ATHLETIC TRAINING EDUCATION JOURNAL

www.natajournals.org
ISSN: 1947-380X
DOI: 10.4085/1103152

EDUCATIONAL TECHNIQUE

Instructional Strategy: Administration of Injury Scripts

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Context: Learning how to form accurate and efficient clinical examinations is a critical factor in becoming a competent athletic training practitioner, and instructional strategies differ for this complex task.

Objective: To introduce an instructional strategy consistent with complex learning to encourage improved efficiency by minimizing intrinsic cognitive load and effectiveness by emphasizing the development of mental schemas. This strategy, called *illness scripts* in medicine, was adapted as *injury scripts* for athletic training.

Background: Athletic training students are taught to learn a universal clinical reasoning process for conducting clinical examinations that consists of extensive collecting of patient data and matching these data to a hypothesis, referred to as a *hypothetico-deductive approach*. This process is burdensome to cognitive load storage capacity and delays development of expertise in diagnostic accuracy.

Description: Injury scripts is a clinical reasoning strategy consistent with complex learning, where the evaluation of knowledge and skill competencies or key features of specific conditions are integrated in an incremental, simple-to-complex progression. This strategy will improve learning efficiency and effectiveness. The context in which cases are presented should emphasize real-life scenarios.

Clinical Advantage(s): Improved efficiency of student learning and enhanced effectiveness in the professional preparation of knowledge and skills for injury evaluation.

Conclusion(s): By integrating evaluation competencies or key features of specific conditions, they can be stored as injury scripts in long-term memory, saving space in working memory and ultimately minimizing intrinsic cognitive load. As students migrate through the curriculum, existing injury scripts will expand by consolidating additional information and effectively prepare them to be competent professionals in clinical examination and diagnosis. Students must also recognize that if specific data collected do not match a script, further analysis is needed to avoid diagnostic error.

Key Words: Intrinsic cognitive load, schema, illness scripts, complex learning

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Full Citation:
Schilling J. Instructional strategy: administration of injury scripts. *Athl Train Educ J*. 11(3):152–157.

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INTRODUCTION

Teaching and learning strategies are based on two general learning paradigms.[1] One paradigm, reductionism, argues a "whole," or an integration of domains, can be learned by gaining an understanding of its individual parts.[1] A second paradigm, holism, challenges this philosophy by stating that a whole can only be learned when the parts remain integrated as a dynamic unit.[1] Although evidence[2,3] exists to support the presentation of independent elements of information for novice students, there are authors[4] who believe the future of education in the field of medicine should avoid the isolation of specific knowledge and skills, and they advocate for complex integration of biomechanical, physiological, and environmental interactions to optimize a physician's ability to provide quality medical care. Learners need exposure to the integration of knowledge and skills throughout their educational experience to be competent in what they will encounter in the workplace. Athletic trainers repeatedly encounter situations such as evaluation and treatment of musculoskeletal injuries requiring an integration of skills, knowledge, and attitude domains. If domains of information are learned in isolation, this interaction may be overlooked, preventing a transfer of learning.[5]

Traditionally, a student conducting a clinical examination is taught to collect data (eg, history, observation, palpation, range of motion, strength and special tests), requiring a filtering process to finally conclude a diagnosis. This strategy is asking novice students to retain a considerable amount of information. A more efficient and effective strategy for learning evaluation skills in athletic training education would be through groupings of signs and symptoms consistent with specific conditions and the use of "complex learning."[6] This complex learning concept was created to provide information to learners in a gradual, simple-to-complex element-integration framework.[6] Research in the area of cognitive science is providing evidence in support of complex learning by demonstrating how learners store information effectively[7–10] through schemas and efficiently[11–13] by reducing intrinsic cognitive load. The term *schema* represents a cluster of information stored in long-term memory as one element.[13] *Intrinsic cognitive load* is a term referring to elements of relevant information stored within the working memory system.[14] The creation of schemas for storage in the long-term memory system is essential for reducing intrinsic cognitive load in working memory. Illness scripts (in medicine), or, in the case of athletic training, I will coin *injury scripts*, are a type of mental schema specific to signs and symptoms consistently found with particular musculoskeletal conditions.

