

Science of Learning Strategy Series: Article 4, Application to Educational Meetings

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Abstract The science of learning (learning science) is an interprofessional field that concerns itself with how the brain learns and remembers important information. Learning science has compiled a set of evidence-based strategies, such as distributed practice, retrieval practice, and interleaving, which are quite relevant to continuing professional development. Spreading out study and practice separated by cognitive breaks (distributed practice), testing oneself to check mastery and memory of previously learned information (retrieval practice), and mixing the learning of distinct but related material (interleaving) represent strategies that are underutilized in continuing professional development. Participants and planners alike can benefit from learning science recommendations to inform their decisions. The common intervention of the educational meeting provides an opportunity to illustrate the benefits of these three learning-science strategies in continuing professional development.

Keywords: science of learning, learning science, distributed practice, retrieval practice, interleaving, continuing education, continuing professional development, educational meetings

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ABOUT THE SCIENCE OF LEARNING STRATEGY SERIES

Consistent with a 2019 *Journal of Continuing Education in the Health Professions*' editorial by Kitto about informing the continuing professional development (CPD) imagination,¹ the emerging and interdisciplinary field of the science of learning, which concerns itself with how the brain learns and remembers important information, is a compelling but relatively unfamiliar field that stands to inspire CPD participants and planners to think about educational interventions differently. Moreover, the science of learning (learning science) has compiled evidence in support of a set of strategies²⁻⁶ that can help CPD more effectively influence clinician knowledge, skill, attitude, competence, and even performance. The purpose of the series is to bring attention to evidence-based, learning-science strategies and to provide some background that might be helpful to CPD stakeholders considering the strategies. The first three articles in the series introduced three evidence-based, learning strategies: distributed practice,⁷ retrieval practice,⁸ and interleaving.⁹ In this fourth article of the series, the authors demonstrate the application of the series' strategies to a common CPD activity, the educational meeting.

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DESCRIPTION AND EXAMPLES OF STRATEGIES APPLIED TO CPD

This series focuses on three of the most relevant learning-science strategies to CPD, specifically distributed practice, retrieval practice, and interleaving. For more details on these strategies, please see the previous articles.⁷⁻⁹ As a review, *distributed practice* is the repeated study of priority information from a content area with a cognitive break, ideally a full night's sleep, between study or practice sessions. As an example, a nurse practitioner taking a longitudinal course has dedicated 8 hours of study per week toward the course. Instead of the initial plan of studying all day on either Saturday or Sunday, the nurse practitioner decides to divide the time, spending 4 hours on Saturday (with a 5-minute break each hour) and 4 hours on Sunday (with similar breaks). Importantly, to ensure spaced repetition, overlap exists between the priority information studied on both days. *Retrieval practice* involves effortful recall of previously studied or practiced information from long-term memory prior to additional study within a content area. For example, a physician studying for a specialty certification exam purchases access to a question bank that contains items like those on the actual exam. The physician uses the practice questions as a major part of preparation, complementing a set of review guides for directed reading. Finally, *interleaving* is the mixing of previously learned information with current and upcoming information from the same content area. As an example, during each study session, a pharmacist taking a CPD course to meet relicensure requirements spends 15 minutes reviewing practice questions about previously covered material and 15 minutes reading about an upcoming topic before devoting 60 minutes to mastering a current topic. These three strategies are distinct but complementary ways that are effective approaches to mastering and remembering information, be it knowledge, skill, attitude, competence, or behavior.

