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Clinical Reasoning in Athletic Training Education: Modeling Expert Thinking

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Objective: To address the need for a more definitive approach to critical thinking during athletic training educational experiences by introducing the clinical reasoning model for critical thinking.

Background: Educators are aware of the need to teach students how to think critically. The multiple domains of athletic training are comprehensive and complex. Thinking is the fundamental connection between didactic and experiential components. Therefore, clinical thinking must be viewed as a critical part of experiential education in athletic training.

Description: Research from educational journals in medicine, physical therapy and athletic training, as well as relevant texts, were searched to investigate the theoretical and practical underpinnings of clinical thinking models. Definitions, applications, and the historical underpinnings of the clinical thinking processes in allied health were reviewed and presented to highlight the need for athletic training educators to better appreciate the thinking processes of students and practitioners. Practical suggestions for the implementation of clinical reasoning in athletic training are presented.

Application: Athletic training requires clinically based decision-making and problem solving skills. Medical educators recognize differences between the thinking of novice and expert practitioners, and have investigated the nature of clinical cognition as part of their formal curriculum. As AT's professional scope and credibility expand, the process of teaching, fostering, and evaluating clinical reasoning is paramount for AT educators.

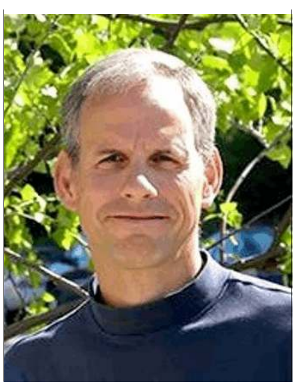
Key Words: clinical thinking, experience, case pattern presentation, hypothetico-deductive reasoning, differential diagnosis

"The belief that all genuine education comes about through experience does not mean that all experiences are genuinely or equally educative. Experience and education cannot be directly equated to each other. For some experiences are mis-educative. Any experience is mis-educative that has the effect of arresting or distorting the growth of further experience." (John Dewey, 1938, p25)

As legendary educational philosopher John Dewey[1] fluently stated in *Experience and Education*, true and meaningful education is in essence, the *sum total* of one's experience. For the casual observer, this may seem logical enough, but a more thorough analysis of Dewey's progressive philosophy reveals a deeper layer of thinking regarding the idea that not *all* experiences are necessarily *educative*. Put differently, educators should not naively assume that all pre-determined and well-designed learning experiences of a particular curriculum would automatically result in *positive* educational experiences. For Dewey, the ultimate challenge lies not in planning for, administering, or identifying the actual educative experiences. The challenge is to appreciate the myriad mis-educative experiences that contribute towards, and complicate, *all* experiential learning. This implies that despite the good intentions of curriculum developers and pedagogues alike, educational experiences are not always translucent.

Certain aspects of any experience are bound to go unnoticed or underappreciated, and it is these effects that can have more power over how a student perceives his or her experience. For example, a clinical supervisor might portray a negative attitude towards certain policies and procedures governing the clinical education program, or even dismiss some of the pedagogical initiatives that a program has instituted on behalf of student learning and outcomes. If allowed to persist, these attitudes will inevitably affect the student's overall experiences and lead to unintended learning. The very real presence of this dynamic in experiential education requires educators to both appreciate and account for the unexpected experiences that undoubtedly occur in most, if not all experiential endeavors.

Despite the many organizational changes that ongoing reform has brought from various accrediting agencies, *the* central



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component of clinical education has and always will be the core principle of Dewey's progressive education—*experience*. As AT education consists of a significant amount of clinical experience in order to complete the educational mission required for professional development and competency, the educative experience(s) of today's students must be scrutinized in order to better understand the actual experience(s) being garnered by students. In keeping with Dewey's declaration as it relates to AT education, clinical experiences can become *mis-educative* if hidden forces or dynamics having the potential to negatively affect the experience are not respected. For AT program personnel empowered to develop tomorrow's competent clinicians, it should be readily acknowledged that experience does not exist in a vacuum—it is neither immune to outside or unpredictable forces nor as controllable as some may like.

Perhaps Dewey's theory of mis-educative experience(s) can be better appreciated by considering how all elements of a particular curriculum infiltrate the intended educative experiences for those involved. In many, if not most, curricula there often exists a gap between teacher and student, between message sent and message learned; a distance best signified as the immeasurable difference between *perceived* teaching, and *actual* student learning. The "how" of knowledge construction and acquisition often remains hidden or unappreciated to both the learner and teacher in mis-educative environments. The cognitive reasoning and thinking processes required to validate learning, knowledge acquisition, and experience are often ignored, or at least under-represented, in far too many cases.

In AT, where students leave the relative safety and order of the classroom to venture into the chaotic and uncertain clinical environment, often with different instructors, the potential for gaps between teaching and learning are even more challenging. If not duly accounted for, the pedagogical gap between the expert and the neophyte can result in passive students and an imposition of subject matter and ways of thinking and learning that in the end, "forbids much active participation by pupils in the development of what is taught."[1 p19] In effect, learning to think in contextual and varied situations can become, in a sense, "hidden" if the process of thinking is not explicitly included and elucidated as a central principal of the formal curriculum. In the end, students not taught to think independently or critically are subjected to a Deweyanian mis-education that will stunt further intellectual and professional growth.

On the Professional Need to Think

Professional educational programs are intended to produce highly competent and talented professionals equipped with pre-determined cognitive and technical proficiency in their respective domains, and in possession of the numerous tools and skill sets needed to succeed in subsequent experience(s). Certainly, AT is no different in this regard. Competence is a professional necessity that presents its share of challenges to all allied healthcare providers. But perhaps more relevant to the current conversation is the recognition that it is equally challenging for educators empowered to instill and develop professional competence in their students. Inherent in and central to this challenge, is Knight's [2] observation in a recent editorial--that some "type" of critical thinking, or other high level cognitive processing should be at the heart of these endeavors; and thus a central, and formally expressed element of the respective curricula. In medicine, this concern has been articulated recently by Groopman,[3] who has lamented the manner in which he was (not) taught to think in medical school, and the subsequent disconnect he experienced between the didactic and clinical elements of his curriculum. Despite their extensive education, Groopman contends that physicians have long been *mis-educated* by their medical school professors and supervisors because they failed to teach them how to *think* like physicians. Because Groopman felt disconnected from his supervisors in regards to their thinking during his clinical education and the manner in which they failed to teach thinking to him, this practice ultimately filtered into his own clinical experience(s). From Groopman's perspective, he feels as though he has become part of a bothersome, yet recurring cycle of medical mis-education that has since played a large part in stunting the advancement of medical practice. Not only does Knight cite Groopman in his call for *better thinking*, but he goes so far to say that we too, have been guilty of not teaching our athletic training students how to think.

With increasing emphasis on the documentation of learning outcomes and experiential education in our discipline, both the explicit and implicit roles that thinking and experience play in clinical education must be critically examined to determine if athletic training education programs practice what they profess. By taking advantage of Dewey's philosophy of experience and his associated sentiments regarding thinking and the teaching thereof called for by Knight and Groopman, the intent here is to generate a discourse concerning the processes by which thinking can be taught and learned in athletic training education. This paper intends to critically examine the role that thinking plays in the educative experiences of athletic training students by comparing and contrasting the ways that *clinical thinking* operates in other allied health care education programs and professional practice. Secondarily, an effort will be made to augment athletic training pedagogy by introducing *clinical reasoning* as a viable and apropos cognitive model that possesses the potential for more educative, active, and meaningful learning experiences for athletic training students.

