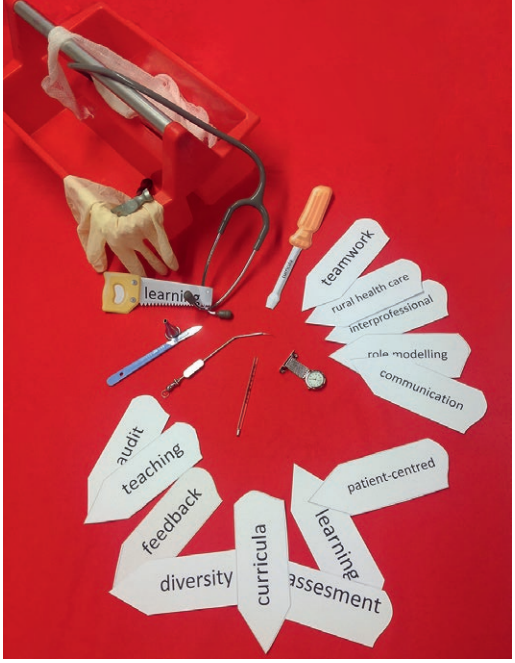

Cognitive learning theory for clinical teaching

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Editor's note: Cognition is the act of knowing, perceiving and processing information specifically in relation to brain functioning and mental processes. Thus cognitive learning is about using thinking to learn, where such thinking may be affected by external and internal factors. As the authors of this toolbox article describe, cognitive learning theory may be applied to explain and facilitate retention and translation of clinical knowledge. The theory and its application are presented through a series of six concepts relevant to clinical teaching practices: retrieval practice; spaced learning; interleaving; self-practice; reflection; and elaboration. Each of these is discussed in ways that clinical teachers may apply easily in practice. In particular I feel that the table of strategies to integrate cognitive learning theory into clinical education will be of great practical benefit.

We strive for better ways to help our learners create lasting knowledge that will translate into improved care

INTRODUCTION

The scenarios outlined in Box 1 will be familiar to learners and teaching staff in clinical education. We frequently continue to rely on educational strategies, such as repetition and re-reading, that are flawed in promoting the retention of knowledge.[1,2] As educators and teachers, we strive for better ways to help our learners create lasting knowledge that will translate into improved care for our patients.

In this toolbox article, we discuss six key aspects of cognitive learning theory, as it relates to health professional education and clinical teaching. Cognitive learning theory refers to a learning theory that focuses on perception and the processing of information.[3] In the setting of clinical teaching, this theory and its principles can be applied to help learners with the retention and translation of medical knowledge. We provide specific examples of how to integrate these six concepts into clinical teaching practices.

RETRIEVAL PRACTICE AND SPACED LEARNING

Memory is enhanced with active rather than passive practice. Periodic relearning of material prevents the typical memory decay that we all experience. Testing, or retrieval practice, is a well-studied and powerful tool to help with the

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Box 1. Examples of educational scenarios commonly encountered in the clinical setting

- Slide after slide flashes by as the lecturer speaks about the management of inpatient hyperglycaemia during the noon conference. You try to keep track of teaching points and realise that despite hearing and reading about this topic previously, you have a hard time remembering some of the key aspects of the material.
- On rounds you ask a team of students to present the case of a patient with *Clostridium difficile* colitis. As you listen to one learner discuss the management plan, you note that he is struggling with the salient aspects of the plan, despite teaching about this topic to the team yesterday.
- As part of the educational leadership team, you review the learners' scores from a training examination and note low scores for some topics; however, these topics seem to be more than adequately covered in teaching conferences. Despite the repetition, it is apparent that your learners are not retaining the information.

retention of information.[4] Spaced learning, also called distributed learning, can significantly improve long-term retention without requiring additional time.[5,6]

Use questions to revisit key learning points in the clinical setting

Studies demonstrate that learners recall approximately 50% more information when they test themselves rather than simply studying without testing.[7,8] Testing forces one to elaborate and make connections to prior knowledge; ultimately, it enhances later retention, a phenomenon known as the testing effect.[9] This can be easily accomplished by regularly incorporating questions into a teaching session to reiterate and emphasise key learning points; this will have the added benefit of assessing learner knowledge and understanding. These questions can be presented within case-based scenarios that help to engage the group in discussion, or by using audience response systems for shorter question-and-answer techniques. These methods can easily be employed in a variety of teaching settings, such as the conference scenario described above.

