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PERSPECTIVES

Case-Based Analogical Reasoning: A Pedagogical Tool for Promotion of Clinical Reasoning

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Context: One of the most common instructional methods utilized to promote learning transfer in health profession education is examination of a single patient case. However, in non-healthcare settings this practice has shown to be less effective in promoting learning than the examination of multiple cases with cueing.

Objective(s): The primary objective of this article is to provide athletic training educators a rationale for implementing a multiple case-based analogical reasoning technique to improve students' learning transfer.

Background: Case-based analogical reasoning is a pedagogical technique that improves problem solving by helping learners identify a common structural principle shared among multiple cases. Identification and transfer of the shared principle facilitates solving novel problems or patient cases. When cueing is coupled with the process, transfer of the structural principle to the problem is enhanced.

Description: This article discusses cognitive learning theory and provides empirical evidence to support the use of case-based analogical reasoning to improve athletic training students' clinical reasoning. It also provides the educator practical tips for implementing the technique in classroom and clinical settings.

Clinical Advantage(s): Improving the transfer of structural principles may improve solving novel problems in the clinical environment, which should also improve the quality of patient care.

Conclusions: Clinical reasoning and learning transfer may be improved among health professional students during a case-based analogical reasoning process when cued to look for the shared structural principle among cases. Students who engage in multiple-case examination with cueing may be more apt to recall their learning and use it when faced with novel cases in the clinical environment.

Key Words: transfer of learning, cueing, schema

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INTRODUCTION

The historical goal of teaching has been to foster students'ability to transfer what they have learned from one context to another.[1] Indeed, a primary goal of athletic training educators is to ensure that newly minted athletic trainers are able to retain and transfer their requisite knowledge and problem-solving skills so they may provide consistently high-quality care to their patients.[2] Athletic training education reform now mandates athletic training curricula address students' development of clinical reasoning in most domains in order to promote quality patient care.[3]

Clinical reasoning has been defined as "the practitioner's ability to assess patient problems or needs and analyze data to accurately identify and frame problems within the context of the individual patient's environment."[4(p227)] Clinical reasoning requires both problem-solving and critical thinking in order to effectively diagnose and manage a patient's condition.[5,6] The clinical reasoning process requires recall, analysis, and transfer of accumulated knowledge and patient encounters to solve novel clinical problems.[5] Pelaccia et al[5] posit clinical reasoning involves the use of two cognitive systems: intuitive and analytical.

Researchers[5,7,8] have found a valence exists for learners' use of the intuitive or "tacit" system for generating initial hypotheses to problems, particularly when time constraints are present. The intuitive system facilitates recognizing and immediate processing of structural patterns inherent in a problem, situation, or case.[7] Recognition of patterns between current and past experience is a mode of non-analytical reasoning that occurs unconsciously and allows clinicians to form initial hypotheses and diagnoses.[5] The system also utilizes identification of contextual cues to enable early (ie, within seconds) hypothesis formation.[5] Novices, however, often lack a robust catalog of patient encounters, which limits their recognition of patterns between their past and current clinical experiences.[9] This may cause novices to make diagnostic errors[10] and impede the clinical reasoning process in situations that require immediate action.[11]

When the intuitive system fails to generate initial hypotheses or the initial hypotheses are questionable, the learner will use hypothetico-deduction, a form of analytical reasoning. In the analytical or "rational" conscious system, learners gather information from the current situation and recall knowledge stored in memory to form a judgment about its application to a problem.[5] According to Pelaccio et al,[5] hypothetico-deduction "…is a process in which diagnostic hypotheses are tested analytically (by questioning the patient, making a clinical examination, etc.) … and is also utilized to confirm or invalidate solutions that have been generated non-analytically."[(p3)] However, Eva et al[7] have demonstrated that when novices use both the tacit and analytical systems for hypothesis generation, clinical reasoning is improved. By supporting novice learners in tacit pattern recognition and analytical reasoning, instructors may foster clinical reasoning to improve the quality of patient care.

A promising pedagogical tool for improving clinical reasoning and transfer of learning among health professional novices is case-based analogical reasoning (CBAR) with instructor cueing.[9,10] CBAR is a pedagogical technique that improves problem solving by assisting learners with the identification of a common structural principle or concept shared among multiple cases for solving a future problem or case.[9] Moreover, the technique can be constructed to prompt students to engage in hypothetico-deduction, particularly in the clinical setting.