The purpose of this article is to introduce an instructional strategy that will assist athletic training students in mastering clinical reasoning skills using injury scripts in an incremental fashion to better facilitate complex learning. The ability to optimize storage capacity in working memory by reducing intrinsic cognitive load, using long-term memory, and ultimately improving learning efficiency can be accomplished by initiating a design in accordance with this framework. Learning knowledge and skills in an integrated fashion, as they are encountered in the workplace, also provides a greater likelihood of transfer and learning effectiveness. This article will provide a background in understanding injury script formation and its supporting evidence for minimizing intrinsic cognitive load and improving learning effectiveness with clinical examination skills. Examples of how this concept can be applied in Athletic Training Programs are also provided.

COMPLEX LEARNING TO MINIMIZE INTRINSIC COGNITIVE LOAD

In the early 1980s, Sweller[15] proposed a human cognitive architecture model to explain the cognitive load theory of learning, which consisted of both short-term and long-term memory systems to store information.[13] The short-term or working memory system is a conscious processor that is hampered by the ability to only store 3 to 5 meaningful elements of information at one time.[16] Long-term memory has a large storage capacity with the ability to develop chunks of information called *schemas* that are treated as one element,[14] and an unlimited number can be formed.[17] Mental schemas are capable of expansion by engulfing related incoming information.[14] Together, the working memory acts as a filtering system that processes information in a way to form schemas in long-term memory.[14] It is theorized the working memory system is labored by intrinsic and extraneous cognitive loads.[18] *Extraneous cognitive load* refers to information presented that is not necessary for the learner to be exposed to in order to understand certain concepts.[18] *Intrinsic cognitive load* is subject matter that is needed to gain a comprehension of concepts and whose complexity is determined by the quantity of integration between the elements of information.[14] Information consisting of high element interactivity significantly increases intrinsic cognitive load, compromising valuable space in working memory.[19] Therefore, adjusting the information using the complex learning model will create a manageable intrinsic cognitive load and improve learning efficiency.

Complex learning is initiated any time students are introduced to knowledge and skills that need to be integrated to understand a real-life task.[6] A whole-task approach involves more than simply learning the parts of the whole, as suggested with reductionism. The student also needs the ability to coordinate and integrate the parts.[6] Whole-task approaches to learning introduce an integrated set of elements to the learner from the onset to assist in developing a "holistic vision" that continues through the entire educational process.[5] An effective instructional design for complex learning does not require students to memorize individual elements of knowledge or skills, but rather it ensures students are capable of coordinating multiple related elements in an integrated fashion while exposed to an authentic environment.[6] The level of complexity is contingent on the number of elements, number of interactions between the elements, and knowledge base required for comprehension of the elements.[6] Complexity

of a whole-task is based on a spectrum from the simplest to the most complex case a professional would encounter in real life.[6] Simple tasks consisting of minimal element integration present low intrinsic cognitive load, whereas complex tasks require a more elaborate knowledge base for effective learning.[5] Consequently, if it is required of students to learn subject matter that consists of integrated elements of information, such as with professional health care programs, it is imperative to use the complex learning model for efficient and effective learning.

ILLNESS SCRIPTS IN CLINICAL REASONING

A clinical examination traditionally is learned using an analytical process consisting of gathering data and filtering them to fit a hypothesis. This process is referred to as the *hypothetico-deductive reasoning model*.[20] This approach is common for novice and intermediate level students or advanced practitioners who encounter atypical cases.[21] Expert clinicians have been found to use a more efficient clinical reasoning model of pattern recognition where they are able to match an integrated set of synchronous features representing a specific condition that is stored in long-term memory, along with relevant data shared by a patient.[22] If irrelevant data are collected during a clinical examination, the working memory system could overload unnecessarily.[20] An efficient clinical reasoning process that minimizes extraneous data is necessary for learning effectiveness.