Learning & Thinking in AT Education

Both the practice of AT and the education of future ATs centers on the accumulation of vast and interconnected knowledge and experiences. Accredited programs are charged with ensuring the matriculation of competent entry-level ATs in possession of more complex and diversified skill sets, than our groundbreaking predecessors.[4] Clinical education of the 21st Century has seen considerable transformation, including expanded cognitive domains and psychomotor skills. Today's clinical experiences are characterized by a greater structure, scope, and rigor, that together are intended to improve and validate the clinical competency of future ATs. Today's aspiring ATs must know more and be able to do more in an increasingly diverse array of professional settings. In addition, program administrators must also pay heed to both the type and quality of experiential learning provided; for the ultimate goal should reside in preventing the mis-education of students. These recent trends challenge the ability of educators and students to interconnect the didactic and the clinical into a coherent and competent whole capable of addressing all of the possibilities. More than at any time in the history of AT education, today's students must experience a different kind of education if educators intend to connect the didactic to the clinical in a manner that ensures genuine educative experiences.

Connecting the Didactic to the Clinical for Educative Experiences

Not only must administrators be concerned with the various attitudes and intentions associated with field-based or clinical experience, but as Groopman[3] argues, also the way(s) in which clinical educators themselves *think,* and in turn teach *thinking to their students.* By association, the way(s) that students learn to think when they leave the classroom and enter the clinical realm of learning must also be given serious regard. The point here is that "thinking," or how an aspiring clinician is taught to learn how to think, should serve as the primary conduit for connecting the didactic and clinical islands of effective and reflective experience. As Knight[2] and others before him have argued, some manner of critical thinking should be situated at the heart of programs' pedagogical endeavors in order to meet the collective mission of developing competent, entry-level clinicians.[5-9] Since AT is an allied health profession essentially centered around competent clinical practice, perhaps the generically termed critical thinking can be contextualized better by using clinical thinking to represent its pedagogical and practical purposes. The ability to think clinically must be delineated as the *modus operandi* around which the intended and ultimate program outcomes are centered; or as Knight has stated, the way to "bridge the gap of classroom knowledge and practical application… thereby help students become knowledgeable, confident, critical thinking professionals."[2 p81] After all, when one considers the interconnected roles of learning and experience, *thinking* drives *doing*, and *doing* can only be improved and progressed by *thinking*.

To Dewey,[1] educative experiences are not truly meaningful without a cognitive element that obliges the experience(s) to be based upon intellectual preparation, reflected upon with metacognitive (thinking about thinking) strategies, and remediated with further learning and experience(s). It is this continual and critical cycle that is at the heart of all teaching and learning. If clinical competency is indeed the desired outcome, novice students cannot be given volumes of predetermined knowledge and skills, and then directed to "connect" them with practice and experience on their own volition. In such a top down scenario, one Dewey characterizes as "static,"[1 p19] neophyte students are taught to perform long, undulating and predetermined evaluations (say, for an ankle) that include almost every plausible history question, manual muscle tests, and special tests relevant to the ankle in order to attempt to come up with a plausible impression or diagnosis. In this static curriculum, there is no cognitive scaffolding that directs the inquiry or connections between knowing and doing, and so it becomes a search and destroy mission where the inexperienced learner relying on memory and recall ends up with far too much information to sort and organize. Statically trained students effectively get lost during the process of the injury evaluation, and so they struggle to arrive at a rational and scientifically sound impression for a given case. Top down educated students have difficulty organizing their knowledge, and far too often, the experience becomes frenetic, futile, and often mis-educative.

Teaching and learning in such an inert manner effectively encourages the passive recitation of old, previously learned knowledge; while denying the individual learner and self-creation of knowledge.[1 p18] More importantly, a student experiencing mis-education cannot typically think their way through the evaluation in real time, or when questioned by a clinical educator supervising the experience. Such a pedagogy precludes active involvement in the construction of experience(s) because students have not been taught how to think their way through the evaluation process; an oversight that in the end, distorts and arrests further self initiated learning in subsequent experiences. Perhaps Dewey puts it best by asking "How many students for example, were rendered callous to ideas . . . lost the impetus to learn because of the way in which learning was experienced by them…acquired special skills by means of automatic drill so that their power of judgment and capacity to act intelligently in new situations was limited?"[1 p27] If supervising educators wish to avoid passing down what Dewey called, the "standards of rules of conduct" that constrain and constrict genuine experiential education,[1 p17] students must be taught *how* to use, apply, modify, and analyze said knowledge and skills in ways that are not static, predetermined, and contextually irrelevant. As Knight states, "Follow-up application and practice is necessary to convert this inert skill set into a viable, performative knowledge."[2 p81]

AT educators must be responsive to Dewey's contention that any experience ". . . may be so disconnected from one another that, while each is agreeable or even exciting in itself, they are not linked cumulatively to one another . . . and a person becomes scatterbrained."[1 p26] It should be appreciated that disorganized, scatterbrained, and mis-educated students are not exemplary of the intended purposes of recent educational reform. Somehow, experience(s) must be designed and ultimately *experienced* in an organized, progressive, and reflective manner in order to promote mental and physical competence, and subsequent clinical expertise. As current *AT Educational Competencies* explicitly require educational programs to document the ability to think "critically,"[4] students must be taught to think in clinical contexts, as it is the act of thinking that effectively bridges the various components of current and future clinical experiences. For dually partitioned educational programs with two distinctive, yet interconnected components, significant challenges in meeting the intended outcomes of the program indeed exist. To avoid mis-education of both students and faculty, experiences need to be designed to address and evaluate the processes and acquisition of effective clinical thinking strategies. "Providing early and frequent experiences in which diagnostic thought processes and strategies are overtly discussed would broaden student experiential backgrounds."[2,80] Athletic training is not alone in this challenge; perhaps the most daunting task facing allied health educators is how to better connect the didactic and clinical curricula, and how to concurrently develop critical thinking. To make experience(s) truly educative, educators must critically address the ability of students to think like competent professionals.[5-9]

The following questions become more meaningful for educational programs intent on developing clinicians capable of *thinking well* in Clinical settings: 1) Does being competent mean that one can think critically? 2) If so, how does one measure and document the ability to think critically in clinical situations? 3) How does one differentiate between an AT who is thinking well (expert), from one that is not (novice)? 4) How do academics connect the classroom to the clinical? and 5) How do clinical instructors connect the clinical to the classroom so that both parties operate and educate on the same "wavelength"? Scholars involved in allied health education have already carried out significant work in this regard, and fortunately they have progressed the notion of clinical thinking as a more apropos and contextually relevant critical thinking model for allied healthcare professionals.

Clinical Thinking in Allied Health

Allied health educators need to go beyond teaching their students how to "do" AT, nursing, or medicine; they need to provide the skills and framework for the ability to use clinical thinking. The technocratic part, teaching students the facts, figures, steps, rationale, and techniques is not typically difficult for seasoned and well-prepared teachers, and indeed there is a wealth of information on various pedagogically effective methods for doing so. But teaching aspiring healthcare providers how to "be" ATs, nurses, and physicians by modeling expert practice, and teaching them how to think like duly experienced clinicians think[3,10] is not so easily done. In 1978, Elstein and colleagues[11] addressed the potential for teachers by suggesting that the ability to problem solve effectively may be a teachable skill that is independent of specific clinical knowledge. In regards to experience, the process by which expert clinicians think through patient problems when attempting to evaluate injury and illness is perceived by the neophyte as mysterious, intimidating, and sometimes even contradictory to what has been taught in class. That is, what students see, hear, do, and learn during their experiential education can be appreciated as "hidden" if it does not clearly correspond with what has been taught in the classroom.[3] The issue thus becomes, do AT education programs teach AT students how to think like clinicians or do they merely teach them how to know and do AT?