According to Gentner's structure-mapping theory,[12] a structural principle is a set of correspondences between examples or experiences. When cueing (ie, providing hints) is coupled with CBAR, the transfer of the structural principle to a target problem or clinical case is enhanced.[9,10,13] For example, students might be presented two cases with one involving referred unilateral leg pain and the other referred shoulder pain. Through provision of either written or verbal cues from the instructor, students are prompted to compare the cases to uncover an implicit underlying principle shared by both cases. Once discovered, the structural principle can be used to either diagnose or treat a patient who would benefit from the application of the principle. In this example, the concept or implicit structural principle causing the symptoms may be mechanical deformation that increases pressure on a nerve root.

Despite accumulating evidence that the comparison of multiple cases accompanied by cueing is more effective in promoting learning transfer among health care students, particularly among novice learners,[10,13] instructors' use of single patient cases persists in health care education settings.[14] In this article, we provide athletic training educators a rationale for implementing CBAR with instructor cueing. We also give recommendations for practical implementation to promote students' clinical reasoning and to bridge the transfer gap between classroom and clinical settings.

CASE-BASED ANALOGICAL REASONING

Educators and researchers have long struggled to identify instructional methods to optimally foster transfer of learning. Over a century ago, Thorndike and Woodworth[15] set the stage for learning transfer research by identifying that individuals more readily retrieve experiences that are similar in surface features, such as shape, color, or context. Later work, however, demonstrated that individuals value robust structural relationships (eg, principles or concepts) more than surface features when problem solving.[16-18] In the two-case examples described above, the referred pain experienced by both patients differ in anatomical location (a surface feature), but the cases are structurally similar in terms of cause (mechanical deformation of a nerve root) and symptomology.

The human brain organizes similar symptoms or attributes of patient cases, such as pain and numbness, into a category or schema.[19] In this instance, the category could be neuropathies. The brain will also associate the schema's set of attributes with a corresponding structural principle,[9] such as mechanical deformation. Moreover, the brain also compares new patient cases that share similar symptomology, such as tarsal tunnel syndrome, against an existing schema of neuropathies and their associated structural principles. Once the shared principle has been identified among multiple cases, individuals can then utilize it to solve novel problems presented by new cases.[9,10,13]

Cognitive scientists have identified that the process of analogical reasoning capitalizes on the brain's preference to use tacit structural patterns for problem solving.[20] However, the extent to which individuals recognize and utilize surface features or underlying structural principles in problem solving depends upon the quantity and quality of accumulated experiences in a particular domain.[21] Novices demonstrate a preference for relying on surface features first (eg, numbness) whereas experts primarily rely on structural principles (eg, mechanical deformation).[22] Even though surface features facilitate memory recall, structural principles are more effective for problem solving because structural principles provide rules for solving the problem (eg, take pressure off of the nerve and symptoms will subside).[16]

Medical researchers Bordage and Lemieux[23] reported that students who had difficulty with clinical reasoning demonstrated a preference for using signs and symptoms for solving patient cases compared to those who utilized structural relationships or principles that existed among patient cases, which they termed semantic axes. The authors posited that deep understanding of how to address novel patient encounters cannot be derived from clinical signs and symptoms in isolation but must be understood in the context of the semantic structure of a set of signs and symptoms (schema), and ultimately, how these schema are differentiated across multiple patient cases.[24]

Novices typically need help not only with building mental models of a specific domain (eg, neuropathies) but also with retrieving and comparing domain knowledge. Seel[21] defines mental models as "inventions of the mind that represent, organize, and restructure domain-specific knowledge."[(p408)] The cognitive scaffolding and reorganization process that occurs over time to form a mental model assists in bolstering learners' clinical reasoning ability.[5] Mental models contain not only common surface features of experiences shown to aid in retrieval of schemas,[24] but more importantly, structural principles and solution strategies that can be used for novel problem solving.[18] Augmenting Steel's definition of mental models, Eckert and Bell[25] observed that mental models also convey to the learner how to act upon the embedded knowledge, which is essential to demonstrating clinical competency in the clinical decision making process.[26]

CBAR coupled with cueing assists with accomplishing the lofty task of developing clinical competence in three primary ways. Foremost, the process of comparing multiple cases and uncovering their common structural principle builds the learners' schema to aid their problem-solving ability.[21-27] The cases serve as exemplars to mitigate lack of experience in a respective domain.[9] Several studies have reported that engaging novices in comparing multiple case examples for the purpose of applying their shared structural principle assists in the development of quality schema in spite of a lack of real-life experience.[8,28,29]

Second, instructor-provided cues associated with cases may assist learners with retrieving past memories,[30] help them identify structural principles shared in the cases,[8] and serve as triggers for problem solving.[21] Clark and Harrelson[31] asserted that successful transfer depends on the encoding (memory formation) of cues with an experience because cues are one of the most important factors for recalling an experience.

