Developing the Master Learner: Applying Learning Theory to the Learner, the Teacher, and the Learning Environment

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Abstract

As a result of the paradigm shift to a competency-based framework, both self-directed lifelong learning and learner-centeredness have become essential tenets of medical education. In the competency-based framework, learners drive their own educational process, and both learners and teachers share the responsibility for the path and content of learning. This learner-centered emphasis requires each physician to develop and maintain lifelong learning skills, which the authors propose culminate in becoming a "master leaner." To better understand the development of these skills and the attainment of that goal, the authors explore how learning theories inform the development of master learners and how to translate these theories into practical strategies for the learner, the teacher, and the learning environment so as to optimize this development.

The authors begin by exploring self-determination theory, which lays the groundwork for understanding the motivation to learn. They next consider the theories of cognitive load and situated cognition, which inform the optimal context and environment for learning. Building from this foundation, the authors consider key educational theories that affect learners' abilities to serve as primary drivers of their learning, including self-directed learning (SDL); the self-assessment skills necessary for SDL; factors affecting self-assessment (self-concept, self-efficacy, illusory superiority, gap filling); and ways to mitigate the inaccuracies of self-assessment (reflection, self-monitoring, external information seeking, and self-directed assessment seeking).

For each theory, they suggest practical action steps for the learner, the teacher, and the learning environment in an effort to provide a road map for developing master learners.

Editor's Note: A commentary by A. Kuper and C. Whitehead appears on page 1594.

The paradigm shift toward competencies in medical education focuses on educational outcomes for physicians.[1–3] In a competency-based framework, learners must drive their own educational process,[4] learners and teachers jointly must share responsibility for the content and path of learning,[4] and learners, teachers, and learning environments must interact to achieve the necessary outcomes of physician education.[4–11] Given this learner-centered focus, lifelong learning skills are foundational to the success of competency-based education.[12] The first step toward acquiring lifelong learning skills is understanding what drives and impedes learning. The literature is replete with theories that inform this understanding, many of which focus on the "self," including self-determination theory, self-directed learning (SDL), self-assessment, self-concept, self-efficacy, self-monitoring, and self-directed assessment seeking.[13–24] Synthesizing and applying these theories may improve learning and facilitate physician growth toward the ultimate goal of becoming a master learner, which we define as "a learner who demonstrates the most advanced level of lifelong learning skills." Indeed, previous research suggests that a focus on the practical implementation of principles from learning theories improves learning.[25]

Thus, the purpose of this paper is twofold: (1) to review select theories that contribute to our understanding of developing the master learner, and (2) to translate these theories from the educational bench and apply them to the clinical setting, highlighting implications for the learner, the teacher, and the learning environment. We wish to underscore that medical students and physicians at all levels are both learners and teachers depending on the context. Therefore, our use of the term *learner* rather than *trainee* is intentional, reminding the reader that a learner does not narrowly represent only a physician-in-training.

On the basis of our educational philosophies and experiences as clinician educators, we focus on theories derived from cognitive psychology, experiential learning, and social constructivism that have the most practical application and impact in the clinical learning environment.

Appendix 1 summarizes each of the learning theories we consider and details select implications for the learner, the teacher, and the learning environment derived from those theories. Figure 1 provides a graphic representation of the interplay of these theories in influencing the development of lifelong learning skills

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that culminate in becoming a master learner.

Elucidating the *Desire* to Learn: Self-Determination Theory

We begin by exploring what drives the desire to learn for individual learners.

Motivation is a powerful consideration for optimizing learning; however, it is often not considered in current approaches to medical education and training.[26] Self-determination theory (SDT) posits that individuals' natural motivation to learn is driven by fulfilling three innate psychological needs: a sense of relatedness, a sense of autonomy, and a sense of competence.[13]

According to SDT, a sense of relatedness—that is, feeling like a member of a community and of a profession—is important in learning. The need for relatedness has implications for the learner, the teacher, and the learning environment. For example, learners should introduce themselves and explain their role to all members of the team, and the teacher should treat trainees as colleagues and not merely subordinates. The learning environment should promote activities that foster intra- and interprofessional relationships; such activities include holding interprofessional monthly staff meetings and engaging junior learners in all decision making for their primary patients. Importantly, research has shown that a context supporting longitudinal relationships (e.g., among learners, patients, teachers, and other team members) facilitates a sense of relatedness[27,28]; thus, the typical assignments of learners to short, monthlong learning blocks could threaten the fulfillment of this innate need. Recognizing this potential disadvantage, Holmboe and colleagues[29] have suggested a need to revisit this traditional training paradigm.