THE ESSENCE OF EDUCATIONAL MEETINGS

Educational meetings represent an extremely common intervention in the field of CPD. Although many specific names (eg, journal club and tumor board) exist for educational meetings, examples of general terms typically associated with educational meetings include courses, conferences, seminars, symposia, workshops, grand rounds, and, of course, meetings.¹⁰ A published intervention guideline describes an educational meeting as an intervention in which (italics omitted) "...a group of professionals assembles to communicate about important information relevant to patient care as part of a series of meetings and/or as part of a multifaceted intervention."^{10,p.561}

Educational meetings are common. Considering formal continuing medical education (CME) activities alone, two major meeting types, *live courses* (ie, in-person and remote) and *regularly scheduled series* (eg, grand rounds), represent most (52.2%) of the 203,861 educational activities accredited by the Accreditation Council for Continuing Medical Education (ACCME) during 2021, the most recent year for which data are available.¹¹ Moreover, educational meetings are heavily attended. These two types of educational meetings alone accounted for nearly 28% (13,798,612) of participant interactions (ie, number of nonunique participants involved) of all accredited CME activities that same year. But importantly, that percentage rises to nearly 72% if one excludes the category of enduring materials.

While CME activities are often considered specific to physicians and, as such, represent a limited proxy for the interprofessional field of CPD, the number of other professionals (eg, nurse practitioners, pharmacists, and physician assistants) participating in accredited CME activities has grown steadily and significantly every year, except one, between 2005 and 2021.¹¹ For 2021, "other learner interactions" (interactions of professionals other than physicians) represented 42.9% of the interactions within courses and regularly scheduled series. Given the widespread prevalence of educational meetings and their increasingly interprofessional nature, they appear to be an appropriate focus to apply learning-science strategies to inform the CPD imagination. Here, we focus on distributed practice, retrieval practice, and interleaving because they are broadly applicable across content areas and participants, are easy to implement, and can have a significant impact on learning.

EXISTING ALIGNMENT OF EDUCATIONAL MEETINGS WITH LEARNING SCIENCE

Recommendations for educational meetings, in some ways, already align with learning science. The intervention guideline introduced in the last section recommends that educational meetings possess the following characteristics: (1) include didactic and interactive components; (2) offer pre-activities and postactivities; (3) ensure that group communication is robust and three-way, that is, between participants and the expert-facilitator, between participants themselves, and between participants and the content; and (4) establish an agenda and meeting type that appropriately reflect desired outcomes and needs of the target audience.¹⁰ Each of the four characteristics encourages encoding, the first biological step of learning, which involves processing information by developing a solid representation of the information in working memory (see **Appendix, Supplemental Digital Content 1**, <http://links.lww.com/JCEHP/A293>).⁷⁻⁹ Consistent with distributed practice, offering pre- and postactivities (the second characteristic) ideally requires participants to interact with priority information at least three separate times, presumably with one or more days between the interactions (ie, pre-activity, meeting, and post-activity). Still, a more intentional application of all three strategies would strengthen participant learning in educational meetings.

ADDITIONAL RECOMMENDATIONS FROM LEARNING SCIENCE

Despite some consistencies between educational meeting characteristics and learning science (encoding and distributed practice), learning science can offer additional recommendations that might improve the effectiveness of educational meetings as a mechanism for learning (Table 1). To enhance distributed practice within educational meetings, such meetings should involve multiple, brief sessions rather than single, long events and should include follow-up immediately and periodically to check understanding and to reinforce learning.¹²⁻¹⁶ Offering more than one session per topic, especially if the content is novel or complex and to address needs that arise through interactions with participants in addition to needs planners had predetermined by examining patient care data, is also consistent with distributed practice. Regarding retrieval practice, educational meetings should involve some type of pretest (even no-stakes) to engage participants by establishing the

TABLE 1.

