

PERSPECTIVE

How to Keep Training—After Residency Training

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Lifelong learning in medicine is an important skill and ethical obligation, but many residents do not feel prepared to be effective self-directed learners when training ends. The learning sciences offer evidence to guide self-directed learning, but these insights have not been integrated into a practical and actionable plan for residents to improve their clinical knowledge and reasoning. We encourage residents to establish a self-directed learning plan, just as an athlete employs a training plan in the pursuit of excellence. We highlight four evidence-based learning principles (spaced practice, mixed practice, retrieval practice, and feedback) and four training strategies comprising a weekly training plan: case tracking, simulated cases, quizzing, and new evidence integration. We provide tips for residents to implement and refine their approach and discuss how residency programs can foster these routines and habits. By optimizing their scarce self-directed learning time with a training plan, residents may enhance patient care and their career satisfaction through their pursuit of clinical mastery.

KEY WORDS: Self-directed learning; Lifelong learning; Learning sciences; Medical education; Clinical expertise.

J Gen Intern Med 37(6):1524–8

DOI: 10.1007/s11606-021-07240-3

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INTRODUCTION

Lifelong learning is a regulatory requirement (ACGME practice-based learning and improvement) and an essential habit to transform clinical experience into clinical expertise, but many graduating residents do not feel prepared to direct their own learning when independent practice begins.¹ Insights from the learning sciences² have not been translated into specific practices to help residents optimize their scarce self-directed learning time and establish routines that extend beyond residency.

A resident's commitment to a self-directed learning plan parallels an athlete who follows a training routine in the pursuit of excellence. Unlike most professional athletes, however, a resident must also learn to be her own coach and select activities that improve performance. To prepare the self-directed resident for these dual roles, we first highlight evidence-based learning principles. We then recommend

specific strategies that can be integrated into a weekly training plan which residents can adopt and continue during fellowship or independent practice.

We focus our advice on the development of a resident's clinical knowledge and decision-making. However, these same principles can be applied to enhance other skills relevant to clinical mastery: communication, teamwork, and health and social system navigation. The development and execution of a training plan is more than an intellectual pursuit. This commitment to lifelong learning can support other clinical practice goals, including medical error reduction and the provision of high-value care.

LEARNING SCIENCE PRINCIPLES

A self-directed learning plan to enhance clinical knowledge and reasoning should accelerate the development of mental models that guide diagnosis and management decisions. An illness script is a mental representation of a disease that encapsulates the epidemiology, pathophysiology, and clinical features of that condition (e.g., post-streptococcal glomerulonephritis).³ A schema is a systematic approach to analyze a defined clinical problem (e.g., acute kidney injury) that provides a framework (e.g., pre-renal, intra-renal, and post-renal) to categorize relevant illness scripts.^{4,5} Although the script and schema concepts have been utilized widely to characterize diagnostic decision-making, recent work has also emphasized the role of these knowledge structures in guiding management reasoning.^{6–9}

Scripts and schemas reside in long-term memory, guide the selection and analysis of data in a patient encounter, drive clinical decisions, and continuously evolve as they are repeatedly accessed and utilized.^{9,10} The goal of a self-directed learning plan is to develop these mental models in concert with experience from diagnostic and management decisions in patient care activities. Four principles from the learning sciences, a multidisciplinary field that examines strategies for building and maintaining knowledge in long-term memory, can inform the activities in a self-directed training plan: spaced practice, mixed practice, retrieval practice, and feedback.

Learning is more durable when it is separated over time (spaced practice) instead of concentrated in one session (massed practice).¹¹ A trial involving instruction of a new surgical skill (microvascular anastomosis) randomized

Received May 24, 2021

Accepted October 20, 2021

Published online February 28, 2022

resident physicians to a single 3-hour (massed) or three 1-hour (spaced) practice sessions, and the latter group demonstrated superior long-term knowledge retention and technical outcomes.¹² Spacing is underutilized because its efficacy is counterintuitive. In massed practice, rapid gains at the end of a single session are apparent to the learner, but the forgetting that follows goes unnoticed. In spaced practice, the forgetting between sessions is apparent when the brain is rechallenged with the same topic. The extra effort expended to *relearn* a forgotten concept is essential to consolidating knowledge.¹³

Mixed practice is the purposeful intermingling of two or more related subjects, skills, or problem types in a practice session. Mixed practice is distinguished from blocked practice, in which a single problem type is clustered.¹³ A study of college baseball players demonstrated that players exposed to blocked batting practice (a sequence of 15 fastballs, 15 curveballs, and 15 changeups) had less improvement than players exposed to mixed practice (45 randomly selected pitches) on measures of hitting skill 6 weeks later.¹⁴ In a study which randomly assigned medical students to blocked practice (e.g., a set of ECGs with myocardial ischemia followed by a set of ECGs with pericarditis) or mixed practice (ECGs of all diagnoses interweaved), the mixed practice group more accurately diagnosed subsequent novel ECGs.¹⁵ (In a similar study of early medical students where mixed practice did not lead to improved ECG diagnostic accuracy, the investigators suggested that basic competence in a subject may be important for mixed practice to be effective).¹⁶ Blocked learning circumvents the challenge of discriminating problem type (e.g., identifying the type of pitch that is thrown). However, determining the nature of a problem (e.g., is this myocardial ischemia or pericarditis?) is a fundamental skill in medicine. Blocked practice can produce impressive short-term knowledge gains (e.g., “cramming” to pass an exam), but mixed practice leads to superior long-term knowledge.¹³