The next psychological need according to SDT—autonomy—speaks to the importance of individuals feeling as if they are acting of their own volition.[13] This definition of autonomy is distinct from that of working independently of others. As an illustration, learners who seek help from another member of the health care team (not acting independently) and use this information to make choices and take actions of their own volition are, as defined by SDT, acting autonomously. Acknowledging this interconnectedness, the concept of "relational autonomy" supports granting opportunities for making choices when individuals demonstrate competence and trustworthiness.[30,31] Thus, autonomy, by this definition, is not trainees performing in the absence of supervision. Rather, relational autonomy occurs when teachers allow learners' plans or ideas to prevail when accompanied by clear, reasonable, and well-supported rationales—even if they differ from what the teacher would otherwise do. Finally, the learning environment, too, should maximize the ability of learners to act of their own volition, both personally and professionally, for example, by allowing learners to have some control over their work schedules or ensuring that they have choices in elective options so that these electives support career goals rather than meet service needs.

The third psychological need, as posited by SDT, is a sense of competence, which is defined as individuals feeling they know something or are able to do something.[13] Although a sense of competence likely naturally arises from experience, it is important to note that even learners early in development can feel a sense of competence. One implication for the teacher and learning environment is to align learners' responsibilities with their abilities. Another is to present frequent, affirmative feedback that both targets what the learner has done well and explicitly compares the learner's performance with that of more advanced learners, thereby defining a road map for

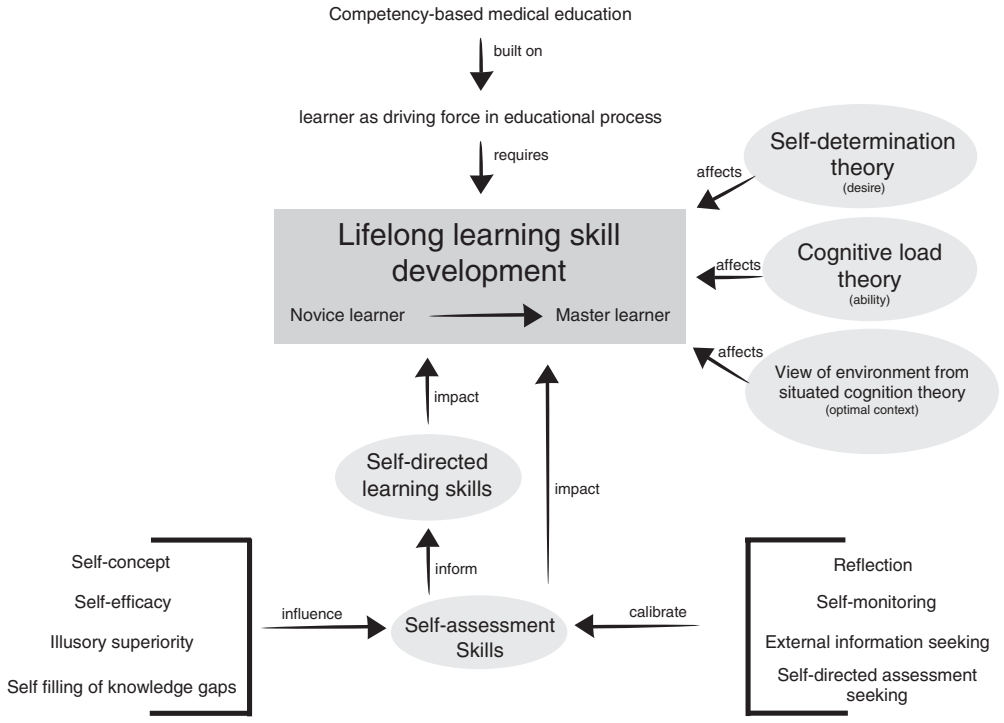

Figure 1 Forces and factors in developing the master learner.

future learning. This feedback should also address improvement opportunities within the context of normal, expected performance during development. When appropriate, teachers empathically underscoring their own struggles at a similar developmental stage can have a powerfully positive effect on the learner's sense of competence as well.

Fulfilling both a learner's need for a sense of autonomy and a sense of competence involves an intricate interplay between teacher and learner. Although *under*estimating learners' level of competence threatens both their sense of competence and autonomy, *over*estimating competence also threatens these needs by placing learners in situations where they cannot be successful and subsequently feel they are incompetent and unable to act autonomously. Thus, matching levels of supervision and autonomy with levels of competence is critical to driving the desire to learn. The concept of entrustable professional activities described by ten Cate and Scheele[32] advocates linking entrustment decisions to the ability to perform a given professional activity with progressively less supervision, providing a framework—and much hope—for striking this delicate and critical balance.[33]

Optimizing *Ability* to Learn: Cognitive Load Theory

Having discussed drivers for the desire to learn, we will next address factors that affect the ability to learn. Cognitive load is perhaps the most notable of these factors when considering the clinical working and learning environment.