Indeed, allied healthcare educators have identified the "thinking" aspect of practice as central to their overall educational mission; and as such, medical thinking is rightfully and explicitly included in the formal curriculum as intended learning objectives and educational outcomes.[12-15] Medical educator Norman states, "educators agree that clinical reasoning is a central component of physician competence, and objectives related to the mastery of clinical reasoning skills appear in the documentation of most medical schools, licensing bodies and specialty societies . . . but once one goes beyond the phrase to attempt to determine what it is, or to devise instructional approaches or testing methods, matters become much more complicated."[14 p18] Reilly and Oerman concur in pointing out that nursing students undertaking clinical education are continually confronted with problems, either client-or setting oriented with each demanding specific and nuanced resolutions.[15] In other words, the ability to problem solve is not generic to all domains or settings, nor does it seem to be distinctively different amongst the various healthcare professions. Rather, clinical thinking has multiple applications and meanings pending the context and challenges involved, yet seem to be a common mental aptitude amongst experienced healthcare practitioners. Subsequently, allied health educators have spent significant energy investigating the roots of teaching, measuring, and validating various outcomes associated with the thinking elements critical to professional and clinical competency. However, teaching students how to think clinically and independently, and thus by extension providing an effective framework for clinical educators to connect the thinking aspects of the didactic to the experiential, are often left to chance.[15] For many, it is not very difficult to distinguish between an expert clinician and a novice in any allied health care field; but when pressed, it is often difficult to ascertain why or how because of the qualitative and nuanced nature. Aside from technical proficiency and a communal educational background, it is apparent that there exists a certain intangible cognitive process separating expert and novice healthcare professionals when confronting complex clinical problems.[12-13,16]

A More Precise Way of Clinical Thinking: Clinical Reasoning

Recent competency initiatives in medical literature have identified thinking processes that define and give shape to clinical competence.[12-14,16,17] In turn, interest in the cognitive processing of physicians and students and how thinking pertains to practice has helped spawn a line of inquiry and analysis of clinical thinking known as *clinical reasoning*.[14] In any clinical healthcare field, managing patients involves making multiple decisions based on myriad dimensions of knowledge and skill sets, the skillful gathering of subjective and objective data, complex interactions with the patient, family members and other providers, and real time problem solving.[18-24] Thus, the need for a specialized or discipline-specific mode of reasoning and thinking beyond the generic critical thinking concept is certainly logical. Although there are many different definitions of clinical reasoning, most experts agree it is a multi-factorial and complex mental process inclusive of multiple methods for diagnosis formulation; each with their own strengths, limitations, and applications depending upon the individual and context under study.[3] Jensen[24 p2] described clinical reasoning as a "multidimensional concept that involves a wide range of cognitive activities that underlie judgments, decisions, and actions made by health professionals," and that it can be "thought of as an internal dialogue that occurs before, during and after patient care." Perhaps more succinctly, Clinical reasoning can be thought of as the cognitive processes, decision-making, problem-solving, or focused thinking used in the evaluation and management of a patient.[25] Over 30 years of medical education research has revealed two primary types or levels of clinical reasoning that help differentiate the thinking processes of novice and expert clinicians when confronting complex or novel clinical problems: hypothetico-deductive reasoning and case pattern recognition.[14]

Hypothetico-Deductive Reasoning

Hypothetico-deductive reasoning is characterized by proposing plausible hypotheses, and then attempting to prove, or disprove each hypothesis by performing a series of clinical "experiments" in an attempt to solve problems. The hypotheses generated are based on the clinician's existing knowledge base, associations, and experience relative to the problem at hand.[10-11] Thus, experience does matter with hypothetico-deductive reasoning—novices can and do use it as a natural starting point, but experience can make the process more streamlined and efficient. Elstein and Schwarz [25] add that each hypothesis generated is then used to predict what *other* findings ought to be present during subsequent aspects of the exam if the proposed hypothesis were eventually true; much like finding the other parts of the puzzle that fit. Any subsequent diagnostic process conducted as part of the (latter) examination becomes a guided search for the anticipated findings in a type of backwards reasoning.

As data is gradually accumulated throughout an exam guided by hypothetico-deductive reasoning, some competing hypotheses are eliminated if not supported by the data collected up to that point. Depending upon the relative experience and knowledge level, the clinician is eventually left with one, or perhaps just a few, plausible hypotheses that will then guide the ensuing evaluation. As simple and logical as this may sound, and as effective as it may be some of the time, this theorize-test process can be a very long, misguided, and unorganized approach to solving problems; particularly in a busy clinical environment, or when used by students of varying confidence levels.

Although very similar to the traditional scientific method familiar to many, researchers in the field of medico-cognitive processing are not sure of the *exact* cognitive processes involved in hypothetico-deductive reasoning or how it is modified with experience. Despite this uncertainty however, researchers seem to think that more experienced clinicians generate fewer and better hypotheses for diagnostic challenges, and that the accuracy of their early hypotheses are a strong predictor of the eventual, final conclusion.[13,17,25] In contrast, it has been found that novices typically struggle to develop an evaluative plan that is capable of testing their hypotheses, even after they have collected some of the initial data needed to conduct an evaluation. Novices may indeed be capable of using inductive reasoning to formulate early hypothesis as to the nature of the problem, but many seem to then struggle for effective ways to deductively test their hypothesis. As a result, the flow, accuracy, and organization of the subsequent evaluation procedure and processes are not well suited for effective problem solving. Consider the scenario mentioned earlier concerning the student who performs every ankle test and measure he/she has learned, and then has little idea as to what to do with the collected data. Pending the amount of experience (with an ankle injury) and knowledge in hand, it is likely that most students can, when asked, formulate a list of potential diagnoses. But because they likely do not know how to think through a clinical problem, they also do not know to conduct an effective experiment capable of testing their hypotheses.

As effective as a modified scientific method like hypothetico-deductive reasoning appeared to be for novice and less experienced clinicians, expert clinicians seemed to do something different than hypothetico-deductive reasoning to solve problems.[10,11,14] Expert clinicians appeared to think and move faster than hypothetico-deductive reasoning would allow; to skip some standard evaluative steps, yet still come up with accurate outcomes and resolutions to clinical problems. It became clear that clinical competence for any level practitioner was predicated largely on some base level of experience, in combination with the requisite biomedical information memory. The precise mental processes, however, appeared to separate novice clinicians from experts, and drove the bulk of the cognitive research in medical education. In time, scholars transitioned to the idea that clinical expertise was more related to the *kinds* of knowledge experts had, and to the ways that they *organized* their knowledge.[18] Thus, clinical thinking research shifted towards knowledge representations, pattern recognition, or direct automatic retrieval, and away from hypothesis formulation and testing.[25]

Case Pattern Recognition

Expert processing is the consequence of an extensive and multidimensional knowledge base that is constructed and characterized by: 1) more coherent explanations for a problem; 2) more selective uses of data; 3) more inferences from data, and interestingly 4) the use of less basic science for explanations (than relative novices).[26] Although the last may seem contradictory, it is thought that experts actually *use* less basic science to explain disease and pathology because they are able to rely more on encapsulated knowledge and sophisticated intuition that is bred from their contextual experiences. In other words, experts appear to use hypothetico-deductive reasoning less frequently than do novices. Several authors have elaborated on the less scientific, non-analytical approach by describing the ways that experienced doctors use a number of short-cuts, decision trees, or heuristics that seem to be based on previous knowledge and experiences, to work more quickly and accurately than less experienced students and clincians.[11,30] In effect, experienced clinicians relying on previous patient cases are often in a position that they need not reason at all, because the (new) case is easily recognizable from past experiences. This type of thinking led to the evolution of yet another term for expert clinical reasoning—*case pattern recognition*. Using case pattern recognition, or what Schmidt, et al,[27] referred to as exemplars, the experienced clinician recognizes *key features* of a case (signs, symptoms, etc.) that fit within a known pattern of a specific condition.