Diagnosis-to-data or a hypothetico-deductive approach involves gathering a breadth of signs and symptoms presented by an injury and deriving a diagnosis by deduction. This approach[20] has been widely accepted in health care disciplines requiring diagnostic expertise, such as athletic training. An alternative clinical reasoning strategy is constructing illness scripts (in medicine) that require creating an integrated set of related competencies or key clinical features to be stored in long-term memory.[23] Illness scripts suggest a schema be constructed from learning a set of signs and symptoms for an elementary illness and over time adding elements to that schema, increasing the complexity of the condition.[23] The formation of illness scripts as a clinical reasoning model reduces cognitive load in working memory and accelerates learning by taking advantage of the extensive storage capacity of the long-term memory system.

An illness script type of schema was first defined as groupings of knowledge having a direct relationship with specific conditions presented by the patient.[24] They comprised 3 components: (1) enabling conditions (predisposing factors of patient history), (2) consequences (signs and symptoms), and (3) the fault (condition).[24] Illness scripts consist of slots that allow for a range of values or attributes such as pain.[21] These scripts encounter a process called *instantiation* where slots are filled with typical or default values that are easy to integrate with others.[21] Slots can also be filled with atypical values which are unfamiliar attributes that are difficult to process and integrate.[21] Research has demonstrated that novice and intermittent students are able to recall knowledge and may even have competent evaluation skills; however, the attributes lacked cohesiveness and consequently did not integrate well enough to enable the students to accurately diagnose.[25]

Conditions can also have similar patterns, causing multiple illness scripts to overlap.[26] These presentations occur with complex conditions containing atypical features, requiring a more extensive analysis to avoid diagnostic error.[26] Novice students will encounter atypical attributes much more frequently than experts who have been exposed to a variety of conditions. Experts have the ability to encapsulate their knowledge base into clinical knowledge to create patterns of signs and symptoms[27] or scripts that are easily recognized.[22] Conditions that consist of multiple attributes will increase in cohesion with clinical examination expertise. The lack of cohesiveness and a limited number of known attributes have the potential to create and embed multiple illness scripts quickly, which are difficult for novice students.

RESEARCH ON THE USE OF ILLNESS SCRIPTS

The use of schema formation and illness scripts as a superior strategy for clinical diagnostic effectiveness is well supported.[7,9,10,28,29] Inquiry using second-year medical students was conducted comparing schema-based instruction involving categories of clinical key features for each condition and a traditional approach consisting of gathering all data to deduce a diagnosis.[7] The results showed a 30% higher diagnostic success rate with the schema-based–instruction group, emphasizing the importance of structuring knowledge into organized sets to improve retention. Lee et al[9] investigated undergraduate medical students in Hong Kong who were either trained in organizing knowledge by creating illness scripts through a Web tutorial or were self-directed. The illness script intervention not only produced significantly improved diagnostic performance but also received positive satisfaction measures from the students. Furthermore, Eva and colleagues'[10] investigation of undergraduate psychology students' instruction using a combination of pattern recognition and analysis of key features resulted in greater diagnostic accuracy when compared with students who were not given any explicit instruction. An even greater distinction was discovered when attempts were made by instructors to misdirect the psychology students by using atypical features or suggesting an inaccurate diagnosis.

An instructional strategy known as *structured reflection* has also been used with success to promote the construction of illness scripts.[28,29] The technique used in 2 studies required medical school students to list findings of an illness that either supported or did not support a condition, along with features that would be expected of a specific diagnosis. The results demonstrated superiority in diagnostic accuracy with structured reflection strategies compared with conventional techniques such as differential diagnosis.[28,29] Improvement in diagnostic accuracy may have occurred when the reflection techniques encouraged the structuring of existing knowledge into illness scripts that matched specific patient presentations. Instructional strategies emphasizing the formation of scripts in long-term memory have been demonstrated as an effective clinical reasoning strategy to traditional data collecting in both diagnostic accuracy and efficiency.