Cues can be used at anytime throughout the analogical reasoning process. However, for identification of tacit structural principles, cues are best placed prior to the examination of cases in order to prime the brain to identify the structural pattern that exists across cases.[8] Cueing is particularly important for facilitating analogical reasoning among novices. Novick and Holyoak[32] have found novices typically do not engage in active analogical comparison unless cued to do so.

In a classic analogical reasoning study by Gick and Holyoak,[19] when participants were cued or provided with a hint that comparing the two case examples would help them solve a future problem, 80% solved the target problem correctly versus 30% who had knowledge of the examples but received no hint. Among participants who received the case example alone but no comparison examples or hints, only 10% solved the problem correctly. These findings reify the essential nature of providing directive and explicit cueing when engaging learners in an analogical reasoning process to guide them in transferring their learning to solve novel problems effectively.

Additionally, when the cue and learning experience invokes an emotional response, the experience engenders hippocampal encoding of the experience for future recall.[33] An example of how an athletic training educator might associate emotion with the CBAR process is to design case scenarios with characteristics to which students can identify and relate to similar experiences they have had in the past (eg, loss of playing time, debilitating pain or catastrophic injury). Therefore, to optimize clinical reasoning and learning transfer when using CBAR, a primary goal of the educator should be to use cues early and to design cases embedded with an emotional component.

Third, CBAR coupled with cueing can promote clinical competence by reinforcing neural connectivity between existing memories and creating neural connections between new experiences and existing memories.[34] The analogical reasoning process forces the hippocampus and cortex to disassociate surface and structural case attributes scaffolded onto existing memories.[32] Cues encoded with memories serve as a trigger for the memory, enabling more efficient retrieval when needed.[35] The ability for novices to efficiently retrieve existing schema for problem solving reduces cognitive load and improves transfer of learning.[36] The dynamic neural process of recreating a mental scene from either prior experience or exemplar cases fosters the ability to extend the scene and its solutions to future novel problem solving. In this way, the perception of applicability of the learning experience may foster learning transfer.[37]

Edelman and Tononi[38] posited that when individuals recreate a mental scene from their past experiences (the "Remembered Present"), it stabilizes and modifies neural networks for future planning. They identify three requirements for creation of a Remembered Present: categorization of perceptual experiences into schema, formation of schema into concepts, and abstraction of the concepts. The analogical reasoning process with cueing is an ideal pedagogical technique to facilitate creation of a remembered present because the instructional technique promotes memory retrieval, mapping of past and current experience, and abstraction for application to a problem. Additionally, cueing during the case-based analogical reasoning process may serve to cognitively tag the structural principle derived from the comparison of multiple cases, implicitly or explicitly alerting the learner of their presence for use and later recall.

Therefore, for novices to build their clinical reasoning and to execute successful novel problem solving, they must build a repertoire of similar experiences over time, which can be supplemented with CBAR. While expanding their "cognitive tool set," they must be cued to look for the structural principles, patterns, or relationships that exist among disparate cases. Such exposure increases learners' implicit knowledge so they can effectively apply it to dissimilar patient cases when they arise.

CBAR Application Strategies

The theoretical and empirical evidence supporting the efficacy of case-based analogical reasoning described above has applications for strategies to promote learning transfer, including:

1. Have students compare multiple patient cases.
2. Prompt students either through written or verbal cues that there is a hidden "clue" (principle or concept) that the patient cases share.
3. Cue students that they will use the hidden principle for solution of a future patient case.
4. Do not reveal the hidden principle; facilitate students' discovery of it through analysis of the cases.
5. Introduce cues prior to case examination.
6. Compose cases with an emotional component or theme.
7. "Debrief" after the multiple-case comparison activity and relate case principles back to the cases and previous patient experience.

CBAR LESSON DESIGN

When setting out to design and implement a CBAR lesson in the classroom, several factors are important to consider. As recommended by Gentner and Collhouhn,[39] the instructor must construct structurally sound patient cases that are factually valid and have pragmatic relevance to the student. In Figure 1 we present a graphic model of factors to guide athletic training educators in the instructional design of CBAR with cueing for novice preprofessionals.