Cognitive load is the mental energy individuals need to develop a framework for thinking about something (germane load), to understand something as a result of its inherent difficulty and complexity (intrinsic load), and to grasp meaning from something because of the way it is presented (extraneous load).[34] Increasing cognitive load consumes working memory, leading to a decrease in its availability for learning. Thus, factors such as too many complex patients (which increases intrinsic load), overly complex electronic medical records that do not present information in a user-friendly format (which increases extraneous load), and too much new information at once (which increases germane load) can threaten learning by resulting in cognitive overload. For early learners with limited experience, the impact of germane load is especially significant.[35]

The implications of cognitive load for learners emphasize the importance of seeking help when feeling overwhelmed. Implications for both the teacher and the learning environment focus on giving learners an optimal (not too much, not too little) amount of developmentally appropriate work (e.g., engaging in routine inpatient care during internship and then intensive care unit rotations only later during residency). The work should challenge learners, but not exceed their capacity—and teachers should be available and amenable to providing help if and when the work does exceed that capacity. These implications suggest the need for a culture shift, as learners often perceive help-seeking as a sign of weakness in the current clinical learning environment.[36]

Defining the Optimal *Context* for Learning: The Environment from the View of Situated Cognition

Situated cognition theorizes that all learning builds from, and inextricably links to, the environment, the situations, and the culture in which individuals find themselves.[37–39] Learning is thus a visceral experience that involves not only thinking but also touching, feeling, and doing in the actual environment; the learner impacts the environment and the environment impacts the learner. In this Perspective, we focus on how situated cognition influences the view of the environment, recognizing that situated cognition has overlap with other theories we discuss.

Given the foundation that situated cognition provides for viewing the environment, working in a learning environment that optimizes and aligns explicit and implicit (hidden) curricula is critical to achieving the desired outcomes of training.[40] Because mixed messages may undermine learning, teachers must be deliberate in role modeling what they want learners to internalize and emulate. Learners must also recognize the impact that their personal actions have on shaping the culture of the learning environment (e.g., creating a safe rather than stressful environment for other learners). In addition, the learning environment must support the acquisition of desired learner outcomes. For example, if becoming evidence-based practitioners is an expectation for learners, the learning environment should provide learners with role models and teachers who will both help with and model finding, interpreting, and applying evidence. Practical implications of situated cognition for the physical environment include ensuring safe spaces for delivering feedback (which is important for aligning explicit and implicit curricula), providing places for learners to engage in discussions with peers and teachers in relative proximity to point of care (which instills the importance of evidence seeking as an integral part of patient care rather than as an "add-on"), and guaranteeing up-to-date technology to support the search for and retrieval of best evidence (which is important for developing evidence-based practitioners).

Situated cognition has led some to advocate a cognitive apprenticeship model.[37] The word "cognitive" emphasizes that this type of apprenticeship involves learning not only the *skills* of the profession (as in a traditional apprenticeship) but also the *thought processes* of the profession from a master who knows both the culture of the profession and, as a participant in the learning environment, the context. The concept of a cognitive apprenticeship emphasizes a few important points.[37] First, because learning is context-dependent, situating it in the authentic activity of the profession is best (e.g., learning from real patients in their actual clinical environments, such as the clinic, the wards, or the operating room). Second, teachers who are experts and masters in the cognitive, kinesthetic, and psychosocial aspects of the medical profession are central to role modeling and making explicit what is tacit (e.g., reasoning or decision-making processes). Third, interactions with these teachers have the greatest impact when the learner has adequate time and when the curriculum permits continuity, both of which give learners the opportunity to see the patterns of behavior and multiple roles germane to these professionals.[37] Thus, the optimal learning environment for a cognitive apprenticeship is one that emphasizes longitudinal continuity

of setting, teacher, and other health care team members.[27,29] In addition to enhancing learning, the resultant relationship building allows teachers to underscore the positive aspects of learners' performances, to build on strengths, and to provide real-time feedback for performance deficiencies.[41] In turn, learners become comfortable with their teachers, increasing the likelihood that they will explore and ask questions freely. Finally, the cognitive apprenticeship model provides teachers the in-depth knowledge of learners' developmental levels that will enable them to push learners to greater capability through sequenced challenges balanced with appropriate supervision and support.[42,43]

Having considered important factors in the desire to learn, the ability to learn, and the optimal context for learning, we next turn our attention toward instructive concepts and theories that inform learners' ability to drive their own learning.

