

Science of Learning Strategy Series: Article 6, Elaboration

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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 separate but associated information (interleaving) represent strategies that are underutilized in continuing professional development. Participants and planners alike can benefit from learning science recommendations to inform their decisions. Elaboration, the subject of this article, is another evidence-based strategy that relates to how one studies or practices priority information.

Keywords science of learning, learning science, elaboration, continuing education, continuing professional development

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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, skills, attitudes, 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 and related information. The first three series' articles focused on the strategies of distributed practice, retrieval practice, and interleaving.⁷⁻⁹ In the fourth article, the authors demonstrated the application of the series' strategies to a common CPD activity, the educational meeting.¹⁰ In the fifth article, the authors addressed the importance of sleep to learning and memory in CPD.¹¹ In this sixth article, the authors introduce another learning strategy, elaboration, which relates to *how* one studies or practices priority information.

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THE ESSENCE OF ELABORATION

The essence of elaboration is making associations between concepts (eg, principles, procedures, skills, and attitudes) one is trying to learn and other known concepts.^{5,6} The idea is that making connections creates a rich associative network that aids in understanding, promotes organization among related concepts, and increases the likelihood that the information will be remembered later.

To understand elaboration, it is helpful to distinguish between two memory systems, both of which are important to learning.¹²⁻¹⁴ When we learn new concepts, they initially are stored in *episodic memory*. This memory system supports how we remember recent events. After successive memory retrieval attempts across time, knowledge for concepts is transferred to a second memory system, *semantic memory*, which provides organization and structure for fact-based knowledge. One can view elaboration as a strategy where new information is remembered better by deliberately activating existing semantic knowledge for related concepts. Developing rich associative networks can promote understanding of how concepts are similar to or different from one another, both of which are important for remembering and applying what has been learned.¹⁵

CLASSIC RESEARCH UNDERLYING ELABORATION

Within the cognitive psychology literature, elaboration is one of the most frequently discussed concepts. According to Anderson, “one of the most potent manipulations that can be performed in terms of increasing a subject’s memory for material is to have the subject elaborate on the to-be-remembered material.”^{16p285} Although elaboration was discussed—both explicitly and implicitly within the paired-associate learning literature—in the decades prior, the seminal levels-of-processing article by Craik and Lockhart¹⁷ and Craik and Tulving¹⁸ dramatically increased theorizing and empirical investigation of elaboration. The levels-of-processing framework posits that when information is processed at deeper levels, it is remembered better.¹⁷⁻¹⁹ In the classic levels-of-processing procedure, participants are given a list of words and prompted to process each word at varying levels or “depths.”¹⁸ Shallow processing involved processing only the surface details of the words. For example, participants might see “BEAR” and a prompt to indicate whether the word is presented in capital letters (yes or no). The deepest level of processing involved thinking about the meaning of the word (ie, semantics). For example, participants might see “BEAR” and a prompt to indicate whether the word is a living thing (yes or no). In the original article empirically testing the levels-of-processing framework, Craik and Tulving found that deep, semantic processing led to superior memory performance,¹⁸ and pointed to elaboration as the mechanism through which memory was improved. Deeper processing was thought to activate a broader network of semantic knowledge, leading to an enriched or more elaborate memory for the information.

Elaboration has also been investigated as a strategy to improve learning and memory of information more complex than basic word lists. One specific way elaboration has been applied to more meaningful learning is through elaborative interrogation. Learners are prompted to ask “how” and “why” questions and then to provide answers to their questions. The purpose of the procedure is to prompt learners to generate detailed explanations, promoting the development of associations among the new information and what the learner already knows, but also allowing the learner to discriminate among concepts.⁶ In other words, elaborative interrogation is thought to promote learning of similarities and differences, leading to greater understanding and discrimination. In one example, Woloshyn and Stockley²⁰ had grades 6 and 7 students learn facts that were either consistent or inconsistent with prior semantic knowledge (eg, a surprising fact, such as “the sun is made up of every color, including blue and violet”). Some students used elaborative interrogation to learn the facts, explaining why the facts were true. Other students used whatever learning strategy they wanted. Yet others read the facts aloud. The students took a test immediately after learning and 60 days later. Overall, those who engaged in elaborative interrogation remembered more of the information than those in the other two groups, both immediately and after 60 days. Importantly, this was true whether the facts were consistent or inconsistent with prior knowledge. One caveat was that the quality of the explanations generated in the elaborative interrogation condition mattered. When the explanations generated were poor, the advantage of elaborative interrogation was much smaller. Other research in this area has shown that

elaborative interrogation can still benefit individuals with lower prior knowledge compared with simple reading,²¹ but if the quality of elaborative interrogations is particularly poor, it can reduce the benefit of elaborative interrogation or even reverse it.²²