Case Construction

Before building multiple patient cases for comparison or the target case for solution, the instructor must decide which concepts or principles students should acquire from the case-comparison process that could be applied as a solution. After identifying the structural principle, it must be embedded within the cases without explicitly revealing the principle to the learner. Not revealing the structural principle is important because when the brain works to identify tacit structural patterns (eg, mechanical deformation) students are more likely to utilize the structural pattern when solving novel problems than when they focus on surface features[10] (eg, skin appearance).

Patient cases will and should contain surface features such as patient signs and symptoms, but their attributes should assist students in identifying a structural principle rather than revealing it explicitly. Patient case examples, however, do not have to be similar in nature. In fact, dissimilar cases avoid the likelihood of students focusing on shared surface characteristics that are irrelevant to solving the problem.[40] For example, when comparing joint effusion to localized edema of a badly bruised muscle, their surface features are dissimilar, but both share a structural principle of restoring the fluid homeostasis for productive healing. Therefore, students should be cued to search for the structural principle (ie, the relationship both share); otherwise, novice learners' will likely focus on shared surface characteristics—body part, color, size, and shape.

The decision of whether to use worked patient cases will depend on the level of the students' prior experience with the content. A worked case includes a pre-defined solution to the case and is recommended if students have limited or no experience with a particular content area. Worked cases can serve as exemplars of best practice for novice students, which not only builds their schema in a particular domain, but also reduces the cognitive load they may experience during the case comparison process.[27] Cognitive overload results in a decreased capacity to learn and engage in successful problem solving due to the limited capacity of working memory.[36] Novices have been shown to exhibit cognitive overload when processing unknown complex material.[41] If novices do not have the schema present to process the elements of a case, they will have to process each element individually, resulting in high cognitive overload.[36] Wainwright et al[26] point out that health profession education students' clinical reasoning ability develops in incremental stages based on their academic and clinical exposure. Therefore, the construction of worked cases that do not require a high level of abstraction may be essential in the early phases of the students training to avoid cognitive overload.

After cases have been constructed, the instructor has a basis from which to construct the cues or prompts associated with the cases to yield desired learning outcomes. In Table 1 we provide unworked case examples with written cues to guide