Have learners identify key learning points from the teaching or clinical session

Asking learners to identify take-home points or new questions that have arisen during a learning session employs both retrieval and reflective practice, two key aspects of cognitive learning theory.[8] Setting the expectation that team members will be asked to identify two key points at the end of an ambulatory clinic, ward rounds or a didactic session is a powerful method to enhance lasting retention and foster curiosity. In the ward-round example, having the learner review two main teaching points about *Clostridium difficile* colitis at the end of rounds would promote increased retention.

Revisit key learning points throughout clinical rotations

Reviewing or studying information several times with greater intervals between the events enhances the long-term retention of knowledge and concepts.[10,11] Faculty members can accomplish this by keeping track of key learning points and incorporating these topics into future teaching sessions as follow-up questions or brief case scenarios. Didactic sessions can begin with a recap of prior sessions, or ward rounds can include follow-up discussions related to previous patients. This can also be accomplished electronically by circulating key questions or relevant teaching points with learners on a regular basis.

INTERLEAVING

Interleaving topics or tasks allows learners to form links or connections to previously taught information, thereby facilitating the retention and deeper understanding of new material.[12]

Link new concepts with old concepts

Concepts in medicine are often taught in isolation. Diversifying the cases seen or concepts learned leads to stronger links in memory and the enhanced transfer of information to different settings. Asking learners to reflect on how the present information relates to prior learning also helps to facilitate the transfer of knowledge and interleaving of ideas.[13,14] For example, asking your team on rounds how the management of colitis in the current patient differs from the management of a prior case of colitis, or from a hypothetical case in which clinical parameters would dictate a different management plan, allows learners to make stronger links related to this topic.

GENERATION

Learning is enhanced when an individual must generate an answer or solve a problem, rather than having the knowledge simply provided.[15] Generation makes the mind more receptive to new learning and promotes learner retention of new knowledge.[16]

Encourage learners to work through problems

It can be challenging in an environment with close supervision of learners to encourage autonomy and active learning; however, it is important that we continue to foster both of these principles. Learners greatly benefit from experiential learning, where they are able to consider issues and problems new to them and apply concepts previously learned. In all clinical settings, learners should be encouraged to work

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Teaching is a powerful learning tool

through challenging scenarios, by linking previously learned concepts to the current scenario. Information that is readily provided to a learner is often not retained as well as information that a learner thinks about and discovers on their own.[1]

Use pre-tests to promote curiosity

Asking questions in advance of teaching allows gaps in knowledge to be identified and creates cognitive dissonance, which spurs curiosity.[17] Pre-tests can take the form of clinical cases with open-ended questions or more discrete multiple-choice questions, which can be presented using an audience response system. These pre-test questions can be re-visited throughout the session and the answers discussed at the conclusion of the presentation to ensure that learners have an understanding of the concepts. This strategy can be employed in larger didactic settings, such as our noon lecture scenario (see Box 1), to promote learner curiosity as well as retrieval practice.

DELIBERATE SELF-PRACTICE AND SELF-REFLECTION

Evidence suggests that mindless repetition in isolation does not produce lasting results.[18] Deliberate practice is a structured and focused approach to improve performance through clear learning objectives, focused practice, measurement of performance and formative feedback.[19]

Direct observation and feedback of learners

Deliberate practice pushes learners to reach specific goals and provides them with the necessary feedback to achieve these goals.[19] This may be achieved in the simulation centre, where learners are practising a procedure, or it may happen in real-time while observing a learner at the bedside. Training programmes must invest in teaching staff who are motivated to both supervise and provide feedback, but who are also trained to give effective feedback and follow learners through their development into independent doctors. Observing your intern at the bedside, performing a history and physical examination or counselling a patient with regards to their treatment plan, allows for direct and timely feedback for the learner to help them to achieve their goals.

Ask questions of the learners to promote self-reflection

Throughout their careers, practising health professionals must constantly reflect on what they know, what they don't know and how they can improve. Faculty members should model this behaviour and ask questions to stimulate meaningful reflection. After the learner presents his patient with *C. difficile*, consider reflective questions, such as: 'What do we need to know more about to better care for this patient?' Encourage learners to identify uncertainty that might exist at the conclusion of a teaching session or a clinical encounter, and use this as a key teaching point the next time you are together.