In another example, Woloshyn and colleagues²¹ had participants from Canada and West Germany learn facts about Canadian provinces and West Germany states. Thus, participants had high prior knowledge for some facts and lower prior knowledge for other facts. Some participants engaged in elaborative interrogation and were asked to rationalize why the facts were true. Some participants were asked to read the facts to understand them. Some participants—those in the no-exposure control condition—were not exposed to the facts. A test was given immediately after learning the facts. When prior knowledge was higher (Canadians learning Canadian facts; West Germans learning West Germany facts), performance was higher than when prior knowledge was lower (Canadians learning West Germany facts, and the opposite). Importantly, elaborative interrogation led to greater performance on the test than reading to understand, both when prior knowledge was high and when prior knowledge was low.

NEUROSCIENCE UNDERPINNINGS OF ELABORATION

Memory for new information and events, episodic memory, and memory for facts, semantic memory rely on overlapping, yet separable, sets of brain regions.²³⁻²⁵ Episodic memory relies on patterns of activity linking the hippocampus and surrounding regions of the medial temporal lobe to regions of the frontal lobe. The specifically relevant regions of the frontal lobe systematically vary with the type of to-be-remembered content, for example, words, scenes, or faces. Semantic memory typically involves regions of the medial temporal lobe (though not necessarily the hippocampus), frontal lobe regions, and a region within the lateral parietal cortex, the angular gyrus.

In studies of elaboration using the levels-of-processing framework, deeper (more semantic) processing was associated with brain activation in the angular gyrus.^{26,27} More generally, studies varying the activation of semantic information retrieved within an episodic memory procedure demonstrate similar patterns of brain activity.^{28,29} Although many fMRI studies have investigated elaboration, none has specifically used elaborative interrogation.

EXAMPLES OF CPD STUDIES INVOLVING ELABORATION

Although not by name, elaboration is likely happening in some CPD activities already. As one example of a CPD study that is strongly suggestive of elaboration, staff of a quality improvement organization made educational outreach visits to primary care providers and staff of 98 offices for 16 months to promote the use of quality improvement (QI) tools, such as performance reports based on claims data, clinician and patient education materials and reminders, and chart documentation and communication tools, to improve preventive and chronic care of Medicare beneficiaries.³⁰ Educational outreach involves trained professionals making structured visits to clinicians in their workplaces to provide information in support of behavior change.^{31,32}

Although the quality improvement organization outreach workers in this descriptive study experienced some barriers accessing clinicians and staff, the educational outreach visits themselves presented opportunities for discussion about barriers to, and facilitators of, QI tool implementation. Such discussions, particularly when repeated, are consistent with elaboration, as clinicians and staff are making associations between the evidence-based processes of care in need of improvement (the clinical content) and the implementation efforts through which improvement is most effective (the QI process).

In a second example, researchers reported on the evaluation of a multicomponent QI project to improve diabetes care in privately owned primary care practices that served a significant percentage of minority patients.³³ The QI project offered clinician-participants the opportunity to earn continuing medical education credits. Although some elaboration might have resulted from exposure to a variety of sequenced interventions (eg, electronic patient registry training, cultural competency practices and tools education, and selected QI strategies), the incentive of CPD credits through the American Medical Association's (AMA's) performance improvement continuing medical education (PI CME) format requires participating clinicians to document information associated with three distinct phases of PI CME, that is, assessment, implementation, and evaluation.^{34,35} During documentation of the evaluation phase, for example, clinicians must reflect on clinical content and process improvement. Reconciling content with process represents an elaborative activity.

As a third CPD example of elaboration, researchers seeking to improve prescribing behavior among primary care clinicians treating children with urinary tract infections used a commitment to change strategy as part of a multifaceted educational intervention that included a case-based presentation and emailed content and questions, which complemented a guideline release and the availability of condition-specific order sets.³⁶ After an educational activity, commitment to change is an evidence-based strategy that involves asking participants about their intention to change their practice in a specific way and at a specified number of weeks or months later to determine success with the commitment and any barriers to change.³⁷ The study compared two different commitment to change approaches (closed and open ended) to determine the impact of the collective intervention on prescribing behavior for 17 months. Commitment to change involves elaboration in that the strategy required clinicians to reconcile the new prescribing content with the familiar context in which clinicians are providing care.