Learners' Ability to Guide Their Learning: The Good, the Bad, and the Ugly

Discussions about SDL often focus on individuals identifying and addressing learning needs on their own. However, Knowles' original conception clearly identifies SDL as an activity that requires engaging others,[14,44] which underscores the importance of "various kinds of helpers, such as teachers, tutors, mentors, resource people and peers."[14] Absent external sources of feedback and information, SDL relies on a learner's ability to self-assess, with all of its limitations (some question whether anyone is, absent external input, truly capable of being an effective self-directed learner).[45] Thus, we embrace Knowles' original definition: SDL is possible only insofar as the learner engages the teacher and the learning environment as necessary external sources of information. The implication for the teacher is to push learning beyond the learner's comfort zone, calibrate the learner's self-assessment, and provide frequent feedback. The learning environment, in turn, should ensure the time and processes necessary for learners and teachers to conduct a systematic review of, and to reflect on, performance.

The "bad and the ugly" in self-assessment

The first step of self-assessment is to compare information about oneself with perceived standards.[19] However, the literature on self-assessment suggests the outcomes of this process are fraught with inaccuracies.[15,21] We will address this challenge by briefly reviewing what we believe to be the most relevant psychosocial and cognitive constructs that influence the accuracy of self-assessment, including self-concept, self-efficacy, illusory superiority, and gap filling.

Self-concept. Self-concept is the general opinion individuals have of themselves as compared with others, and it incorporates both cognitive and affective components.[18] Although self-concept may be tied to a specific domain (e.g., the learner believes he is a good anesthesiologist), it is free from specific contexts and tasks. Given its global nature, strategies to mitigate a poor self-concept that is interfering with the learner's ability to succeed generally require going beyond the teacher–learner relationship or the learning environment into realms such as psychological counseling. However, teachers must be aware of those learners whose high self-concept does not align with their low performance because these learners require particular attention and investment (see illusory superiority, below).

Self-efficacy. Self-efficacy is the comparison of self with the "master" level.[18] Unlike self-concept, it is task-specific (the learner believes she possesses exemplary endotracheal intubation skills) and is affected by many factors, ranging from the seemingly trivial (a compliment from a teacher prior to an intubation) to the profound (the learner has previously saved a patient's life with a rapid fiberoptic intubation). There is also reciprocity between self-efficacy and success; to illustrate, high self-efficacy for intubation increases the chance of success at the procedure, and likewise, a successful attempt reinforces self-efficacy for intubation. Thus, learners must set themselves up for success by asking for help when they are unsure and engaging in the deliberate practice of challenging component skills (e.g., visualizing the cords).[42] The teacher, much like a coach who gives the team a pep talk and reviews key strategies both before and throughout a game, must boost self-efficacy through positive reinforcement and priming with information helpful to success. Priming pushes learners beyond what they can do alone, extending them to the limits of their current developmental level.[43,46] To further enhance self-efficacy, the teacher should focus learning strategies on processes (e.g., positioning the patient, manipulating the laryngoscope, choosing endotracheal tube size) as well as on the desired outcome (successful endotracheal intubation) so as to allow opportunities for success with parts of the process even in the event of an outcome failure (unsuccessful intubation).[42] In fact, starting with a process orientation and later moving to an outcome orientation optimizes learning when compared with focusing on process or outcome variables alone.[47] Furthermore, learners who engage in self-guided practice of procedural skills increase their skill retention when they focus on process goals, rather than on outcome goals.[48]

The learning environment can also support or hinder self-efficacy. For example, an operating room schedule that both allows time for learners to work with teachers on skills and fosters an environment that promotes a sense of team is more likely to promote the development of self-efficacy than one in which the attending surgeon or the institution view this teaching as a burden that slows the schedule and negatively affects the financial bottom line. In the latter case, teachers may want to increase the relative time spent with learners in the simulation lab to compensate for the lack of teaching time in the operating room.

Illusory superiority. The tendency for individuals to view themselves as above average compared with others, or illusory superiority, is another potential pitfall of self-assessment.[49] Complicating this, even those who perform the worst often believe they are above average, rendering these learners the most inaccurate in self-assessment.[17] These individuals lack the metacognitive skills necessary to gain insight from observing and comparing their own efforts with the superior efforts of others. Thus, they are both "unskilled and unaware," making them unable to correct their misperceptions on their

own.[17] Although this group of learners is difficult to mentor because of their lack of insight, Kruger and Dunning[17] have demonstrated that even these learners are capable of more accurately calibrating their self-assessments if they receive training for the task at hand. Thus, teachers and the learning environment can play a significant role in addressing an unskilled and unaware learner by providing the opportunity to practice the skill, by providing encouragement in the form of step-by-step coaching, and by providing frequent feedback through dialogue that ensures learner understanding.