Recommendations to Improve Educational Meetings as a Learning Mechanism Grounded in Learning Science-Based Strategies

Strategy	Recommendations
Distributed practice ⁷	<ol style="list-style-type: none"> 1. Offer multiple sessions or activities over time (a longitudinal program) rather than a single event 2. Offer multiple sessions or activities for complex topics and to capture participants' self-identified needs 3. Keep each session or activity relatively brief (1–2 h) 4. Follow-up within a day or two of each session and then periodically thereafter
Retrieval practice ⁸	<ol style="list-style-type: none"> 1. Use a pretest to engage participants in the topic, ideally involving recall (short answer and essay) rather than recognition-style questions 2. Ask questions about important information during each session to check understanding and include open-ended items that encourage participants to convey self-identified needs 3. Follow-up with a posttest, preferably using recall questions that require explanations and justifications
Interleaving ⁹	<ol style="list-style-type: none"> 1. Include follow-up on prior learning and discuss barriers to application 2. Introduce new information with explicit ties to previously learned information 3. Involve participants in planning upcoming topics, including consideration of participants' own needs

relevance of important information, and educational meetings should include questions during, and in follow-up to, each session, including open-ended items that encourage participants to convey self-identified needs that might inform future sessions.^{14–18} Questions that require the use of language (short answer and essay) to explain are generally superior to those that require only recognition (multiple choice), as open-ended questions tend to require more effort.¹⁷ Discussing some previously learned material in each session, perhaps asking about barriers to implementation, will leverage the benefits of interleaving, especially if previously learned material has links to the current session and if the session involves some planning of future meetings that participants can inform by way of their own needs.^{15,16,18,19}

To complement these recommendations relevant to all educational meetings, we provide specific comments about three common CPD meetings, that is, the one-day conference, the multiday conference, and the regularly scheduled series. The one-day conference would most benefit from learning-science strategies, as such a format is a single event confined to one block of time. As such, a 1-day conference would certainly benefit from pre- and postactivities, ideally interleaved with other educational activities during the conference itself, thus ensuring distributed practice and interleaving. In addition, adding a pretest or posttest would achieve some degree of retrieval practice to improve this meeting type. Turning to the multiday conference, it has the prospect of distributed practice if some meaningful repetition of priority information is planned, ideally across separate days of the meeting. Similarly, interleaving is also possible if the multiday conference requires activities that involve making connections between topics addressed across the conference's offerings. Retrieval practice could be one way to accomplish interleaving by having participants explicitly consider the connections between topics. Finally, the regularly scheduled series is perhaps best positioned to apply these learning-science strategies, but only if some repetition of priority information occurs across its sessions, ideally using pretests and posttests or similarly reflective activities, which would also achieve some level of interleaving of content. An explicit meeting agenda that involves evaluation (with feedback) of prior sessions and planning of future ones would be consistent with all three strategies.

Most consistent with a multiday conference, a nice example of an attempt to introduce distributed practice into a typical CPD approach accomplished this goal while also incorporating retrieval practice and interleaving into the course, although not named explicitly.²⁰ The prospective study involved mastery of minimally invasive surgery skills, transforming a typical short-term (2–3 day) intensive course, what the authors describe as “massive practice,” into a 3-session longitudinal experience, termed “distributed practice.” The training sessions were four months apart, and each involved classroom instruction and simulation practice. During each session, participating surgeons received identical training on priority skills. In addition to being distributed, the course included retrieval practice by way of a pretest during the first session and a re-evaluation (repeat testing) of the same skills in the two subsequent sessions. Moreover, the course included interleaving in that in each of the three sessions, participating surgeons worked on five distinct but complementary skills (eg, cutting and suturing) fundamental to minimally invasive surgery. This study demonstrates how learning science can transform a traditional CPD activity into one that is both feasible and effective.

RECOMMENDATIONS FOR CPD PARTICIPANTS AND PLANNERS

These three learning-science strategies can be used alone and in combination in a variety of ways. In this section, the authors provide recommendations to serve as examples for participants and planners.

What can CPD participants do to improve their learning through educational meetings?