RECOMMENDATIONS FOR CPD PARTICIPANTS AND PLANNERS

What Can CPD Participants Do to Leverage the Benefits of Elaboration?

For CPD *participants* considering educational options to make significant improvements in knowledge, skills, attitudes, and other important outcomes, selecting an educational activity that typically involves deep processing (eg, with questions such as, "How might this updated guideline affect people with different but common comorbidities?") is superior to an activity that generally involves superficial consideration (eg, with questions such as, "What are the guideline updates?"). Activities that involve discussion, particularly with challenging questions (eg, From the standpoint of basic science, why might long-term results be different for these two treat-

ments?), are more likely to involve elaboration. Unfolding case discussions, QI initiatives, and educational outreach visits are more likely to provide elaborative educational opportunities. Elaboration forces the brain to encode information more deeply (manipulate information in working memory), which, in turn, increases the likelihood of consolidation (store information in long-term memory), and if repeated, as in a longitudinal activity, with retrieval (ie, access information currently stored in long-term memory for additional consideration in working memory) (see **Appendix, Supplemental Digital Content 1**, <http://links.lww.com/JCONTINEDUCHEALTHPROF/A294>, for more details about encoding, consolidation, and retrieval).⁷⁻¹¹ If educational activities available to participants do not predictably involve elaboration, participants can improve the activities by supplementing them with other efforts, such as generating how and why questions and responses with a colleague and posing such questions during questions and answer periods. Practice tests might also support elaboration, particularly if they involve open-ended questions that require explanations and for which feedback and explanations are available.

What can CPD Planners Do to Leverage the Benefits of Elaboration?

CPD *planners* can enhance the educational value of educational activities by providing participants with opportunities (eg, unfolding case discussions) to deeply process priority information, ideally through longitudinal programs that involve some meaningful repetition, spacing, and reflection. With elaboration in mind, discussions that necessarily involve how and why questions, and that strive to generate individual and group understanding of the meaning of information given what is already known about clinical care are likely to be elaborative. Even a single event can become elaborative through carefully timed and communicated pre- and postactivities. Sequencing a longitudinal activity is a strategy that might allow for integration of elaboration, transforming a traditional educational meeting (eg, grand rounds) into a more effective activity.³⁸ Finally, some explanation about elaboration, that is, the strategy's rationale and evidence, may be helpful to participants, including the goal of generating a semantic memory for the content rather than just an episodic one.

CONCLUSION

Elaboration is a learning-science strategy that increases the likelihood that a learner will deeply process important information, developing rich associations between what is new and what is already known. Essentially, elaboration helps turn event-based or episodic memories into fact-based or semantic ones, which are easier to access later given that semantic memories are better organized and more stable in long-term memory. Cognitive science research in support of elaboration dates back decades, and while more recent, neuroscience has begun to offer biologic explanations that explain the strategy's effectiveness. CPD participants should seek educational activities that provide them with opportunities for multiple, detailed discussions, gravitating toward longitudinal programs that involve how and why questions that support integration of new with existing knowledge. CPD participants can supplement nonelaborative activities with actions that involve elaboration, such as preparing questions and answers in advance and taking advantage of practice tests with open-ended questions that

provide answers and explanations. CPD planners should design activities, ideally longitudinal, that protect time for deep discussions, such as through unfolding cases with complementary, thought-provoking pre- and postactivities. Explaining the rationale and evidence behind elaboration will likely increase enthusiasm for more participation in learning. Learning science can inform the imagination of CPD participants and planners alike, and elaboration is yet another vehicle to enhance knowledge, skills, attitudes, competence, and performance.

Lessons for Practice

- Elaboration is an evidence-based strategy that supports learning and memory by helping participants develop rich associations between what they are learning and what they already know, promoting organization of and access to the information.
- Elaboration requires CPD participants to deeply process information, translating learning episodes (episodic memories) into fact-based episodes (semantic memories), which are better organized and more accessible.
- CPD planners should provide explanations about the strategies that inform their educational offerings, and planners should use formats (eg, unfolding case discussions with how and why questions) that are likely to require elaboration.

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