Studies have also inquired how expert practitioners approach clinical reasoning compared with novice practitioners.[8,27,30,31] Wainwright et al[30] investigated the distinguishing characteristics between novice (ie, less than 1 year of experience) and expert (ie, greater than 8 years of experience) physical

therapists during the clinical decision-making process. A common theme emerged where expert practitioners used formalized illness scripts with their clinical examinations, whereas novice practitioners had no organized system when collecting patient data. Additional research supporting schema formation was found with expert (ie, a minimum 5 years of experience) versus nonexpert (ie, final year in clinical) clinicians in the field of medicine.[8] The expert clinicians used the recognition of new patient problems in relation to similar past cases as a diagnostic reasoning strategy and were more accurate in their clinical diagnosis than those who used a diagnosis-to-data method of clinical reasoning.[8] Although the time span for students in medical school is limited, it could be observed that grouping items into illness scripts in clinical reasoning assignments played a more prominent role with fourth-year students than with second-year students.[27] There is also evidence suggesting expert clinicians take less time to process a clinical condition,[27] thus reducing cognitive load,[21] in addition to being more accurate with their diagnoses.[8,27,31] Acknowledging how expert practitioners approach clinical reasoning can influence the instruction of students to improve clinical diagnostic accuracy and efficiency.

Recent research has highlighted the importance of exposing students to authentic environments when incorporating illness scripts. Wainwright et al[30] found that physical therapy students' integration of illness script attributes improved when the students were exposed to real patients. Consequently, it would be optimal for students to confront clinical examinations of real patients, beginning with less sophisticated conditions followed by a gradual increase in features throughout the academic process. Research[7,9,28,29] using medical students found significantly improved diagnostic performances compared with conventional approaches by developing illness scripts or structured reflection scenarios. It is also well documented that expert clinicians process illness scripts, enabling them to provide greater diagnostic accuracy more efficiently than novice learners.[8,27–29] These results support the importance of pattern recognition and the formation of schemas as illness scripts in diagnostic success and learning effectiveness. Although the use of injury or illness scripts in Athletic Training Programs has not been studied to date, findings have been consistently favorable in diagnostic accuracy with medical[7,9,28,29] and psychology[10] students and are used extensively by experts in medicine[8,27,31] and physical therapy.[30]

USING INJURY SCRIPTS IN ATHLETIC TRAINING EDUCATION

The creation of schemas to minimize intrinsic cognitive load and improve learning effectiveness presents a unique instructional strategy in athletic training education. Instead of emphasizing the thoroughness of an evaluation process from beginning to end or a diagnosis-to-data method, it stresses learning the integrated whole beginning in an elementary form as a script. Once embedded in long-term memory, more features can be added and engulfed by the established whole-condition script.

When performing a clinical examination, instead of a student acquiring a universal evaluation process or generic analysis that is consistent for any injury, the process would be presented as elementary-to-complex injuries of "injury script" nature. The scripts consist of groupings of signs and symptoms consistent with specific injuries. Scripts can be built on previous information from features of similar patient cases stored in long-term memory as schemas. Injury scripts can engulf additional features with repeated exposure to a particular condition. Although the ultimate goal is to consistently perform a thorough clinical analysis while considering typical and atypical features of a condition, novice students lack the schemas to achieve this goal. Attempting to understand an entire evaluation and treatment process involves far too much element integration resulting in excessive intrinsic cognitive load[19] and the inability to initiate injury script formation.[23]

Existing competencies in athletic training education range from very specific, distinct elements of information to an extremely complex integration of elements referred to as *clinical integration proficiencies*.[32] The competencies in the Clinical Examination and Diagnosis content area in the 5th edition of the National Athletic Trainers' Association *Athletic Training Educational Competencies* are stated as general categories, such as history taking, observation, palpation, and special tests, to install the hypothetico-deductive model of clinical reasoning. A simple-to-complex integrated competency framework is needed to facilitate a complex learning model. Presenting skills and knowledge to the student in an integrated fashion should improve the transfer of learning and instruction effectiveness. Also, creating integrated sets of information as single elements will minimize intrinsic cognitive load in working memory and optimize learning efficiency.

Instruction of key features consistent with a specific condition initiates an integrated prototype of a script for future recognition. This is a critical element introduced early in the curriculum to facilitate clinical reasoning. Once elementary schemas consisting of low element interactivity are created, they are expanded upon, exposing the learner to relevant information enveloped by existing schema. The student must also have the ability to recognize atypical features during an examination, requiring a more in-depth analysis of the condition. Athletic trainers are presented with multiple scenarios consisting of complex integrations of knowledge and skills requiring mastery for the safety and optimal care of patients. Therefore, creating schemata in the form of injury scripts is essential in the development of competent clinical reasoning skills for entry-level certified athletic trainers.