CPD *participants* should select a longitudinal meeting series over a single meeting event, or if single events are desirable for other reasons (eg, networking and convenience), participants should augment a single session with preactivities and postactivities (including opportunities to reflect on and share needs), separated by one or more days to take advantage of the benefits of distributed practice. Consistent with retrieval practice, participants should take advantage of pretests (or find questions themselves if not offered) to prepare themselves for learning by determining relative strengths and weaknesses for the information, sharing such determinations with CPD planners. Even informal conversations with colleagues about performance data and challenging cases can create cognitive dissonance about the relevance of particular content. Identifying questions to ask during meetings (eg, during Q&A sessions) or following up with questions, can extend mastery and memory. Taking advantage of posttests, particularly of the recall variety, which tend to be more effortful than recognition questions, can reinforce and extend learning. Engaging in preactivities, the meetings themselves, and postactivities creates opportunities to interleave information. Interleaving increases the likelihood that participants will make connections and develop a coherent sense of related information. Also consistent with interleaving is reflecting on what has been learned at meetings and how that information relates to current and upcoming educational opportunities. Even if sessions address seemingly independent topics (eg, some grand rounds programs), participants can reflect on the ways in which topics have underlying conceptual relationships to patient care.

What can CPD planners do to improve educational meetings using learning-science strategies?

CPD *planners* can gravitate toward offering programs spaced over time,²¹ whether that means developing a regularly scheduled series over a single live session or creating meaningful preactivities and postactivities associated with single events. Mixing in-person and virtual formats is a common way to accomplish some degree of distributed practice. Integrating questions (retrieval practice) into activities is an effective way to promote learning, particularly if such tests are in the service of learning and if participants receive feedback and guidance on their answers.^{2,22} Including open-ended items that encourage participants to reflect on and share self-identified needs complements patient care data that planners may have and can inform activities to increase relevance for participants. Planners can distribute questions in advance of a meeting to leverage distributed practice and retrieval practice. For example, asking questions in advance of sessions can be a part of a needs assessment, which can prioritize meeting content and prepare participants to learn while simultaneously meeting an accreditation requirement. Likewise, posttests can be part of meeting evaluations, satisfying another accreditation requirement for such while reinforcing information learned. Regarding interleaving, through unfolding cases and similar exercises, planners can help participants to make connections between what they know

(discussing needs assessment results), what they are learning (during meeting time), and what they still need to learn (sharing evaluation results and how participants' self-identified needs have informed ongoing activities). Finally, the voluntary nature of CPD makes it such that learning science will only have value if it is embraced by planners and participants alike, so explanations of the rationale for educational decisions is important for planners to offer. As part of an explicit meeting agenda, having regular conversations with participants about learning science and evidence-based strategies can generate buy-in for new ways of approaching CPD and can facilitate the use of effective learning strategies by participants in the future.²¹

CONCLUSION

The science of learning offers a variety of evidence-based strategies to improve learning within CPD activities. Three strategies in particular, distributed practice, retrieval practice, and interleaving, are relevant to CPD and offer improvement ideas to participants and planners of one of the most common interventions, the educational meeting. Distributed practice can improve educational meetings by ensuring that they are longitudinal in nature with brief activities spaced over time to allow participants numerous opportunities (before, during, and after) to process priority information. Through pretests, posttests, and questions during sessions, retrieval practice can improve educational meetings by encouraging participants to access what they have stored in long-term memory before using that information again in another learning activity. Finally, interleaving can improve educational meetings by encouraging participants to reconcile what they know with what they are learning and what they are preparing to learn in a series. Learning science can inform the imagination of CPD participants and planners alike and thus improve educational meetings and other CPD interventions as vehicles to enhance knowledge, skills, attitudes, competence, and performance.

Lessons for Practice

- Through preactivities, multiple sessions, and postactivities, distributed practice can improve educational meetings by giving participants numerous opportunities to consider priority information and to process it during cognitive breaks between learning activities.
- Through pretests, session questions, and posttests, retrieval practice can improve educational meetings by encouraging participants to examine what they have stored in long-term memory before working with priority information again in a new activity.
- By reconciling what participants already know with what they are learning and preparing to learn, interleaving can improve educational meetings by helping participants to develop a coherent understanding of a topic or subject.