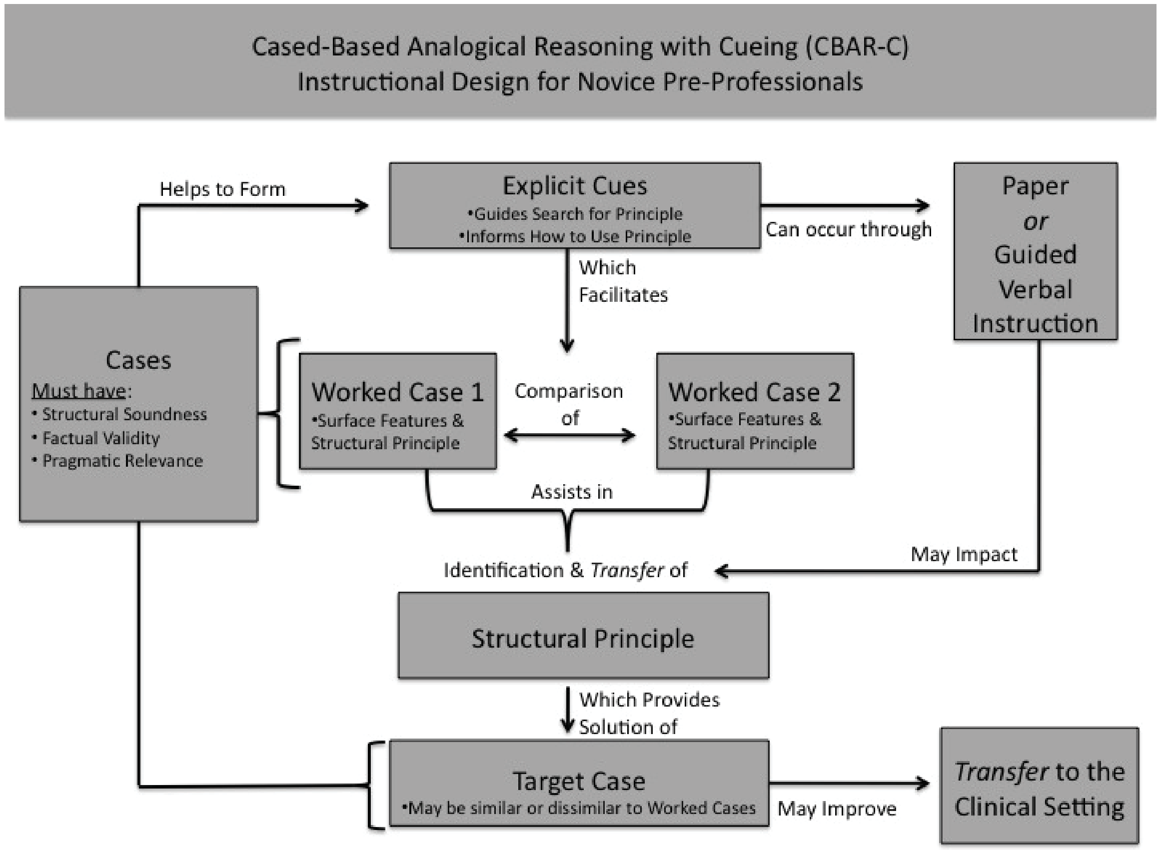

Figure 1. Case-Based Analogical Reasoning with Cueing Lesson Design

instructors in the case construction process. Depending upon class size and resources available, the instructor can use either a written or oral method to deliver the cases and cues. Regardless of presentation format, cues should explicitly guide students what to search for when assessing the cases and how to use their observations to solve a target problem. The target problem, or case to be solved, can be superficially related or unrelated to the comparison cases but should be solvable from the structural principles or concepts gained from the case comparison process.

Pragmatic Relevance

If learners perceive that patient cases are factually valid and relevant to their professional training and practice, they are more likely to transfer their learning from the lesson to new cases and scenarios.[37] Shayo and Olfman[28] reported a significant improvement in transfer and self-efficacy among computer science undergraduates after they had been exposed to multiple relevant case examples rather than generic database examples. Engendering learners' self-efficacy when engaging in complex tasks is essential because it encourages learners to persevere in attaining their goals when challenged cognitively,[42] which typically occurs among novices when presented with unfamiliar tasks.[36]

When learners are exposed to relevant case examples, they are likely to identify them as applicable for solving problems they may encounter in the future. Their perception of the applicability of cases may serve as a cue for identifying structural principles that underlie the cases.[37] In appreciating the applicability of cases, learners may experience an increase in motivation to transfer case principles and a subsequent increase in self-efficacy because they feel they can use the principles to solve future problems.[42] The Perception of Applicability Model by Speicher and Kerhrahn[37] illustrates how instructor cues can assist students in retrieving memories from prior experience as well as in gaining insights about the applicability of a current learning experience for addressing future clinical problems.

The Model also points to the need for learners to appreciate the applicability or pragmatic relevance of learning activities that instructors construct for them. Yelon et al[43] found among 73 physicians in a medical education teaching fellowship that the process of determining the applicability of a teaching technique for potential transfer rested heavily on the learner's identification and mapping of the technique to their schemas. The end result of the teaching fellows' mapping process assisted them in identifying the utility of their learning experiences for accomplishing a future goal or solving a problem. Novices, however, do not typically possess a rich base of experience to recognize the applicability of a current learning experience for future application.[30] When introducing CBAR with cueing, instructors can assist

Figure 2. Sample Comparison Cases with Written Cues

Please read the following two cases. Comparison of the two cases will help you produce a solution(s) for a third target case.

Case 1: A 65-year-old male triathlete presents with complaints of left moderate shoulder pain. History reveals shoulder subluxation one year ago secondary to a cycling accident. The patient underwent rehabilitation, but pain persists primarily in the upper trapezius and scapular area. The patient also reports that one month ago they started to experience persistent focal numbness at the lateral forearm. Palpation reveals multiple trigger points in the left upper trapezius, biceps and rhomboids. Motor function is within normal limits, but a mild sensation deficit is noted on dermatome testing at the lateral distal forearm. Cervical right lateral flexion with distraction relieves the forearm numbness but not the trigger points.

Case 2: A 22-year-old female hurdler presents with a two-year history of right moderate hamstring pain of unknown origin that has been unresponsive to traditional therapy. The patient reports her pain increasing with hurdling and sitting for prolonged periods of time. Upon evaluation, dermatome testing is within normal limits and hamstring strength is slightly diminished, but is not painful with testing. The right ilium is elevated, muscular spasm of the quadratus lumborum is present and moderate tenderness is found over the right lumbar sacral area along with multiple trigger points in the same area. Right lateral and forward trunk flexion increases pain at the mid-belly of the hamstrings.