Based largely on cognitive research questions generated from various studies on chess masters, medical researchers began to think that contextual experience played a significant role in the ways expert clinicians think.[8] It was theorized that chess masters' ability to recall memory was derived primarily from practice with thousands of case scenarios, and not from individual and discriminate pieces of data that helped to formulate working hypotheses. In other words, chess masters readily recognized patterns on the board, which allowed them to more quickly analyze the problem and make subsequent skilled moves. In contrast, amateur chess players see individual chess pieces scattered throughout the board and attempt to analyze each potential move for its value and predicted success. In medical case pattern recognition, individual *pieces* on the board are not the king, queen or pawn, but rather, various signs and symptoms that signify particular illnesses and injuries. Together, the various pieces formulate recognizable patterns that are more evident to the expert, than to the novice.

Case pattern recognition is a mental process predicated upon comparing new cases to those that have been successfully encountered in the past.[27] Correctly identifying the key features of a past case pattern help experts arrive at plausible diagnoses earlier, thus producing a faster, more streamlined and efficient evaluation process; usually with higher accuracy. In an AT context, medial elbow pain in a 13-year-old little league baseball pitcher would be a key feature of a potential Little Leaguer's elbow and sharp, shooting pain would indicate peripheral nerve involvement, while a mallet finger deformity would be a key feature of a DIP extensor tendon rupture.

Expert nurses perceive the clinical situation more as a whole and use past concrete situations as the working paradigm for new clinical cases.[15] And physical therapy researchers have included the process of engaging with patient's (and their families) as critical parts of the clinical reasoning process.[20,21] For those experts using pattern recognition, this type of non-analytical automaticity often occurs without conscious awareness, much like driving to work the same way each day or performing a Lachman's test for the 1,000th time.

Clinically, a particular set of symptoms (quality of pain, alleviating/aggravating factors) and signs (foot drop, flattened deltoid, fatigue with repeated overhead activity, etc.) can suggest a diagnosis very early and accurately (usually within the history taking step), and subsequent experiences with similar cases allows the clinicians to build his/her own internal library of patterns; each composed by collecting and organizing the key features of each pattern encountered. Groopman[3] reiterates a common perspective in stating that the majority of correct diagnoses originate in the critical history-taking portion of an examination; an indication that the earliest elements of a provider-patient interaction are capable of illuminating several significant key features like past illness/injury, mechanism of injury, obvious signs, and reported symptoms; and contributing factors make up a particular case pattern associated with a specific injury or illness. The skilled clinician readily recognizes these key features, and is adept at structuring the evaluation process in a way that is streamlined and efficient in both breadth and depth. For example, experienced ATs will undoubtedly agree that "seeing the injury happen" is the most significant piece of the diagnostic puzzle of a field based evaluation of an acute injury, or recognize that a lateral shift is a key feature for an acute herniated lumbar disc. In subsequent encounters, experts with these stored patterns are able to quickly recognize the key features as being representative of the stored pattern (i.e., once a clinician has encountered patients complaining of fatigue with repeated overhead activity, and has subsequently learned that this is a key feature of multidirectional glenohumeral instability, they will more quickly and accurately conclude the proper impression the next time they encounter this key feature). In contrast, a less experienced student incapable of using pattern recognition as a cognitive strategy will conduct a very lengthy evaluation (using hypothetico-deductive reasoning) consisting of numerous history questions, palpations, muscle tests, and a multitude of special tests to attempt a reasonable impression; a process that is much lengthier and much less accurate for making a formal diagnosis.

Strategic shortcuts, however, can lead yo misjudgment and errors; especially if misused by less experienced clinicians or even by those experienced clinicians in a hurry to complete a task or impress a novice observer. Mistakes of judgment can also occur in cases where subtle differences exist between the case at hand and those from previous experience.[10] In the latter scenario, features that don't fit the case pattern (signs, symptoms, findings, etc.) can be easily ignored or discarded as atypical, which can sometimes lead to mistakes due to blind sightedness that may occur in the rush to decision making. Used effectively, a more modest and cautious clinician will respect exceptional features (ones that do not fit), and re-direct their thinking towards new, as of yet un-experienced cases by reverting back to hypothetico-deductive reasoning as their mode of thinking to solve the problem.[18] Thus, the proper use of case pattern recognition requires careful and reflective experiences with mounting case problems in order to be properly developed and used as a primary cognitive strategy; and should only be used judiciously by experts, as one type of tool in their cognitive tool chests. Table 1 lists the advantages/disadvantages and characteristics of both hypothetico-deductive reasoning and Case pattern recognition strategies.

A Synthesis of Strategies for Clinical Reasoning

Students should be taught what case patterning is and how it is developed early in the educational experience so that a perspective on "where" to go with clinical thinking is developed as experience mounts. Students must also be taught, however, to not use case pattern recognition as the chief or sole strategy for problem solving and decision-making.[11,15,27] Without adequate guidance, supervision, and continual two-way conversations between mentor and student regarding the actual thinking process used (both forward and

Table 1. Characteristics, advantages, and disadvantages of HDR and CPR clinical reasoning strategies

CR Strategy	Characteristics	Advantages	Disadvantages
Hypothetico-deductive reasoning	• Procedural or analytical reasoning • Inductive and deductive • Relationship between Signs/Sxs and potential Dx • Primary method for novices • Experts use for novel problems	• Thorough • Linear & organized • Linear • Easily teachable and learnable	• Slow & arduous • Too many diagnoses considered • Too much data collected • Stumped by unexpected results or data
Case pattern recognition	• Non-analytical reasoning • Deductive • Organized • Streamlined • Intuitive • Utilizes key features • Utilizes differential diagnoses	• Fast • Conclusions often reached with imprecise data • Recognizes "features that don't fit"	• Lacks certainty • Requires extensive experience • Shortcut errors

backwards), the basis for such recognition on the part of the expert can be dangerous and ill-conceived. Therefore, numerous authors have made a concerted effort to coalesce the differences between analytical and non-analytical clinical reasoning into a more universally applicable concept.[11,17,29] By coalescing analytical (hypothetico-deductive reasoning) and non-analytical (case pattern recognition) methods into a more flexible platform for clinical reasoning, it is thought that all bases will be covered for clinicians across the spectrum of context and experience.[29]

A fluid spectrum model, such as that proposed by Eva,[29] encompassing both analytical and non-analytical processing, is a plausible way to situate both the totality (various types), and the contextuality (place, condition, patient, etc.) of how clinical reasoning operates dependent upon accrued experience. At one end of the spectrum are students and novice clinicians using basic recall and a rudimentary form of hypothetico-deductive reasoning as their primary analytical strategies for all patient problems. At the other end of the spectrum, expert clinicians effectively use non-analytical case pattern recognition for familiar patient encounters. The synthesis of the two processes lies in the middle of the spectrum, where clinicians use an interactive blend of the various processes to solve clinical problems; hypothetico-deductive reasoning for complex or unfamiliar patient problems because they are incapable of recognizing the patterns inherent in the problem and judicious use of case pattern recognition for those cases they have successfully encountered before (i.e., standard lateral ankle sprain, hamstring strain, etc.).