PRACTICAL EXAMPLES OF INJURY SCRIPTS IN ATHLETIC TRAINING EDUCATION

An example of constructing an injury script in athletic training would be the key features consistent with a subacromial impingement syndrome condition and its cause (Table 1). Once the basic, typical features are mastered, the same condition can become more complex by making the subacromial impingement secondary to posterior glenohumeral capsular stiffness. This addition would add an element of complexity to the existing injury script. Additional elements may be consolidated in the schema if, for example, positive tests for multidirectional glenohumeral instability or apprehension were included. An even more complex situation could include atypical features requiring a further analysis (refer to Table 1). To encourage even greater analysis, an atypical symptom of pain around the medial border of the scapula where the pain is actually referred from a cervical disc lesion could be added. This condition

Table 1. Injury Script—Subacromial Impingement Syndrome

Feature
Typical:
(+) Repetitive overhead activity
(+) Hawkins-Kennedy test
(+) Neer test
Additional typical:
(+) Apprehension sign
(+) Posterior glenohumeral capsular stiffness
(+) Multidirectional glenohumeral instability
Atypical:
(+) External rotation lag sign (rotator cuff tear)
(+) Biceps load test II (superior labrum anterior and posterior lesion)
(+) Jerk test (posterior-inferior labral tear)

Table 2. Injury Script—Patellofemoral Pain Syndrome

Feature
Typical:
(+) Pain with resisted knee extension
(+) Pain with steps
(+) Moving patellar apprehension test
Additional typical:
(+) Hip anteversion
(+) Hip abduction weakness
(+) Navicular drop test
Atypical:
(+) Thessaly test (meniscus tear)
(+) Medial patellar plica test (medial plica)
(+) Pain with palpation over inferior pole of patella (patella tendinitis)

introduces symptoms from a different area of the body that would be a typical feature for a cervical disc injury script. This example demonstrates how features from scripts can overlap, requiring advanced expertise to discern.

Another common condition acquired by athletes is patellofemoral pain syndrome. A set of key features consistent with patellofemoral pain is presented in Table 2. This basic script could also engulf additional typical and atypical features to become more complex. For example, hip abductor muscular weakness or a positive navicular drop could be additions that demonstrate possible complexities. Other injury script examples are low back pain, cervical pain, lateral or medial elbow pain, hip pain, and ankle pain. Illness scripts could also be appropriate for athletic training students for an awareness of red flags. Examples of illness conditions are asthma, diabetes, and infections.

Conditions involving diagnostic neural testing would present an opportunity for students to address the quality of such tests (eg, sensitivity and specificity). This would create an even more complex scenario. Students need to also embed atypical "red flag" features into long-term memory. These features could include numbness or paresthesia in the extremities, unexplained weight loss, and unexplained observed or palpated growths. Initial mastering of simple injury scripts consisting of a limited number of features that are placed in long-term memory should be followed by a gradual introduction of new features to be engulfed by the existing scripts. Emphasis should be made on the rationale for gathering these key features and why they are synonymous with the specific condition for more effective embedding of the script, instead of rote memory of the elements. Once typical features are complete, one should begin including features that are not synonymous with the condition to begin challenging students with a further analysis and differential diagnoses.