To continue our intubation example, a learner who is both unskilled and unaware may be unable to intubate patients that her teacher thinks are routine given the learner's developmental skill level. When reviewing the cases, this learner may provide reasons for the lack of success that do not correlate with the actual degree of difficulty arising from the patient characteristics and circumstances. In this hypothetical situation, the best way for a teacher to help the learner is to recognize her as unskilled and unaware and engage her in repeated deliberative practice opportunities in the simulation suite, removed from direct patient care. Only after repeated success in this environment should the learner and the teacher return to the authentic learning environment of the operating room, and even after they return to this environment, the learner should remain under continued direct supervision until she demonstrates sufficient and consistent performance to allow the teacher to begin to entrust her with more distant supervision.[32,33]

Self-filling of knowledge gaps. Most learners possess a limited ability to identify their knowledge gaps.[15,21] Even when identifying gaps, learners may be unlikely to redress them because of the motivation and energy necessary to fill gaps in areas they perceive to be difficult or uninteresting.[21] Thus, optimally, learners and teachers would share the responsibility of gap filling: Learners should seek feedback from their teachers, and teachers in turn should provide specific feedback based on direct observation of their learners' abilities.

For the learning environment, gap filling is perhaps best accomplished by creating a culture of safety in which there is value and acceptance for questioning, not knowing, and acknowledging limits. Teachers modeling this behavior can ensure that learners readily and openly acknowledge and fill gaps without fear of untoward consequences, which, in turn, facilitates appropriate help-seeking behaviors.

The limited ability of learners to assess and fill knowledge gaps play out in study habits as well. Re-reading material is a common learning strategy, but *familiarity* with information is often mistaken with knowing and understanding; thus, individuals tend not to study what they perceive they already know, even if that perception is incorrect.[50] A more effective learning strategy is reading, then developing short-answer questions, and after some time delay attempting to answer those questions.[51] Individuals also tend to study material the longest when they judge their rate of learning to be the highest.[50] This reality, coupled with the fact that learners perceive the least familiar material as the most difficult and time-consuming to learn, compounds the difficulty of learning new information to fill gaps. Using our example from anesthesiology, a learner who is knowledgeable in pediatric anesthesia but has the greatest knowledge gap in cardiac anesthesia may be tempted to study new areas of pediatric anesthesia rather than cardiac anesthesia, as she perceives the latter to be difficult and time-consuming to learn. Although this approach may lead to additional gains in an area of greater knowledge (pediatric anesthesia), it fails to fill the gaps in cardiac anesthesia. The teacher can mitigate such barriers by sequencing recommended learning tasks according to level of difficulty, making each component task seem less onerous.

Creating "good" in self-assessment

Although there is much that is concerning (the "bad" and the "ugly") with self-assessment, there are strategies and habits that provide hope ("the good"). These include reflection and self-monitoring as well as external information and self-directed assessment seeking.

Refection and self-monitoring. A seminal article by Eva and Regehr[16] provides a more optimistic view of the utility of self-assessment by distinguishing the higher accuracy of concurrent self-assessment from the inaccurate outcomes of summative or predictive self-assessment.

Concurrent self-assessment is knowing when one is overwhelmed and/or unable to successfully accomplish a task *during* or *in the act of* working on the task (e.g., a learner handing over a difficult intubation to her teacher during a resuscitation). Concurrent self-assessment builds on Schön's[52] work on reflection. Reflection on action, reflection for action, and reflection in action parallel, respectively, the summative, predictive, and concurrent functions of self-assessment. Reflection on action is thinking through what went well and what could have gone better after completing a task. Reflection for action is anticipating how to execute a future task successfully. Reflection in action entails both thinking about how to execute a task successfully while performing it and processing the moment-to-moment intrinsic feedback necessary to continue carrying it out. All three types of reflection are important to self-improvement and patient safety; however, reflection *in* action is likely most critical as it is the most accurate.[16]

Whereas reflection on action leads to summative and general "self-concepts of ability that in turn lead to a leisurely decision to learn more about a particular domain," reflection in action leads to "repeatedly enacted, situationally relevant assessments of self-efficacy … [aimed at] addressing emergent problems and continuously monitoring one's ability to effectively solve the current problem."[16] A learner may inaccurately believe that her past performance is exemplary (summative self-assessment), or—absent evidence to support the supposition—she may believe that her future performance will be successful (predictive self-assessment); however, these inaccurate self-assessments are less important if, in the moment, she notes her efforts are not going well and asks a teacher for help.