This fluid synthesis model represents and reinforces the idea that clinical reasoning is a complex cognitive process, one that relies both on analytical and non-analytical approaches that are buttressed and initiated by the storage and acquisition of vast amounts of knowledge. Furthermore, the knowledge and skills learned must then be integrated with reflective experience and a clinical thinking process that provides for the construction of highly organized, and easily accessed clinical case patterns.

There are numerous considerations that contribute to the processing involved in both case pattern recognition and hypothetico-deductive reasoning. They can be used as the focal points of any critical pedagogy in AT education.[18] Together, they summarize the roots of both analytical and non-analytical clinical reasoning, and possess the potential to displace more linear and mechanical cognitive processes (i.e., "HOPS", proficiency check offs, etc.), including: 1) identifying relevant clinical information (key features for differential diagnosis); 2) interpreting the meaning of the information; 3) generating hypotheses which provide a coherent explanation of the patient problem; 4) testing and refining the hypotheses with further data collection; 5) establishing a working diagnosis; and 6) developing the ability to organize clinical experiences into readily retrievable case patterns.

Hypothetico-Deductive Reasoning in AT

Students start as novices with most, if not all of the information presented in their early class work and subsequent clinical encounters. It is unlikely they will use a cognitive strategy beyond the basic recall of previously stored knowledge. A novice student (say, a first semester sophomore), in possession of some of the necessary knowledge and psychomotor skills required to evaluate a shoulder dysfunction, and of the basic steps in performing a clinical evaluation (most likely, the "HOPS" format), will typically feel compelled to recite their knowledge of all relevant information. In lieu of thinking their way through the evaluation, neophyte students are most likely focused more on the process of doing or robotically repeating everything they have been taught pertaining to shoulder injuries and evaluation (for example), with the ultimate intent of leaving no stone unturned. Yet in the end, most neophyte students are incapable of offering few, if any, viable hypotheses regarding the nature of the pathology if asked.

While learning to effectively use hypothetico-deductive reasoning for cognitive processing, however, novice students with some base level experience may haphazardly formulate up to four or five potential hypotheses towards an eventual diagnosis after gathering some initial information (rotator cuff tear, rotator cuff tendonitis, bursitis, biceps tendonitis, glenohumeral instability, deltoid strain, etc., for a shoulder evaluation). Then, based on their initial impressions, they will conduct a comprehensive, and most likely scattered evaluation in an attempt to test, and or rule out each competing hypothesis. As the interaction continues between the student and the patient, an intermediate level student who is more familiar with hypothetico-deductive reasoning will pose further questions, and conduct additional examination techniques in order to support or refute their initial hypotheses. The more inexperienced and tentative the student or novice clinician, the more potential hypotheses are formulated as additional information is gathered, and thus the more time consuming and chaotic the evaluation becomes. Continuing with the prior shoulder example, a student clinician unfamiliar with the complexities of shoulder impingement syndrome may dutifully go through the many ordered steps of a thorough shoulder evaluation, and the interested observer can witness this student asking an inordinate amount of questions (every potential history question they have been taught to ask), and performing an excessive amount of physical examination routines (palpate all soft and bony tissue landmarks, manually muscle test every movement, and perform every special test for the shoulder, etc.) in a chaotic attempt to test the myriad hypotheses that were initially formed; all to find one remaining option.

Ironically, it is in this case that the evaluating student has actually gathered too much information to consider, and so he/she becomes hesitant and tentative when asked to provide a final hypothesis by a clinical educator. Novice clinicians and young students may have the tools required to excavate the information and data needed for a differential diagnosis, but they do not necessarily have the reasoning ability to interpret and synthesize the data collected in order to differentiate between the evident possibilities. In other words, key features cannot be readily recognized and relevant information cannot be sorted and organized. When confronted with such a scenario, younger students often become frustrated and overwhelmed with the challenge at hand, and will sometimes withdraw from the process for fear of being wrong. Without an effective cognitive strategy to process all of these data, the clinical connections cannot be made, and the experience is thus devalued. Obviously, experiences like this contribute more towards miseducation, than they do towards education. All is not lost however; the ability to use hypothetico-deductive reasoning does improve with experience.

The more relevant knowledge a student or clinician has access to, the earlier the initial hypotheses can be formed; and when combined with multiple associations and a greater level of experience, fewer hypotheses need to be formulated because key features and tentative patterns become more readily recognized. In this case, a slightly more experienced clinician, or student can use his/her past experiences and improved knowledge base to expedite the process by condensing the evaluation, and focusing less on the various (and extraneous) bits of information. Mounting experience allows students to look more at the big picture; thus becoming better able to narrow the list of possible diagnoses to two or three likely choices (say, to a supraspinatus tendonitis, biceps tendonitis, or bursitis). Although the list of hypotheses generated gets progressively smaller as the experience mounts, the ever learning clinician still primarily uses analytical processes (hypothesis formulation, test hypothesis, repeat, etc.) to become more confident and resolute in forming a plausible hypothesis. This process accelerates even further as the student clinician experiences multiple cases of each of the potential diagnoses, and has successfully navigated their way through those particular patient problems (thus, gradually moving along the fluid spectrum towards the expert realm).

Since hypothetico-deductive reasoning is a more suitable cognitive model for problem solving for the early to intermediate phases of the curriculum, the processes involved with hypothetico-deductive reasoning should be encouraged and evaluated in as many learning experiences as possible. Novice and intermediate students need to improve their hypothetico-deductive reasoning skills by developing the ability to formulate plausible hypotheses that can be tested in an organized and concise fashion. As their knowledge and experiences mount, they should gradually be able to reduce the number of hypotheses generated, improve their ability to interpret and synthesize the data they collect in testing the hypotheses, and eventually, improve the accuracy of their initial hypotheses with more confidence.

It is important to realize that hypothetico-deductive reasoning *is* an advanced form of clinical thinking that will emerge even further, as it requires the user to go beyond the mere recall and replication that first time students will demonstrate. Familiarity both with the process of an hypothetico-deductive reasoning driven evaluation and with a select group of case problems will allow novices to focus more on important pieces of information while attempting to form an initial hypothesis for a particular patient problem. As novices become more proficient using hypothetico-deductive reasoning for specific cases they have encountered, they should then be encouraged to start organizing their knowledge better by formulating and accessing various case patterns by zeroing in on key features that constitute those case patterns. Effectively, this means that student "detectives" will need to improve their ability to notice key features earlier during the evaluation procedure (most notably, the history), and thus to become better at filtering out those findings that 1) do not directly relate to the problem at hand, or 2) are representative of features that do not fit (thus, necessitating the formulation of a new case pattern).