Retrieval practice, deliberately designed activities which challenge the learner to recall information (e.g., quizzing), leads to enhanced knowledge compared to passive re-exposure to information (e.g., re-reading).¹⁷ Medical students¹⁸ and residents¹⁹ randomized to repeated testing of knowledge instead of repeated self-study demonstrated improved retention of course material 6 months later. Retrieval attempts that are more cognitively effortful (e.g., answering open-ended as opposed to multiple-choice questions) may also lead to better long-term retention of complex information.²⁰ Learners may gravitate towards re-exposure (e.g., re-reading a book chapter) because familiarity with the information is comforting. However, familiarity is easily mistaken for true understanding. Retrieval practice reveals forgotten information, allowing the learner to focus their *relearning* accordingly.

Feedback is an essential element of learning. Experts across a wide range of fields utilize feedback in their practice methods to help close the gap between actual and goal performance.^{21,22} Medical students²³, residents²⁴, and attending

physicians²⁵ all engage in tracking of patient outcomes to enhance their learning. However, efficiently obtaining and learning from feedback is challenging without an effective health information technology system and a coach who can guide reflection and recalibration.

CORE TRAINING STRATEGIES

Just as an athlete’s coach sets a training plan with essential exercise routines, residents can design their own training program. We suggest three training strategies, informed by the learning sciences, that should comprise a self-directed learning plan: case tracking, simulated cases, and quizzing.

Case tracking is the systematic follow-up of patient outcomes. Just as athletes study their “game tape,” master clinicians regularly identify and reinforce learning points from their clinical experiences.^{26,27} Optimal case tracking begins with a specific question (e.g., “will the pleural fluid cytology be positive for malignancy?”) recorded in a log so the anticipated and ultimate outcome can be compared and a learning point discerned.²⁸ Learners should prioritize tracking common issues (e.g., sore throat, erythematous leg) where recalibration will have the greatest long-term impact. It is also important that residents track situations where they feel confident so that strongly held but ultimately inaccurate projections can inform future forecasts. Reviewing the “game tape” of a clinical decision uses both spaced learning and feedback to transform experience into expertise.

Experience with varied clinical situations is a foundation of clinical expertise.²⁶ Simulated cases allow residents to increase their cognitive workload without increasing their clinical workload. Simulated cases are featured in medical journals, apps, podcasts, videos, and social media platforms (Table 1). Although published cases do not unfold according to the reader’s decisions, learners can approximate real-world practice by pausing periodically to commit to a differential diagnosis or management plan before reviewing the expert discussion and decisions.^{29,30} Continuous engagement with multiple sources of simulated cases, which feature unannounced and heterogeneous clinical challenges, typifies mixed practice.

Quizzing is a deliberate method of testing understanding. Structured quizzing is available through journals, apps, and questions banks (Table 1). A learner can also design her own quizzes (e.g., using a digital flashcard program³¹) to reinforce knowledge from a simulated case or from questions that arise during patient care.³² Learning opportunities at the point of care are often lost to the time pressures of clinical medicine.³³ A resident who develops a system to capture lessons in real time (e.g., by making notes on a smartphone during rounds) can quiz herself on these insights during subsequent self-directed learning time. Retrieval practice through deliberately designed quizzing reveals knowledge gaps and installs information in long-term memory through reinforcement.

Table 1 Training Resources

| Training strategy | Representative resources |
|--------------------------|--|
| Simulated cases | <ul style="list-style-type: none"> • <i>Journals</i>: Journal of General Internal Medicine Exercises in Clinical Reasoning, New England Journal of Medicine (NEJM) Interactive Medical Cases, Journal of Hospital Medicine Clinical Care Conundrums, and NEJM Case Records of the Massachusetts General Hospital • <i>Apps</i>: Human Diagnosis Project • <i>Podcasts</i>: Clinical Problem Solvers |
| Quizzing | <ul style="list-style-type: none"> • <i>Learner-created flashcards</i>: paper or digital (e.g. Anki) • <i>Question banks</i>: MKSAP • <i>Journals</i>: JAMA Network Clinical Challenge, NEJM Image Challenge • <i>Apps</i>: Figure 1 |
| New evidence integration | <ul style="list-style-type: none"> • <i>Literature aggregators</i>: ACP Journal Club, ACP Journal Wise, NEJM Journal Watch, ACCESSSS • <i>Journal podcasts</i>: NEJM This Week, JAMA Editors' Summary, Annals of Internal Medicine Podcast, American Family Physician Podcast • <i>Twitter</i>: tweetorials, journal clubs, visual abstracts |