Think about the similarities between these two cases. What are the key similarities in the two cases? Write them down below.

Key Case Construction Attributes:

- Cases are relevant to practicing athletic trainers.
- The cases are factually correct and sound.
- The structural principle (mechanical disc deformation) is implicit.
- Each case shares similar (trigger points) and dissimilar (age and sport) surface attributes.
- Written cues are provided to alert learners to actively compare both cases and that comparing the two cases will assist in solving a future problem.
- The complexity and nature of the cases (unworked) is consistent with the level of the learners (ie, students who have basic knowledge and limited clinical experience).
- Cases can be modified into worked cases for novice learners by providing the treatment approach and associated outcomes for each case.

Key Target Case Construction Attributes:

- Prior to reading or presentation of a third target or novel case, cue students to identify and articulate the concept or structural principle the previous two cases shared.
- Cue students that the novel case can be solved by applying the concept or structural principle.
- Ensure that the target case can be solved based on the structural principle in the comparison cases.
- The target case can be like or unlike the previous cases.
- Additional cues can be provided based on instructional goals but should avoid revealing the structural principle imbedded in the comparison cases.

students in identifying not only structural principles across cases but also how the multiple-case comparison and transfer of learning process mirrors clinical practice.

Cue Construction

Once learning outcomes have been set and cases constructed, the instructor should develop explicit cues in either a written or verbal format to guide students in identifying and using the embedded structural principle in the comparison cases for solution of a novel target patient case. Researchers[20,32] have reported that if the structural principle is easily identified or provided, transfer and problem solving is compromised. Solution of a target case should not be solvable from prior or common experience alone. Rather, cues should be directive enough to prompt learners to transfer the structural principle and/or optimal treatment method desired by the instructor. Therefore, asking students to apply what they have learned or personally experienced in the past may be too vague for meaningful application. Instead, instructors should be explicit with cues, asking learners to identify a principle or solution strategy common among the comparison cases for application to the target case. An instructor may ask, “Taking into consideration the presentation of both cases, what underlying mechanism may be responsible for their symptomology? What treatments might be appropriate to address that mechanism?” These cues direct learners to actively compare the worked cases and abstract the underlying mechanism, principle, or concept responsible for the signs and symptoms without explicitly identifying the structural principle both cases share.

We have used a written format to deliver cues for identification of the structural principle when using worked patient cases. Other researchers[9] have successfully used an oral delivery method. Providing cases and their cues on paper provides a standardized method of delivery to a large student group. In addition, placing both cases to be compared on the same sheet of paper is a form of implicit cue recommended by Gentner et al[9] that promotes case comparison. We speculate that when the two cases are in the same field of vision versus being on separate sheets of paper, the brain may gravitate more towards comparing the cases. Paper-based formatting of case descriptions may also free up students' working memory because they are not required to remember the cases or cues. Moreover, freeing working memory may decrease cognitive load, contributing to improved transfer.[36] Oral delivery, on the other hand, provides students with an opportunity to affirm their understanding of the cue and the cases through feedback from the instructor. However, orally responding to multiple students in a large class may prove time-consuming for the instructor and introduce variability that may be hard to control with a research study.

CBAR Lesson Design Key Points

In sum, when designing CBAR with cueing lessons, instructors should keep in mind the following points:

1. Construct cases that are factually valid and have pragmatic relevance.
2. Utilize worked cases for novice learners.
3. Compose the cases and their cues without explicitly revealing the structural principle.
4. Avoid using complex structural principles or cases early in the development of the student's clinical reasoning to avoid cognitive overload.

DISCUSSION

CBAR with cueing is a pedagogical tool that can improve students' transfer of structural principles to enable novel problem solving[10,37] and may aid in bolstering clinical reasoning. Researchers have found CBAR with cueing assists in building domain specific knowledge and solution strategies among students with limited patient experience.[9,10,21,37] The practical application of this tool exists any time instructors use case examples to foster learning. Therefore, use of CBAR with cueing in both the classroom and clinical settings may help supplement the student's lack of experience with domain-specific knowledge and clinical exposure to patients.