INSTRUCTION OF INJURY SCRIPTS IN ATHLETIC TRAINING EDUCATION

Instructing athletic training students in the formation of injury scripts is a strategy that will increase learning efficiency and accelerate their path to expertise in the clinical examination process. Experts[25,27,30,33,34] in the application of illness scripts to learn clinical examination skills have made several recommendations. Instead of instructing students on the collection of patient factors without organization or meaning, encourage injury script formation early in the curriculum with authentic tasks[33] and emphasize simple conditions that are absent of extraneous information.[25] In other words, create scripts that are initially elementary using signs and symptoms specific to a condition and preferably practiced on real patients. Also, repeating identical cases may speed up script development,[25] and once a script appears embedded, begin to provide similar cases with atypical values, gradually increasing in complexity.[30] Another important aspect, which Athletic Training Programs do well, is to align the introduction of knowledge didactically with clinical education exposure to accelerate encapsulation and development of illness scripts.[25] Asking learners what findings they would consider irrelevant in addition to typical features helps students at the intermediate level improve recognition.[30] Researchers emphasize the use of clinical reasoning skills to create scripts and not the memorization of prototype cases.[30] For example, encourage students to think about why these key features are consistent with a specific injury and to not simply memorize the specific elements associated with a condition. This would be a critical thinking strategy that requires adequate background in the subject matter before initiating.

To enhance clinical examination expertise efficiently, novice students need to model after experts who have sophisticated reasoning processes and an accumulation of experience.[34] Instruction should focus on students recognizing patterns of information, as experts do.[27] Students need to develop as many scripts as possible during their academic career. Give athletic training students exposure to real patients early and often because authentic environments will assist in transfer of knowledge to the workplace.[27] They also need to be aware that when clinical data do not match a script, they must use more of an analytical approach and gather the information necessary to develop a hypothesis.[27]

CONCLUSIONS

Instructional strategies in Athletic Training Programs traditionally have emphasized the training of a universal clinical

examination process consisting of collecting all possible data required of any diagnosis. Once collected, these data are matched to a specific hypothesis to determine a diagnosis. This approach requires considerable amounts of information placed into working memory and an inability to match this information to hypotheses that do not exist. It has been observed[8,27,30,31] that expert clinicians separate themselves from novice through pattern recognition in the way of illness scripts. The use of illness scripts with students has been shown to decrease cognitive load and increase diagnostic efficiency.[7,9,10,28,29] The development of schemas in long-term memory should be a goal for educators in programs requiring learning complex, integrated skills. For athletic training students to master evaluation skills effectively and efficiently, instruction should emphasize the development of injury scripts with real patients, early and often in the educational process. To be consistent with complex learning, the scripts should begin in a very elementary fashion and gradually increase in complexity. Students need to also develop an awareness of red flags and atypical features collected during a clinical examination that are not consistent with an existing script, calling for further analysis.