Teaching students to use hypothetico-deductive reasoning as the *modus operandi* for evaluating injury and illness is indeed a form of critical thinking, and because it allows the clinical instructor to review and question a student's thought process and provide appropriate feedback and needed remediation, it is surely an effective, safe and recommended tool for young, novice clinicians to emulate and employ. In fact, numerous medical educators agree that novice clinicians in medicine use hypothetico-deductive reasoning as their primary cognitive mechanism for evaluating injury and illness.[10-14,20-24]

Case Pattern Recognition in AT

Case pattern recognition is recognized as a higher cognitive process that is consistently displayed by more expert clinicians,[29] yet ironically, is arguably more difficult to identify, teach, and learn by those vested in allied healthcare education.[30] If we return to the six summative components of synthesized clinical reasoning presented earlier, we can see that case pattern recognition consists chiefly of the use of process #1 (identifying relevant clinical information (for diagnosis)) in order to arrive at process #5 (establishing a working diagnosis) much quicker, and hopefully much more efficiently. Realistically, it is not as simple as going from step 1 to step 6; there is arguably a certain amount of analyzing and cognitive processing occurring when using case pattern recognition, but it is thought to be an automated process whereby experts do not reason at all.[21] As students and clinicians gather real world clinical experiences with various manifestations of disease, injury and pathology, she/he increasingly and adeptly organizes knowledge and experiences into an accessible array of recognizable clinical case patterns . As cognitive organization and departmentalization occurs with increasing experiences, the developing clinical case patterns provide the platform from which more experienced students can readily and adeptly address similar problems in the future.

Key features are intricate clues that once put together, help spell out the clinical puzzle in question. For example, hearing or feeling a loud "pop" and witnessing profuse edema in the knee after sustaining a valgus rotation force to the knee are key features of an ACL rupture; reproducing pain with palpation in the anatomical snuff box is a key feature of a fractured scaphoid, or a sudden onset of a fever with an erythematous and severely painful throat with petechiae are key features of strep throat. As experts pick up on key features, they readily and rather non-analytically recognize and associate these key features with known and experienced case patterns, and then typically formulate an accurate and quick diagnosis. Returning to our shoulder example, more expert clinicians using case pattern recognition as their strategy will quickly recognize that sharper pain in the deltoid and at night are indicative of a rotator cuff strain, or that fatigue with repeated overhead activity is a key feature of multidirectional instability of the glenohumeral joint.

The subsequent evaluation is an efficient and streamlined process designed to support the diagnosis that has been associated with the recognized pattern, and allows students to accurately predict the results of the physical exam *before* the physical evaluation procedures are conducted, all with a higher degree of accuracy and understanding. In this scenario, the physical tests performed actually serve as confirmations of the case pattern recognized (less tests are performed because multiple hypotheses do not have to be tested), and in time, further contribute to the development and reinforcement of case patterns for these injuries.

As previously mentioned, if certain features don't fit the pattern presented, or if the encounter is novel, the expert clinician then returns to using hypothetico-deductive reasoning as the primary mode of cognitive processing; thus demonstrating the fluid spectrum that interconnects the domains of clinical reasoning alluded to earlier. The fluid and interconnected nature of hypothetico-deductive reasoning and case pattern recognition for clinical reasoning can be demonstrated rather easily by considering typical clinical confrontations for ATs first in the classroom, and then in the clinic. As clinical educators witness students thinking in these manners, they are better able to challenge, probe and evaluate the reasoning processes used, and thus provide effective feedback not only directed towards the accuracy and execution of the evaluation, but also towards the clinical thinking process employed. As a critical point of emphasis, for the clinical experiences to be truly educative, they must be connected to classroom learning; and using key features and pattern recognition during formal instruction can be an effective way to accomplish this challenge.

Clinical thinking needs to be developed as students progress in their coursework and begin to learn the various signs and symptoms of the various injuries and maladies covered in many prevention and care classes. For example, young students covering the foot and ankle begin to learn the specific anatomy involved, the mechanism of injury, how the injury will present itself in acute and/or chronic situations, what signs and symptoms to look for, and what steps to take in the evaluation process. In a way, these rather standard and common strategies are examples of using clinical pattern recognition as a mode of clinical learning, and so the foundation for later work is being laid already in most educational programs. But in order for a higher level of thinking to be elucidated, and thus for students' experiences to be more educative, three things need to happen to enhance clinical thinking and clinical decision making across the curriculum. Clinical reasoning needs to be: 1) defined, or operationalized in the classroom as the cognitive structure "of choice" for making differential diagnoses; 2) used as a pedagogical core for classroom teaching and learning around which exercises are designed; and 3) carried into the clinical education phases of the learning experiences by ensuring that clinical education plans and educators alike recognize the utility and intent of clinical reasoning.

Clinical Reasoning Across the AT Curriculum

There are three elements of developing clinical reasoning: Teaching what it is, emphasizing it in diadactic classes, and practicing it in the clinic.

1st Element. Clinical reasoning must be taught if students are expected to use it for problem solving.[2] In order to give meaning to the various evaluation schemas used to learn the "how to" of diagnostic decision making, students must be presented with "what" clinical thinking and reasoning are in the practical sense. More directly, it is required to formally teach students what hypothetico-deductive reasoning and case pattern recognition are, what they mean, how they work, and their role in clinical thinking at before they enroll in (or at the beginning of) their primary assessment class (es) so they can begin to better organize their knowledge, and perhaps more importantly, their thinking in ways that reflect clinical thinking, and not just memorization. Providing specific examples throughout the curriculum, some basic (e.g., a standard lateral ankle sprain case), some intermediate (e.g., an otitis media case), and some advanced (e.g., a herniated nucleus pulposus case) will then set the table for all subsequent learning experiences. Specific learning objectives for the instructional unit on clinical reasoning include understanding what processes are required to formulate differential diagnoses, knowing how hypothetico-deductive reasoning and case pattern recognition differ, the difference between novice and experienced clinicians, the fluidity between the two techniques, and that no clinical reasoning strategy will be effective in the absence of content and skill mastery (students must still “know their stuff”).

Students should also be made aware that they will be expected to learn and become comfortable using hypothetico-deductive reasoning as their primary mode of thinking and learning for their assessment and diagnostic endeavors, in both the classroom and clinic. From a practical standpoint, don’t expect that all students will reach the expert status (primarily using hypothetico-deductive reasoning as their cognitive strategy) with all clinical encounters. But, the goal should be explicitly stated that by the end of students’ clinical education, they should be capable of displaying the effective use of case pattern recognition for many of the more common cases they encounter; while at the same time displaying the use of hypothetico-deductive reasoning for those less common, and more challenging clinical cases that present themselves on occasion.

2nd Element. The second element of an across the curriculum clinical reasoning pedagogy is that didactic instructors incorporate the tenets of hypothetico-deductive reasoning and case pattern recognition in their classes, especially assessment, treatment and rehabilitation classes. Doing so reinforce the concepts, and helps the development of the neophyte clinician. Class assignments and outcome measures should reflect the tenets of hypothetico-deductive reasoning and case pattern recognition. For example, exam questions should be geared towards the identification and relevance of the key features of different illnesses and pathologies. Students should be required to list specific and plausible differential diagnoses for case studies, and support their rationale for each based on the key findings presented. Presenting the various maladies as cases and comparing and contrasting them under the moniker of differential diagnosis (making), requiring students to present clinical cases by identifying and differentiating key features that are specific to cases under consideration, using whiteboard sessions to illustrate the cognitive processes involved in case problem-solving, and using other problem-based strategies with appropriate feedback are just some of the ways capable of fostering this type of clinical thinking. Table 2 represents an example of an exercise (on paper, or on the whiteboard) in clinical reasoning that can be used to present the concepts, for assignments or in class work, or for evaluating students understanding.

Table 2. Differential Diagnosis Schematic

Case Scenario: A 21 y. o. competitive swimmer presents c/o bilateral shoulder fatigue that’s been gradually progressing by occurring earlier during workouts and competition. Denies previous hx of trauma or pathology to either shoulder, observation WNL aside from typical upper quarter posture (moderate kyphosis and protracted shoulders) associated with chronic swimming activity. Palpation negative for deformity, or pain.