These three strategies—case tracking, simulated cases, and quizzing—are informed by learning theory and are problem-based. A final training strategy—new evidence integration—addresses the imperative that a learner upgrade her mental models by incorporating emerging medical knowledge into practice. An individual clinician cannot stay abreast of all new studies in a field³⁴, and exclusive reading of primary literature is not an efficient strategy to make changes to clinical practice.³⁵ Instead, residents should develop a system of interacting with the secondary literature, which scans and summarizes important studies.³⁶ Journal summary programs are a convenient, high-yield resource to maintain awareness of new research (Table 1). Social media platforms, such as Twitter, can connect residents to medical communities that disseminate infographics or contextualize studies through digital journal clubs. Medical podcasts discuss important studies in a medium that learners can integrate with other daily activities (e.g., commuting or exercising).

IMPLEMENTATION CONSIDERATIONS FOR THE LEARNER

Just as an athlete consolidates the most effective training methods into a series of workouts, learners can map core

training strategies in a weekly plan (Table 2) that fits with their clinical and personal duties.

Short and frequent sessions capitalize on learning science principles (i.e., spaced and mixed practice throughout the week instead of massed or blocked practice on one day). Planning a specific time and location increases the likelihood of executing a training session.³⁷ Exploiting a pre-existing routine as a cue to begin a session (e.g., riding the bus to work) can help solidify these activities into self-sustaining habits.³⁸

Picking only 1 or 2 training strategies at the outset may increase the chance of successful completion, particularly if the behavior can be captured as a SMART goal (i.e., specific, measurable, achievable, relevant, and bound to the weekly timeline).³⁹ An example SMART goal for case tracking could be “I will add 2 new cases and review 2 previous cases in my case log every week.”

At the conclusion of the week, the learner can step into the role of coach to reflect on progress. The learner should review updated scripts and schemas and perform an honest appraisal of setbacks (with self-compassion if goals are not fully realized). The weekly reflection should finish with a modification of the training plan based on the upcoming week's activities and schedule. Planning for realistic—not aspirational—training time is required to maintain week-to-week consistency and establish a habit.

Table 2 A Sample Self-Directed Learning Plan. (MKSAP Medical Knowledge Self-Assessment Program, ACP American College of Physicians, NEJM New England Journal of Medicine)

| Training strategy | Weekly SMART goal | Target time per week | Result |
|--------------------------|--|----------------------|------------------|
| Case tracking | Add 2 new cases, review 2 old cases | 20 min | Completed |
| Simulated cases | 1 Human Diagnosis Project case | 10 min | Completed |
| Quizzing | 3 MKSAP questions | 10 min | Did not complete |
| New evidence integration | Review weekly NEJM Journal Watch email | 10 min | Completed |

Learning goal: To build general internal medicine knowledge and clinical reasoning skills

Schedule: 10 minutes each weekday morning before clinic starts (plus a 5 minute reflection on Friday morning).

Total time target per week: 55 minutes

Friday Reflection: I did not complete the MKSAP questions. I think the major obstacle for completing these is access to a computer. Next week, I will download the phone application so that I can do the questions anywhere.

IMPLEMENTATION CONSIDERATIONS FOR RESIDENCY PROGRAMS

Although self-directed training is an individualized pursuit, residency programs and faculty are strong sociocultural influence on the formation and optimization of learning plans.⁴⁰ Programs can set an expectation that residents develop learning plans with peer and faculty coaching. For example, as interns develop their plans, senior residents can share their preferred learning resources. Programs where attendings and residents provide feedback to nighttime admitting residents^{41,42} or where faculty review long-term patient outcomes with residents²⁴ can establish a culture of case tracking. Residency programs can designate faculty learning coaches who model and develop self-directed learning plans, guide reflections, advise on the selection of high-quality case simulation and medical literature resources, and assure the establishment of a habit by the end of residency.

CONCLUSION

Lifelong learning is an essential skill and an ethical obligation of the physician. Before residents enter independent practice, we suggest they establish a training program grounded in the learning sciences that is strategically mapped into their limited discretionary time. A self-sustaining learning plan aligns with intrinsic motivators at work including autonomy (self-direction), purpose (connection to a higher goal), and mastery (getting better at a craft).⁴³ Our recommendations are evidence-informed but not field-tested. We hope the articulation of self-directed learning plans can lead to their study, critique, and refinement to ensure they realize the promise of improving the experience of medicine for physicians and patients alike.

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Declarations: None

Conflict of Interest: Dr. Krimmel-Morrison is a contributor for *Practical Reviews*, for which he receives a fee for writing summaries of internal medicine research articles.

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