Many athletic training clinical instructors may already be employing case-based analogical reasoning with cueing without realizing it. Intuitively, many instructors prompt students in the classroom and the clinic to compare one patient case to the other (eg, multiple knee reconstruction cases) to enable students to identify patterns in both presentation and treatment approach. Clinical instructors can use CBAR in the clinical environment to help students reinforce and apply their classroom learning. Edelen and Bell[44] found that nursing students demonstrated higher levels of clinical reasoning during their first clinical experience when faculty integrated CBAR processes in the clinic compared to students who worked with faculty that did not use CBAR processes. Additionally, classroom instructors can pull from students' clinical experiences for case comparisons and applications to lecture or classroom case discussions. In both settings, however, instructors must actively cue novice students to engage in the analogical reasoning process and to apply their learning to a novel problem; otherwise, students will be less likely to do so, which may delay the development of their schema and clinical reasoning. Moreover, even if students are able to identify structural principles and apply them correctly, instructors should periodically challenge students to apply them to similar and dissimilar cases in a variety of contexts to ensure they have fully grasped the principles.

CONCLUSION

Case-based analogical reasoning with cueing facilitates students' recall and transfer of learning. This pedagogical tool shows promise for promoting the types of learning that may significantly improve students' problem-solving ability and clinical reasoning. With the emergence of research demonstrating the power of multiple patient case examinations with cueing, the traditional practice of singular patient case examination both in and outside the classroom may be less effective for building clinical reasoning skills and promoting transfer of learning. Much work remains to be done though to examine the effectiveness of various delivery methods of cases and cues as well as their utilization in traditional learning and clinical practice settings. Future studies should examine the ways and extent that CBAR with cueing impacts a health professional student's clinical reasoning skills and if it improves the quality of patient care they provide in the clinical setting.

REFERENCES

1. McKeough A, Lupart JL, Marini A. *Teaching for Transfer: Fostering Generalization in Learning.* Newark, NJ: Lawrence Erlbaum; 1995.
2. Schellhase KC. Applying mastery learning to athletic training education. *Athl Train Educ J*. 2008;3(4):130-134.
3. National Athletic Trainers' Association. Athletic Training Education Competencies. 5th (Ed).:http://www.nata.org/education/competencies. Accessed February 2, 2012.
4. Murphy JI. Using focused reflection and articulation to promote clinical reasoning: an evidence based teaching strategy. Nurs Educ Perspect. 2004;5:226–231.
5. Pelaccia T, Tardif J, Triby E, Charlin B. An analysis of clinical reasoning through a recent and comprehensive approach: the dual-process theory. *Med Educ Online*. 2011;16.
6. Rochmawati E, Wiechula R. Education strategies to foster health professional students' clinical reasoning skills. *Nurs Health Sci*. 2010;12(2):244–250.
7. Eva KW, Hatala RM, LeBlanc VR, Brooks LR. Teaching from the clinical reasoning literature: combined reasoning strategies to help novice diagnosticians overcome misleading information. *Med Educ*. 2007;41:1152-1158.