Generic Nature of Case: Chronic overuse, bilateral shoulder dysfunction

Possible Diagnoses (Hypotheses)	Hx/Observation (Key S/S)	Key Contributing Factors	Significant Physical Exam Results	Other Info Needed to Make Dx

List the most likely diagnoses, in order, and then justify/reason why by listing and explaining both the key features that support your decisions, AND those features that don't fit:

1. ______________________________
Reasoning:

2: ______________________________
Reasoning:

3. ______________________________
Reasoning:

Ideally, using hypothetico-deductive reasoning and case pattern recognition as learning strategies will encourage and funnel students to recognize key features that differentiate, and to seek out relationships, cause and effect scenarios, logic, and clinical patterns when they study and garner clinical experiences. A thinking paradigm that synthesizes the tenets of hypothetico-deductive reasoning and case pattern recognition is a viable substitute for a curriculum based on rote and linear learning with an emphasis on facts and figures, and hoping that the static use of HOPS, or SOAP formats for clinical decision making will make students critical thinkers. In the end, the ultimate pedagogical goal is to help students better organize their knowledge into patterns that are marked by key features and essential to formulating differential diagnoses with complex clinical problems. If teaching and learning via hypothetico-deductive reasoning and case pattern recognition are effectively implemented as the primary cognitive strategies in the classroom, instructors will then be able to evaluate student learning in like fashion by designing tests and other evaluation tools around the tenets of hypothetico-deductive reasoning and case pattern recognition (in addition to the necessary factual information required). If students know what hypothetico-deductive reasoning and case pattern recognition are and if they have been regularly used in the classroom by instructors, students will begin to feel comfortable with tests and measures that attempt to evaluate the higher level thinking processes required to adequately confront complex clinical problems.

Later, during more advanced classroom contexts, students can be asked to identify key features in all elements of the evaluation (starting with the history and observation) that can help differentiate the potentialities, and to begin to recognize clinical case patterns as measures of their ability to use case pattern recognition. Once a pattern is recognized, students can be asked to indicate which physical procedures they wish to perform; and even further, to predict what the results of those tests and measures will be before performing them. They can be asked to differentiate the diagnosis by indicating what the key feature (signs, symptoms, contributing factors, etc.) represent (and how they tie back to the anatomical, biomechanical, and pathophysiological principles involved), which pieces of data were relevant and/or irrelevant to the case pattern recognized, which features (if any) did not fit, and most importantly, just what they were thinking and why.

3rd Element. The third element of a clinical reasoning pedagogy involves the ever-essential clinical education component; the arena designed to display what has been learned in the carefully designed class and laboratory elements of the curriculum. In order for the classroom work with clinical reasoning to *mean* anything, clinical experiences must be connected to the didactic by insuring that clinical thinking is a central part of the education plan. Both clinical learning and evaluation must be centered on the ideals of hypothetico-deductive reasoning and case pattern recognition by requiring clinical educators to carry forth the didactic efforts described above. Admittedly, this may prove to be the most difficult element of such a pedagogy, as control over what happens in many students' clinical education is sometimes diminished.

If clinical thinking becomes a focal point of the curriculum though, clinical instructors will know what hypothetico-deductive reasoning and case pattern recognition are, what their role in the clinical education component is, and be aware that they are largely responsible for this critical element of students' educative experiences. This would require of course, that clinical educator workshops include clinical reasoning as core components of their learning objectives.

All clinical educators in an open, thinking based curriculum will know that clinical reasoning is the program's philosophical and theoretical lynchpin for clinical and experiential education; they will be committed to helping it work, just as much as the program director, clinical coordinator and other faculty members associated with the respective program.

Of course, this last step requires that clinical educators become aware of their own clinical thinking styles, as well as their personal clinical strengths and weaknesses, and that they will be evaluating students on their ability (at least in part) to perform hypothetico-deductive reasoning and case pattern recognition as primary means of clinical thinking in subsequent experiences.

One method for incorporating clinical reasoning into the experiential elements of a program is to institute a system whereby students are asked by clinical educators to present their case after performing an evaluation (live, standardized, or mock). Table 3 is an example of a clinical teaching paradigm that emphasizes clinical reasoning processing. It is loosely based on the medical education model whereby 3rd and 4th year medical students are expected to do a "work up" on patients and subsequently present their findings as a "case" to their resident and attending physician(s).

When used effectively, case presentations can help students better organize their biomedical recall, thinking process (clinical reasoning), evaluation skills, and diagnostic decision making, regardless of academic level. As students present cases in medical theatre style, the clinical mentor is able to probe and evaluate the students' thinking process as they look for hypotheses generated, recognition of key features, and the eventual ability to formulate, recall, and recognize case patterns. When repeated, students know what will be expected of them after performing an evaluation via the feedback they receive, and thus they will begin to model their thinking process based upon clinical reasoning as the thinking, problem solving process of choice. Furthermore, when students watch a clinical mentor perform an evaluation, they will be able to better direct their questions regarding what the clinician was thinking throughout the process and what strategy was used to make a differential diagnosis; further extending the feedback loop that is so central to effective pedagogy.

In order for clinical educators to effectively carry out a clinical reasoning-based pedagogy, they must be consistent in the use of the terminology and be able to foster the process of clinical reasoning in their interactions with students. Clinical instructors must also be aware as to who is primarily using (or capable of) hypothetico-deductive reasoning for thinking, and who is using case pattern recognition as their *modus operandi*, and subsequently, how they can assist in the transformative and interactive process between the two.

Conclusions

Medical educators have a good conceptual idea of what clinical reasoning is, know that expert clinicians possess it, and realize that future practitioners need to acquire and demonstrate it in order to provide high quality practice and safe healthcare. The problem, however, is that these same medical educators still struggle to find effective ways to teach and evaluate clinical reasoning to their students.[10,14,25,29,32] Despite being a core component of all medical

Table 3. Clinical Reasoning Paradigm for Clinical Instruction Using Case Presentations

! Encourage students to do a "work up" of athlete/patient, without necessarily being told what to do, other than to "do a work up."
  " Younger, less experienced students should be observed daily
  " Upper level, more experienced students can perform independently, or with loose observation
! Pending academic level, the work up will consist of all, or some of the following components:
  " Medical Hx (younger students can just take a history initially, then add steps as learning progresses)
  " Observation
  " Physical Exam (including vitals if necessary)
! Work should be appropriate for student level, and for classes they've had (dependent upon curricular core and sequence). For example:
  " Juniors' questioning is based on classes completed in sophomore year, and accruing as junior year progresses with additional classes
  " Seniors should be capable of addressing issues relative to most of their core classes such as assessment, modalities and therapeutic rehabilitation; and should be able to eventually synthesize an increasing amount of general medicine issues.
! Following completion on the work up performed, students are asked to *Present the Case*, and pending class level, report **significant findings** & **key features** relevant to the following:
  " History
  " Observation
  " Physical Examination
! Assess the accuracy of biomedical knowledge and psychomotor skill performance checks:
  " Show me what you found?
  " Relevant anatomy, biomechanics, pathomechanics, etc.?
! Impression (Dx):
  " What do you think it is?
    - When did you first think of this impression?
  " What makes you think that? What did you find that supports that?
    - What are the key features you used to formulate your hypothesis?
      # Hx & Observation
      # Contributing Factors
      # Physical Exam
  " or, what can you eliminate as a possibility?
    - Why did you eliminate certain possibilities?
  " Have you experienced this type of case before? If yes, what are the specifics?
! Differential Dx
  " What else might it be?
  " Are there any "features that don't fit"?
  " What else do you need to know in order to formulate a diagnosis?
! Based upon your impression, what is the appropriate *Plan of Care*?