In other words, learners who may inaccurately summarize and predict their performance can, nonetheless, accurately judge a situation in which they are at the edges of their current level of competence and need help to proceed.[20] Such learners show promise for self-monitoring in the moment. Self-monitoring, however,

is highly context-specific, such that the degree of accuracy in judging ability in one context or with one task does not necessarily equate with this same degree of accuracy in another context or with another task.

External information and self-directed assessment seeking. Although self-monitoring in the moment is important for patient safety and quality improvement, this moment-to-moment correction of performance is unlikely to lead to more accurate self-assessment as a whole.[15] Thus, seeking external information and feedback becomes a critical component of learning and filling gaps in knowledge in the broader sense.[15,16] Eva and Regehr[15] aptly name this activity, which master learners perform unbidden, "self-directed assessment seeking."

Self-directed assessment seeking requires learners to know what sources of external feedback are most effective (e.g., valid and reliable) both generally as well as for themselves personally. They must also learn to reflect on, internalize, and incorporate feedback into their daily practice and to use that information to drive future learning.[15,16] For the teacher, the content and method of feedback delivery, as well as the relationship with the learner, are essential determinants of whether learners will internalize this feedback in a manner that changes their behavior.[4,13] Teachers, thus, must ensure that a learner's sense of competence is not under threat even when constructive feedback is necessary, and the learning environment must engender a culture and context that embraces and promotes bidirectional feedback between learners and teachers. To illustrate, the operating room must provide a setting that cultivates a learner's sense of relatedness with the other individuals present and that allows her to be open and in "learning mode" as a colleague rather than in "defensive mode" as an outsider.[13]

Although the task of seeking external feedback is necessary, it faces notable challenges. Three particular challenges are as follows: (1) learners may fear receiving disconfirming information and either allow these emotions to thwart learning and behavioral change or even outright discount the feedback they receive from teachers[19,23,24,53]; (2) teachers may worry about damaging their relationship with a learner, and/or they may provide an assessment that is subjective or highly dependent on their own characteristics rather than those of the learner[23,24,54]; and (3) the learning environment may not be one in which the learner feels safe, or it may lack role models who demonstrate the value of feedback.[23,24] The implication for teachers is that they should focus on relationship building, which is a prerequisite for credibility. Further, learners will likely perceive these efforts as an investment in themselves. Likewise, restructuring the learning environment to support longitudinal experiences (rather than block rotations) will likely facilitate the relationship building that promotes behavior change resulting from feedback.[27–29]

Putting It All Together: Developing Master Learners

The complex nature of learning both challenges and informs the ability to achieve the goal of developing the lifelong learning skills that culminate in becoming a master learner. This development is central to the shift toward competency-based education in which learners must play a central role in their education to achieve the educational outcomes necessary to care for patients and in which teachers must help facilitate the personal and professional growth necessary for learners to achieve success.[4,55] Our journey through multiple learning theories suggests the following broad principles for creating master learners in the context of a competency-based education approach:

(1) While learners must take responsibility for their learning, they must also seek external information to guide their efforts and calibrate their self-assessments;

(2) While teachers must allow learners to assume responsibility for their learning, they must provide the role modeling, support, and feedback necessary to guide learning and assessment; and

(3) While the learning environment impacts learners and teachers through defining the culture and context in which professional formation occurs, learners and teachers must attend to the reciprocal impact they have on the learning environment so as to ensure they are also creating a meaningful learning environment for others.

These principles provide a path forward in developing master learners in the era of competency-based education. They allow learners to apply learning theory to their own learning processes; they provide guidelines for developing teachers as partners in this learning; and they illuminate means of adapting the learning environment to maximally support learner–teacher partnerships. We hope readers will use these and our more specific, practical suggestions in their own journeys toward mastery, in facilitating the journeys of others, and in creating learning environments that optimize every participant's experience.

