. In: Pennebaker JW, ed. Emotion, disclosure, and health. Washington, DC: American Psychological Association, 1995.
94. Elam C, Stratton TD, Andrykowski MA. Measuring the emotional intelligence of medical school matriculants. Acad Med 2001;5:507-8.
95. Schwenk TL, Whitman N, eds. Residents as teachers: a guide to educational practice. Salt Lake City: University of Utah Press, 1984.
96. Shiffrin R, Schneider W. Controlled and automatic human information processing: perceptual learning, automatic attending and general theory. Psych Rev 1977;84:127-90.
97. Hoffman RR, ed. The psychology of expertise: cognitive research and empirical AI. New York: Springer-Verlag, 1991.
98. McGee SR, Irby DM. Teaching tips in the outpatient clinic. J Gen Internal Med 1997;12(April,Suppl 2):S34-S40.
99. Lesky LG, et al. Strategies to improve teaching in the ambulatory medicine setting. Arch Inter Med 1990;150:2133-7.
100. Baron RA. Countering the effects of destructive criticism: the relative efficacy of four interventions. J Applied Psychol 1990;75:235-45.
101. McEwen BS. The neurobiology of stress: from serendipity to clinical relevance. Brain Res 2000;886:172-89.