Evaluation of Clinical Reasoning PEARLS:

The focus of questioning should be relevant to the gradual development of Clinical Reasoning and the use/ performance of appropriate skill sets (not all apply, all the time):

! Relevance of findings (what are key findings in Hx?)
! Formation of a hypothesis (impression)
! Differential Dxs
! Objective data that supports hypothesis (PE)
! Accuracy of biomedical knowledge
! Proper demonstration/ execution of psychomotor skills required
! How does information (qual. & quant.) gathered related back to the initial hypothesis
! Based upon impression formulated, what are the elements of the plan of care? (Tx, management & rehab)
! As each semester passes, integration of information relevant to skills and clinical reasoning should be expected as students' knowledge base increases (i.e., Srs. should be able to integrate assessment, modalities and rehab into their work up, etc.).
! Use consistent terms when asking students to perform an assessment, or when evaluating a specific clinical competency.
  " Please perform a "work up" of that athlete/patient
  " Please present your case to me when you are done
  " What has your hypothesis?
  " What are the relevant findings of your evaluation that support your hypothesis?
  " Do you recognize a pattern here? Have you experienced this case before?

education, the pedagogical responsibility to teach students how to develop and use effective clinical reasoning, there are numerous challenges for doing so. Educators and researchers struggle to comprehend the precise cognitive processes that give rise to high level clinical reasoning, and more importantly, how to accelerate its acquisition during the early educative and clinical years of 3rd and 4th year interns.[18] Although most researchers seem to agree on what clinical reasoning *is*, and agree that it is *the* fundamental and requisite connection between didactic and clinical education for medical students, there is significant debate as to the precise mental processes involved, how to best teach students, and how to evaluate this requisite ability in objective manners remains. In short, medical schools desire to know how to apply the theory behind clinical reasoning to both the practice and education of medicine. Likewise, AT educators are required to teach their students how to think critically, yet little structure has been provided for doing so beyond a general call for critical thinking exercises and outcomes.

Central to the ability of the student clinician to improve their clinical reasoning abilities is the need for constructive feedback from their clinical mentor so that the clinical experience is truly an educative experience. The AT curriculum must be "opened up" by revealing the thinking element of clinical education on the behalf of both the student and the preceptor. In order to accomplish this task, the feedback must not only challenge students' content knowledge and skill mastery, but also the thinking processes of the students in question.

Are students using hypothetico-deductive reasoning, case pattern recognition, or both to solve problems? Are they using any particular cognitive process other than memorization? How do educators transition students from simple recall to the hypothetico-deductive reasoning mode of thinking, and eventually towards a case pattern recognition process? These are the questions that must be addressed if clinical education is to become critical.

At the same time, clinical educators must create a regular dialogue with young and experienced student/clinicians that is capable of fostering a culture whereby students learn to evaluate and reflect upon their own thinking (thinking about thinking). In reality, it is the clinical educators who have the chief opportunities and responsibility to reveal and examine any flaws that students have in their clinical thinking and learning. And it is the clinical educators who must take what the classroom instructor has started and model effective clinical thinking for their students. Simply put, as learners learn to learn with guided experience, they gradually morph into more skilled detectives by becoming better at identifying key features that make subsequent and similar case problems more readily recognizable.

Students immersed in such an educative experience that teaches them how to think clinically are slowly moving towards expert clinical thinking by relying less on analytical techniques (hypothetico-deductive reasoning) and more on non-analytical cognitive processes (case pattern recognition) for clinical problem solving.

As an allied health profession that routinely evaluates injury and pathology, and subsequently makes treatment, management, referral, return to play, and rehabilitative decisions on behalf of the patients it oversees, AT should be no different in its need for, and representation of, clinical reasoning as a core skill set for its practitioners. Although the NATA's 4th Edition competencies require critical thinking and integrated analysis abilities throughout the entire curriculum, the document only contains one general reference to critical thinking (it is again repeated in a generic context at the end of each of the individual proficiencies).[4] Expressed more directly, the latest competencies fail to require or mention any specific mode of clinical thinking as an obligation for educating entry-level athletic trainers.

This exclusion is not so much a denial of rights or order, but rather, an opening for educators in search of an effective cognitive mechanism capable of better connecting the clinical to the didactic and vice versa. Although many, if not all contemporary AT educators are duly familiar with the need to foster critical thinking abilities in their students, many may not be aware of the nature and relevance of a more specific clinical reasoning process or of its inherent connection to AT education and clinical practice as it has been represented by the medical education literature.

Although all AT students accrue significant clinical experience(s) and are assessed on myriad proficiencies relative to clinical practice, no student experiences during their clinical education, all of the potential illnesses and injuries for which they are didactically prepared. Even the most organized and resourceful educational programs cannot possibly provide for this, either on paper, or in reality.

Thus, the question becomes, how do educators prepare students to confront the unknown or the inexperienced or to truly learn over time?[7] Certainly, this challenge offers no easy formula for success, but educators intent on improving their students' clinical attributes and performances must search for and develop creative and effective ways to construct a pedagogy of thinking for their respective programs.

Like medicine and other allied health professions, AT possesses an inherent need to teach, cultivate, implement, and evaluate a more specific cognitive process for clinical thinking as a central pedagogical and clinical foci in their curriculum.[7-9] As it has been shown to exist in both medicine and physical therapy, clinical reasoning is a dynamic, evolving, and complex cognitive way of thinking that transforms the clinician from novice, to expert with increasing experience.[22,23]

Nendaz and Bordage[31] claim that typical medical students learn how to acquire data in a thorough and linear fashion, but seldom have the opportunity to simultaneously incorporate the process of collecting case data and diagnostic reasoning; a shortcoming that differs greatly from how experienced doctors "work". In fact, their intervention strategy with medical students revealed that short educational sessions were successful in enabling students to use early abstract transformations to reflect problem representation, while also improving the ability to recall specific findings associated with various case problems that were encountered. In light of these findings, Nendaz and Bordage have actively called for early problem representation to be formally implemented in the medical curriculum, preferably during the process of knowledge acquisition and organization, and that it should focus on eliciting and recognizing key patient findings in order to improve the problem solving skills of its students.

As it has been presented, clinical reasoning possesses the capacity to make clinical education more *educative* for the learner by giving the thinking process some semblance of shape and form. Returning to Dewey's notion of truly educative experience, educators must appreciate his concerns for disconnected and rote learning when he wonders ". . . how many [students] acquired special skills by means of automatic drill so that their power of judgment and capacity to act intelligently in new situations was limited?"[1 p26]

In order to improve the ability of future ATs to practice independently in a competent, ethical, and compassionate manner, they must be taught what it means to think and reason clinically like an expert, so that they too, can transform into experts with a cognitive strategy akin to our colleagues in medicine. In a recent editorial on critical thinking, Knight laments the notion that recent AT graduates "suffer from an inability to apply their knowledge and skills when dealing with actual patients,"[p79] supporting a common sentiment that "much of our education is founded on the lowest level of thinking-rote memorization", and that "…students are constrained by a common experiential background that is devoid of the types of experiences that cultivate critical thinking."[2 p80] In fact, much of Knight's commentary serves as direct support for the central thesis of the current paper—the need to develop and implement a pedagogy of thinking that's capable of bridging classroom knowledge to clinical education through experiential thinking.

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