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Appendix 1

Summary of Learning Theories and Select Implications for Learners, Teachers, and Learning Environments

Learning theory or construct	Main points of learning theory or construct	Select implications for the learner	Select implications for the teacher	Select implications for the learning environment
Self-determination theory[13]	A sense of **relatedness** is one of three psychological needs that drives learning	• Introduce self to team members, patients, and families in all new environments • Acknowledge the contributions of others and offer to help other team members	• Consciously integrate new team members through orientation, introductions, and explaining team goals • Use first names for all team members • Show value for the personal lives of team members	• Optimize continuity for the learner–teacher and/or learner–team dyads (e.g., through longitudinal rather than block rotations)[27–29] • Facilitate team building through activities such as team training and frequent team meetings/huddles built into the daily routine
	A sense of **competence** is one of three psychological needs that drives learning	• Seek feedback and develop an improvement plan with your supervisor to optimize competence • Avoid assuming responsibilities beyond what you can reasonably achieve • Seek help when needed	• Explore learners' ideas and help them solve problems • Give, receive, and model how to incorporate feedback • Work with learners to design improvement plans • Praise and celebrate learner and team successes • Avoid assigning responsibilities beyond what the learner can reasonably achieve	
	A sense of **autonomy** is one of three psychological needs that drives learning	• Demonstrate trustworthiness to facilitate autonomy by explicitly acknowledging limits, following through on all tasks, and telling the truth[31]	• Allow learner to act of his or her own volition related to learning activities when possible (e.g., allow learners to direct discussions based on their learning needs) • Assess learners and align the degree of supervision with their performance level (i.e., relinquish control when you can)	• Acknowledge/support education as a key mission of the team, practice, and/or institution • Ensure adequate back-up systems • Create a "just culture" that focuses on learning from errors and improving rather than blaming and punishing (www.justculture.org).
	The sense of autonomy and the sense of competence possess intertwined implications—Both under- and overestimating learners' level of competence threatens their sense of competence and autonomy		• Balance level of autonomy and supervision with level of performance and competence	
Cognitive load theory[34]	Cognitive load is the mental energy required (1) to develop a framework for thinking about something (germane load), (2) to understand something as a result of its inherent difficulty and complexity (intrinsic load), and (3) to grasp meaning as a result of the way something is presented (extraneous load)[34]	• Engage in appropriate help-seeking behaviors when feeling overwhelmed	• Gauge learner capability to handle volume and complexity of patients (germane and intrinsic load) • Think out loud to demonstrate framework for clinical decision making (germane load)	• Avoid systems and protocols that complicate rather than simplify effective and efficient task completion (extraneous load)

(*Appendix Continues*)

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Learning theory or construct	Main points of learning theory or construct	Select implications for the learner	Select implications for the teacher	Select implications for the learning environment
Situated cognition[37]	• Learning is constructed from the learner's experiences • The learning environment impacts the learner just as the learner impacts the learning environment	• Recognize environmental factors that help or hinder your own learning and modify your learning strategies accordingly • Recognize your personal impact on helping or hindering the learning environment (e.g., creating a safe rather than stressful environment for learning as a supervisory resident or fellow)	• Ensure personal behavior aligns with the desired values of the profession • Know your learners and build on their experience • Foster curiosity by welcoming questions and exploration • Match the learning needs of the learner or team to the right location, timing, and forum (e.g., teaching on sensitive issues in a private space that respects confidentiality) • Optimize continuity for the learner and teacher to work together for the sake of learning (e.g., through longitudinal rather than block rotations)[27–29]	• Avoid giving learners mixed messages by ensuring that what is explicitly taught aligns with what the institution desires learners to implicitly learn • Prioritize authentic learning environments (e.g., clinical care areas) over didactic learning environments (e.g., lectures) • Optimize continuity of team members within the clinical microsystem to maximize educational outcomes (e.g., through longitudinal rather than block rotations)[27–29]
Self-directed learning	• Taking primary responsibility for all phases of learning (identifying needs, planning to meet those needs, working to meet those needs, reflecting on what has gone well and on what has not gone well in learning efforts) • Requires the assistance of external resources to ensure learning needs are accurately and adequately identified and addressed	• Develop an individualized learning plan (ILP), using feedback in its creation and make the ILP a dynamic document by reviewing it with a mentor, implementing the outlined strategies, and visiting and updating it frequently based on reflection • Seek multiple sources of feedback on performance to focus priorities for learning • Develop learning plans based on feedback • Mitigate the pitfalls of self-directed learning both by seeking external input from teachers, mentors, and peers on identified learning needs and improvement plans and by accepting mentor challenges to expand learning beyond comfort zones	• Establish a routine schedule to engage and guide learners in dialogue about their reflections, self-assessments, and learning plans • Challenge learners to explore areas of need outside of their comfort zones • Schedule routine follow-up with learners to reinforce accountability to learning goals	• Systematize guided reflection and feedback, such as journaling, critical incident and error reporting, semiannual reviews, and ILPs • Provide resources to help learners with a variety of learning styles meet identified needs (e.g., feedback, library resources, online learning modules, and employee assistance programs)