Create time for learner reflection

Learners are likely to benefit from dedicated time for reflection.[20–22] Creating the time and space to carry out reflection is often overlooked because of competing demands and the pressures of time. Consider ending teaching sessions 5 minutes early, and have learners use this time to reflect on what they have learned or what questions they still have. By providing the time and permission to actively reflect, teachers are creating a safe space for learners to integrate their thinking, establish connections and identify gaps that need to be filled. Interactive methods such as 'think–pair–share', where learners think through a problem or question in pairs and then share their thoughts with the larger group, can be incorporated to facilitate group reflection and sharing. Larger didactic sessions can employ these strategies to allow learners to solidify their learning.

ELABORATION

Relating material to prior knowledge or to past experiences allows us to develop a deeper understanding of the information.[23,24] By invoking a metaphor or visual image when teaching, or by putting a concept into our own words, we use the skills of elaboration. This form of elaboration expands mental cues for later recall and transfer of information.

Promote higher-order thinking of learners with 'why' and 'what if' questions

Pushing learners to develop a deeper understanding of new information facilitates the ability to apply, analyse and synthesise information. Consider asking your learner to explain their findings with 'why' and 'what if' questions that encourages them to understand physiological concepts. Create hypothetical situations to extend the learning: 'How would your management of *C. difficile* colitis change if this patient had inflammatory bowel disease?' Seek a deeper understanding of their knowledge and prevent premature closure by asking them to extend their differential diagnosis. Consider using concept maps to create more complex and comprehensive links to other material.

Encourage all learners to teach in the clinical setting

Teaching is a powerful learning tool. Although it is frequently assumed that the most senior member of a clinical team will provide the teaching, this deprives other team members the opportunity to learn through teaching. Thus, it is important to encourage the entire team to participate in teaching. Have all members of clinical teams teach about concepts that

Table 1. Strategies to integrate cognitive learning theory into clinical teaching

Cognitive learning theory technique	Teaching setting
Have learners identify two or three main learning points and two or three questions at end of session (*retrieval practice, deliberate practice/self-reflection*)	Ward rounds, small group sessions, ambulatory precepting
At beginning of session, have learners revisit two or three learning points from prior day or session (*retrieval practice, spaced learning*)	Ward rounds, small group sessions
Incorporate questions throughout session to reiterate and emphasise key learning points. An audience response system can be used for shorter questions (*retrieval practice*)	Lectures, ward rounds, small group sessions, ambulatory precepting
Periodically develop quizzes based on prior learning points and cases and re-circulate using a common platform (*spaced learning, interleaving*)	Lectures, ward rounds, small group sessions, ambulatory precepting
Observe learners directly 'in action' (procedure, performing a history and physical exam, leading a family meeting, etc.) and provide clear and effective feedback (*deliberate practice/self-reflection*)	Ward rounds, ambulatory precepting
Divide learners into small groups during session, allowing time to work through cases/questions and teach ideas to larger group (*deliberate practice/self-reflection*)	Small group sessions, lectures
Use pre-tests to help learners identify gaps in their knowledge and to stimulate curiosity (*generation*)	Lectures, ward rounds, small group sessions, ambulatory precepting
Have learners review topics relevant to an upcoming case or talk (*generation*)	Lectures, ward rounds, small group sessions, ambulatory precepting
Challenge learners to develop a deeper understanding by asking 'why' and 'what if' questions (*elaboration*)	Lectures, ward rounds, small group sessions, ambulatory precepting
Encourage learners to link new findings or concepts in the present case to prior cases and topics, and have them elaborate on concepts (*elaboration*)	Lectures, ward rounds, small group sessions, ambulatory precepting
Encourage all learners to teach (*elaboration*)	Ward rounds, small group sessions, ambulatory precepting

Using cognitive learning theory in clinical settings can greatly enhance knowledge retention and application

they have just learned about in a lecture. Start conferences with residents of different levels sharing topics that they investigated the day before while caring for patients. Begin daily rounds by asking the more junior members of the team to teach the group about take-home points from the day before. Have the more senior members begin rounds by addressing any questions raised on rounds the day before.

CONCLUSION

Using cognitive learning theory in clinical settings can greatly enhance knowledge retention and application. The principles of cognitive learning theory can easily be incorporated into a variety of clinical teaching settings, such as conferences, ward rounds and ambulatory clinics, and can involve all levels of learners, as demonstrated in Table 1. Improving knowledge retention and enhancing the application of that knowledge will ultimately translate into the better care of our patients.