8. Litman L, Reber, AS. Implicit cognition and thought. In: Holyoak KJ, Morrison RG, eds. T*he Cambridge Handbook of Thinking and Reasoning.* New York, NY: Cambridge University Press; 2005:431-453.
9. Gentner D, Loewenstein J, Thompson L. Learning and transfer: a general role for analogical encoding. *J Educ Psychol.* 2003;95(2):393-408.
10. Norman G, Dore K, Krebs J, Neville AJ. The power of the plural: effect of conceptual analogies on successful transfer. *Acad Med*. 2007;82(10):S16-S18.
11. Sage WM. Medical liability and patient safety. *Health Affairs.* 2003;22(4):26.
12. Gentner D. Structure-mapping: a theoretical framework for analogy. *Cogn Sci*. 1983;7(2):155–170.
13. Speicher TE. Effect of cueing on learning transfer among pre-professional undergraduate healthcare students engaged in a case-based analogical reasoning exercise. Paper presented at: Adult Education Research Conference & the Canadian Association for the Study of Adult Education Annual Meeting; June 11, 2011; Toronto, Ontario Canada.
14. Shine KI. AAMC paper. *Acad Med*. 2002;77:91-99.
15. Thorndike E, Woodworth D. The influence of improvement in one mental function upon the efficiency of other functions. *Psychol Rev*. 1901;8:247-261.
16. Duncker K, Lees L. On problem-solving. *Psychol Monogr*. 1945;58(5):1-113.
17. Holyoak KJ, Koh K. Surface and structural similarity in analogical transfer. *Mem Cogn*. 1987;15(4):332-340.
18. Hmelo-Silver CE. Problem-based learning: what and how do students learn? *Educ Psychol Rev.* 2004;16(3):235-266.
19. Gick ML, Holyoak KJ. Schema induction and analogical transfer. *Cogn Psychol*. 1983;15(1):1-38.
20. Reber AS, Millward RB. Probability learning and memory for event sequences. *Psycho Sci*. 1965;3:431–432.
21. Seel NM. Mental models and complex problem solving: instructional effects. In: *Handling Complexity in Learning Environments: Theory and Research*. Philadelphia: Elsevier; 2006:43-66.
22. Chi MT, Feltovich PJ, Glaser R. Categorization and representation of physics problems by experts and novices. *Cogn Sci*. 1981;5(2):121-152.
23. Bordage G, Lemieux M. Some cognitive characteristics of medical students with and without diagnostic reasoning difficulties. In: Research in Medical Education: Proceedings of the Annual Conference. Conference on Research in Medical Education. Vol 25: 1986:185.
24. Lemieux M, Bordage G. Propositional versus structural semantic analyses of medical diagnostic thinking. *Cogn Sci*. 1992;16(2):185–204.
25. Eckert E, Bell A. Invisible force: farmers' mental models and how they influence learning and actions. J Extension. 2005;43(3).http://www.joe.org/joe/2005june/a2p.shtml. Accessed November 10, 2009.
26. 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.
27. Hummel HGK, Nadolski RJ. Cueing for schema construction: designing problem-solving multimedia practicals. *Contemp Educ Psychol*. 2002;27(2):229-249.
28. Shayo C, Olfman L. The role of training in preparing end users to learn related software. *J End User Comput.* 2000;12(1):3-13.
29. Novick LR. Analogical transfer, problem similarity, and expertise. *J Exp Psychol Learn.* 1988;14(3):510–520.
30. O Reilly RC, Rudy JW. Conjunctive representations in learning and memory: principles of cortical and hippocampal function. *Psychol Rev*. 2001;108(2):311-345.
31. Clark R, Harrelson GL. Designing instruction that supports cognitive learning processes. *J Athl Train*. 2002;37(4):S152-S159.
32. Novick LR, Holyoak KJ. Mathematical problem solving by analogy. *J Exp Psychol Learn*. 1991;17(3):398-415.
33. Rudy JW, Barrientos RM, O'Reilly RC. Hippocampal formation supports conditioning to memory of a context. *Behav Neurosci*. 2002;116(4):530-538.
34. LeDoux J. Small change. In: *Synaptic Self: How Our Brains Become Who We Are*. New York: Harmondsworth/ Middlesex; 2002:135-173.
35. Damasio AR. *The Feeling of What Happens: Body and Emotion in the Making of Consciousness*. New York: Mariner Books; 2000.
36. Tuovinen JE, Sweller J. A comparison of cognitive load associated with discovery learning and worked examples. J *Educ Psychol.* 1999;91:334–341.
37. Speicher TE, Kehrhahn M. Analogical reasoning: a process for fostering transfer of learning from the classroom to the clinical practice setting. *Int Forum Teach Stud*. 2009;5(2):52-58.
38. Edelman GM, Tononi G. *A Universe of Consciousness: How Matter Becomes Imagination*. New York: Basic Books; 2001.
39. Gentner D., Colhoun J. Analogical processes in human thinking and learning. In: von Müller A, Pöppel E, Glatzeder B, Goel V, von Müller A, eds. *Towards A Theory on Thinking: Building Blocks for a Conceptual Framework*. London: Springer; 2010:35-49.
40. Gentner D, Markman AB. Structure mapping in analogy and similarity. *Am Psychol*. 1997;52:45-56.
41. Clark R, Ellen J. When less is more: research and theory insights about instruction for complex learning. In: *Handling Complexity in Learning Environments: Theory and Research.* Philadelphia: Elsevier; 2006:283-295.
42. Bandura A. Self-efficacy mechanism in human agency. *Am Psychol*. 1982;37(2):122-147.
43. Yelon S, Sheppard L, Sleight D, Ford JK. Intention to transfer: how do autonomous professionals become motivated to use new ideas? *Perf Improv Q*. 2004;17:82-103.
44. Edelen B., Bell A. The role of analogy-guided learning experiences in enhancing students' clinical decision-making skills. *J Nurs Educ*.2011;50(8):453-460.