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Learning theory or construct	Main points of learning theory or construct	Select implications for the learner	Select implications for the teacher	Select implications for the learning environment
Self-assessment	Comparing self with an ideal standard • There are three types of self-assessment: (1) predictive, (2) concurrent (in the moment), and (3) summative • Concurrent self-assessment is more accurate than predictive or summative self-assessment, the latter two being fraught with inaccuracies	• Make reflection before acting, while acting, and after acting a habit by building it into your daily routine • Recognize limitations of self-assessment and seek continuous external feedback • Engage others as reflectors	• Facilitate and guide reflection • Help learners calibrate their self-assessments with reality • Role model and facilitate reflection, openness to feedback, and behavioral change based on feedback	• Build self-assessment into a robust assessment system for faculty, staff, residents, and students • Develop a culture that values the acknowledgment of limits • Build in reflective activities such as time-outs in the operating room or before a procedure, using the STAR (Stop, Think, Act, Review) technique for patient encounters, and using root cause analyses and team debriefings after errors occur
Self-concept[18]	General opinion of self compared with others • Self-concept includes both cognitive and affective components • Self-concept can be domain-specific (e.g., "I am a good pediatrician.") • Self-concept is context-free and task-free	• Seek external feedback if your self-concept is poor and interfering with your work (e.g., "I am not a good doctor.")	• Sequence learning activities to provide early successes • Refer learners with poor self-concept that is interfering with their work for external evaluation and counseling • Note that performers with high self-concept, but poor performance require special attention and are addressed under illusory superiority	• Make confidential evaluation and support available for learners with poor self-concept
Self-efficacy[18]	Comparison of self with master • Cognitive activity without the affective component seen with self-concept • Self-efficacy is task-specific. • High self-efficacy predisposes learners to success just as success enhances self-efficacy • Low self-efficacy predisposes learners to failure just as failure reinforces low self-efficacy	• Seek help when feeling unable to perform a task • Reflect on successes as well as failures to build confidence that is aligned with your knowledge, skills, and attitudes	• Boost self-efficacy to increase the likelihood of success through activities such as positive reinforcement, practice in a simulation environment, and priming (e.g., reviewing key information before a patient encounter to anticipate difficulties based on learner's past experience) • Avoid low self-efficacy by debriefing "failures" to identify root causes and mitigating strategies • Focus learning strategies on both outcomes and processes (e.g., arm positioning and angle of entry when placing an IV) to achieve small successes even in the event of an outcome failure (e.g., IV not placed successfully)—that is, don't put all your eggs in one basket[42]	• Celebrate system successes and examine failures in order to determine opportunities for systems improvements that provide support for individuals • Build time for teaching, questions, feedback, and debriefing into the structure and flow of the clinical working and learning environment

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Learning theory or construct	Main points of learning theory or construct	Select implications for the learner	Select implications for the teacher	Select implications for the learning environment
Illusory superiority[49]	Tendency to view self as above average • Even some of the worst performers may view themselves as above average, making them unskilled and unaware[17]	• Recognize the human tendency to overestimate performance when self-assessing • Observe higher performers to calibrate self-assessment • Note that learners who are both unskilled and unaware will be unable to calibrate their self-concept without help—thus, the onus for improvement is on the teacher and learning environment	• Provide learners with specific comparisons with higher performer(s) to help them recalibrate their self-assessment • Take learners who are both unskilled and unaware out of the clinical learning environment, place them in a simulation /standardized patient environment, and give them step-by-step feedback, ensuring they understand through the use of repeat backs	• Support learners who are both unskilled and unaware through replacing authentic learning opportunities with faculty supervised simulation and standardized patient encounters
Gap filling	• Most individuals possess limited ability to identify or fill knowledge gaps • Attempts—usually unsuccessful—to fill knowledge gaps usually focus on reviewing what one is already familiar with[51] • Fill knowledge gaps by reading and testing after a time delay; substituting re-reading for testing allows familiarity to be mistaken for knowing[51]	• Seek feedback from mentors to help identify and suggest strategies to fill gaps • Focus on new material and frequent testing when studying on own; don't just reread information • Return to areas of deficiency frequently over time for testing • Approach new material with the expectation that it will be more difficult and plan learning strategies accordingly	• Help learners identify and fill gaps through sequencing tasks by level of difficulty to incrementally fill the gap and through using questions during/after learning experiences to reinforce/ensure understanding and learning (e.g., concluding didactic lectures with questions)	• Schedule periodic times for mentors and learners to review gaps (e.g., review in-training exam results) • Provide a safe learning environment where questioning, not knowing, and acknowledging limits are accepted and valued