REFERENCES

1. Kamhi AG. Paradigms of teaching and learning: is one view the best? *Lang Speech Hear Serv Sch*. 1994;25(3):194–198.
2. Pollock E, Chandler P, Sweller J. Assimilating complex information. *Learn Instr*. 2002;12(1):61–86.
3. Clarke T, Ayres P, Sweller J. The impact of sequencing and prior knowledge on learning mathematics through spreadsheet applications. *Educ Technol Res Dev*. 2005;53(3):15–24.
4. Federoff HJ, Gostin LO. Evolving from reductionism to holism. *JAMA*. 2009;302(9):994–996.
5. Van Merrienboer JJG, Kirschner PA, Kester L. Taking the load off a learner's mind: instructional design for complex learning. *Educ Psychol*. 2003;38(1):5–13.
6. Van Merrienboer JJG, Clark RF, de Crook MBM. Blueprints for complex learning: the 4C/ID-model. *Educ Technol Res Dev*. 2002;50(2):39–64.
7. Blissett S, Cavalcanti RB, Sibbald M. Should we teach using schemas? Evidence from a randomized trial. *Med Educ*. 2012; 46(8):815–822.
8. Coderre S, Mandin H, Harasym PH, Fick GH. Diagnostic reasoning strategies and diagnostic success. *Med Educ*. 2003; 37(8):695–703.
9. Lee A, Joynt GM, Lee AKT, et al. Using illness scripts to teach clinical reasoning skills to medical students. *Fam Med*. 2010; 42(4):255–261.
10. Eva KW, Hatala RM, LeBlanc VR, Brooks LR. Teaching from the clinical reasoning literature: combined reasoning strategies help novice diagnosticians overcome misleading information. *Med Educ*. 2007;41(12):1152–1158.
11. Sarfo FK, Elen J. Developing technical expertise in secondary technical schools: the effect of 4C/ID learning environments. *Learn Environ Res*. 2007;10(3):207–231.
12. Pociask FD, DiZarro-Miller R, Samuel PS. Reducing cognitive load while teaching complex instruction to occupational therapy students. *Am J Occup Ther*. 2013;67(5):e92–e99.
13. Pociask FD, Morrison GR, Reid KR. Managing cognitive load while teaching human gait novice health care science students. *J Phys Ther Educ*. 2013;27(1):58–66.
14. Van Merrienboer JJG, Sweller J. Cognitive load theory and complex learning: recent developments and future directions. *Educ Psychol Rev*. 2005;17(2):147–177.
15. Sweller J. Cognitive load during problem solving: effects on learning. *Cogn Sci*. 1988;12(2):257–285.
16. Cowan N. The magical mystery four: how is working memory limited, and why? *Curr Dir Psychol Sci*. 2010;19(1):51–57.
17. Paas F, Renkl A, Sweller J. Cognitive load theory and instructional design: recent developments. *Educ Psychol*. 2003; 38(1):1–4.
18. Kalyuga S. Cognitive load theory: how many types of load does it really need? *Educ Psychol Rev*. 2011;23(1):1–19.
19. Sweller J. Element interactivity and intrinsic, extraneous, and germaine cognitive load. *Educ Psychol Rev*. 2010;22(2):123–138.
20. Charlin B, Tardif J, Boshuizen HP. Scripts and medical diagnostic knowledge: theory and applications for clinical reasoning instruction and research. *Acad Med*. 2000;75(2):182–190.
21. Custers EJ, Boshuizen HP, Schmidt HG. The influence of medical expertise, case typicality, and illness script component on case processing and disease probability estimates. *Mem Cognit*. 1996;24(3):384–399.
22. Schmidt HG, Rikers RM. How expertise develops in medicine: knowledge encapsulation and illness script formation. *Med Educ*. 2007;41(12):1133–1139.
23. Schmidt HG, Norman GR, Boshuizen HP. A cognitive perspective on medical expertise: theory and implications. *Acad Med*. 1990;65(10):611–621.
24. Feltovich PJ, Barrows HS. Issues of generality in medical problem solving. In: Schmidt HG, De Volder ML, eds. *Tutorials in Problem-Based Learning*. Assen, the Netherlands: Van Gorcum; 1984:128–142.
25. Custers EJ, Boshuizen HP, Schmidt HG. The role of illness scripts in the development of medical diagnostic expertise: results from an interview study. *Cogn Instr*. 1998;16(4):367–398.
26. Kuhn GJ. Diagnostic errors. *Acad Emerg Med*. 2002;9(7):740–750.
27. Rikers RM, Loyens SM, Schmidt HG. The role of encapsulated knowledge in clinical case representations of medical students and family doctors. *Med Educ*. 2004;38(10):1035–1043.
28. Mamede S, Van Gog T, Moura AS, et al. Reflection as a strategy to foster medical students' acquisition of diagnostic competence. *Med Educ*. 2012;46(5):464–472.
29. Mamede S, Van Gog T, Moura AS, et al. How can student' diagnostic competence benefit most from practice with clinical cases? The effects of structured reflection on future diagnosis of the same and novel diseases. *Acad Med*. 2014;89(1):121–127.
30. Wainwright SF, Shepard KF, Harman LB, Stephens J. Factors that influence the clinical decision making of novice and experienced physical therapists. *Phys Ther*. 2011;91(1):87–101.
31. van de Wiel MW, Boshuizen HP, Schmidt HG. Knowledge restructuring in expertise development: evidence from pathophysiological representations of clinical cases by students and physicians. *Eur J Cogn Psychol*. 2000;12(3):323–356.
32. National Athletic Trainers' Association. *Athletic Training Education Competencies*. 5th ed. Dallas, TX: National Athletic Trainers' Association; 2011.
33. Charlin B, Boshuizen HP, Custers EJ, Feltovich PJ. Scripts and clinical reasoning. *Med Educ*. 2007;41(12):1178–1184.
34. Phua DH, Tan NCK. Cognitive aspect of diagnostic errors. *Ann Acad Med Singapore*. 2013;42(1):33–41.