REFERENCES

1. Brown P, Roediger H, McDaniel M. *Make It Stick – The Science of Successful Learning*. Cambridge, UK: Belknap Press; 2014.
2. Gilovich T. *How We Know What Isn't So: The Fallibility of Human Reason in Everyday Life*. New York, NY: Free Press; 1991.
3. Taylor DCM, Hamdy H. Adult learning theories: implications for learning and teaching in medical education: AMEE Guide No. 83. *Med Teach* 2013;**35**(11):e1561–e1572.
4. Roediger HL, Butler AC. The critical role of retrieval practice in long-term retention. *Trends Cogn Sci* 2011;**15**(1):20–27.
5. Cepeda NJ, Pashler H, Vul E, Wixted JT, Rohrer D. Distributed practice in verbal recall tasks: a review and quantitative synthesis. *Psychol Bull* 2006;**132**(3):354–380.
6. Moulton C-AE, Dubrowski A, MacRae H, Graham B, Grober E, Reznick R. Teaching surgical skills: what kind of practice makes perfect?: a randomized, controlled trial. *Ann Surg* 2006;**244**(3):400–409.
7. Roediger HL, Karpicke JD. The power of testing memory: basic research and implications for educational practice. *Perspect Psychol Sci* 2006;**1**(3):181–210.
8. Karpicke JD, Roediger HL. The critical importance of retrieval for learning. *Science* 2008;**319**(5865):966–968.
9. Karpicke JD, Blunt JR. Retrieval practice produces more learning than elaborative studying with concept mapping. *Science* 2011;**331**(6018):772–775.

Cognitive learning theory can easily be incorporated into a variety of clinical teaching settings

10. Carpenter SK, Cepeda NJ, Rohrer D, Kang SHK, Pashler H. Using spacing to enhance diverse forms of learning: review of recent research and implications for instruction. *Educ Psychol Rev* 2012;**24**(3):369–378.
11. Cepeda NJ, Vul E, Rohrer D, Wixted JT, Pashler H. Spacing effects in learning: a temporal ridgeline of optimal retention. *Psychol Sci* 2008;**19**(11):1095–1102.
12. Dunlosky J, Rawson KA, Marsh EJ, Nathan MJ, Willingham DT. Improving students' learning with effective learning techniques: promising directions from cognitive and educational psychology. *Psychol Sci Public Interest* 2013;**14**(1):4–58.
13. Rohrer D. Interleaving helps students distinguish among similar concepts. *Educ Psychol Rev* 2012;**24**(3):355–367.
14. Gavriel J. Memory and learning. *Education for Primary Care* 2016;**27**(1):60–62.
15. Kornell N, Hays MJ, Bjork RA. Unsuccessful retrieval attempts enhance subsequent learning. *J Exp Psychol Learn Mem Cogn* 2009;**35**(4):989–998.
16. Grimaldi PJ, Karpicke JD. When and why do retrieval attempts enhance subsequent encoding? *Mem Cognit* 2012;**40**(4):505–513.
17. Dennick R. Constructivism: reflections on twenty five years teaching the constructivist approach in medical education. *Int J Med Educ* 2016;**7**:200–205.
18. Callender AA, McDaniel MA. The limited benefits of rereading educational texts. *Contemporary Educational Psychology* 2009;**34**(1):30–41.
19. Ericsson KA. Acquisition and maintenance of medical expertise: a perspective from the expert-performance approach with deliberate practice. *Acad Med* 2015;**90**(11):1471–1486.
20. Bachhel R, Thaman RG. Effective use of pause procedure to enhance student engagement and learning. *J Clin Diagn Res* 2014;**8**(8):XM01–XM03.
21. Schlichting ML, Preston AR. Memory reactivation during rest supports upcoming learning of related content. *Proc Natl Acad Sci USA* 2014;**111**(44):15845–15850.
22. Di Stefano G, Gino F, Pisano GP, Staats B. Making Experience Count: The Role of Reflection in Individual Learning. Available at http://www.hbs.edu/faculty/PublicationFiles/14-093_defe8327-eeb6-40c3-aafe-26194181cfd2.pdf. Accessed on 16 February 2018.
23. Reder LM, Charney DH, Morgan KI. The role of elaborations in learning a skill from an instructional text. *Mem Cognit* 1986;**14**(1):64–78.
24. Willoughby T, Wood E. Elaborative interrogation examined at encoding and retrieval. *Learn Instr* 1994;**4**(2):139–149.

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