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REFERENCES

1. Kitto S. Opening up the CPD imagination. *J Contin Educ Health Prof.* 2019;39:159–160.
2. Green ML, Moeller JJ, Spak JM. Test-enhanced learning in health professions education: a systematic review: BEME Guide No. 48. *Med Teach.* 2018;40:337–350.
3. Phillips JL, Heneka N, Bhattarai P, et al. Effectiveness of the spaced education pedagogy for clinicians' continuing professional development: a systematic review. *Med Educ.* 2019;53:886–902.
4. Van Hoof TJ, Doyle TJ. Learning science as a potential new source of understanding and improvement for continuing education and continuing professional development. *Med Teach.* 2018;40:880–885.
5. Weinstein Y, Madan CR, Sumeracki MA. Teaching the science of learning. *Cogn Res Princ Implic.* 2018;3:2–17.
6. Dunlosky J, Rawson KA, Marsh EJ, et al. Improving students' learning with effective learning techniques: promising directions from cognitive and educational psychology. *Psychol Sci Public Interest* 2013;14:4–58.
7. Van Hoof TJ, Sumeracki MA, Madan CR. Science of learning strategy series: article 1, distributed practice. *J Contin Educ Health Prof.* 2021;41:59–62.
8. Van Hoof TJ, Madan CR, Sumeracki MA. Science of learning strategy series: article 2, retrieval practice. *J Contin Educ Health Prof.* 2021;41:119–123.
9. Van Hoof TJ, Sumeracki MA, Madan CR. Science of learning strategy series: article 3, interleaving. *J Contin Educ Health Prof.* 2022;42:265–268.
10. Van Hoof TJ, Grant R, Sajdlowska J, et al. Society for Academic continuing medical education intervention guideline series: guideline 3, educational meetings. *J Contin Educ Health Prof.* 2015;35(suppl 2):S60–S64.
11. Accreditation Council for Continuing Medical Education. *ACCME Data Report: Onward and Upward: Thriving Together in Accredited Continuing Education – 2021*. Chicago, IL; 2022. Available at: <https://www.accme.org/2021-data-report>. Accessed 30 January, 2023.
12. Moulton CAE, Dubrowski A, MacRae H, et al. Teaching surgical skills: what kind of practice makes perfect? A randomized, controlled trial. *Ann Surg.* 2006;244:400–409.
13. Benjamin AS, Tullis J. What makes distributed practice effective? *Cogn Psychol.* 2010;61:228–247.
14. Doyle T, Zakrajsek T. *The New Science of Learning: How to Learn in Harmony with Your Brain*. Sterling, VA: Stylus Publishing; 2013.
15. Carey B. *How We Learn: The Surprising Truth About When, Where, and Why it Happens*. New York, NY: Random House; 2014.
16. Oakley B. *A Mind for Numbers: How to Excel at Math and Science (Even if You Flunked Algebra)*. New York, NY: Jeremy P. Tarcher/Penguin; 2014.
17. Leamson R. *Thinking about Teaching and Learning: Developing Habits of Learning with First Year College and University of Students*. Sterling, VA: Stylus; 1999.
18. Brown PC, Roediger HLIII, McDaniel MA. *Make it Stick: The Science of Successful Learning*. Cambridge, MA: Belknap Press of Harvard University Press; 2014.
19. Carpenter SK, Cepeda NJ, Rohrer D, et al. Using spacing to enhance diverse forms of learning: review of recent research and implications for instruction. *Educ Psychol Rev.* 2012;24:369–378.
20. Nakata BN, Cavalini W, Bonin EA, et al. Impact of continuous training through distributed practice for acquisition of minimally invasive surgical skills. *Surg Endosc.* 2017;31:4051–4057.
21. Van Hoof TJ, Monson RJ, Majdalany GT, et al. Improving medical grand rounds: recommendations. *Conn Med.* 2009;73:601–607.
22. Roediger HL, Karpicke JD. The power of testing memory: basic research and implications for educational practice. *Perspect Psychol Sci.* 2006;1:181–210.