Developing Expertise and Expert Performance

Peter J. Fadde and Patricia Sullivan

Introduction

One of the great joys in life is seeing experts at work in their realms. They routinely do what seems impossible to others. They seem to know what's going to happen before it happens. They save lives in operating rooms and influence lives in classrooms. Some of their domains of performance[1] are as ancient as the medieval guilds; some are emerging so rapidly that formal training and education can't keep up. While the world needs more experts, it also needs them more quickly than the years typically required to "make" an expert. Indeed, as first hypothesized in early 1970s chess research (Simon & Chase, 1973) and later evidenced in research on high-level music students (Ericsson, Krampe, & Tesch-Römer, 1993), attaining the highest levels of expert performance requires around 10 years or 10,000 hours of *deliberate practice* that is directed by a coach, targets specific skills to improve performance, provides timely feedback and repetition to refine target skills, and is effortful rather than inherently enjoyable.

Perhaps because it proclaims the primacy of hard work over talent, the 10,000-Hour Rule has been widely promulgated in popular literature such as *Talent is Overrated: What Really Separates World-Class Performers from Everybody Else* (Colvin, 2008); *The Talent Code: Greatness Isn't Born. It's Grown. Here's How*

---

[1] The term "domain" can have different meanings. In education and instructional design, it often means domains of learning, e.g., cognitive, psychomotor, and affective. We use the term as it is used in expertise studies, to refer to distinct areas of work or performance.

P. J. Fadde (✉)
Department of Curriculum and Instruction, Southern Illinois University, Carbondale, IL, USA
e-mail: fadde@siu.edu

P. Sullivan
Department of English, Purdue University, West Lafayette, IN, USA

M. J. Bishop et al. (eds.), *Handbook of Research in Educational Communications and Technology*, https://doi.org/10.1007/978-3-030-36119-8_4

(Coyle, 2009); *Outliers: The Story of Success* (Gladwell, 2008); *Bounce: Mozart, Federer, Picasso, Beckham, and the Science of Success* (Syed, 2010); and *Peak: Secrets from the New Science of Expertise* (Ericsson & Pool, 2016). Despite the popular as well as theoretical appeal of expertise studies, however, there is a gap between describing expertise and developing it. For instance, the deliberate practice framework that fits so neatly with images of aspiring musicians and athletes fits less well with professionals who may not start their 10,000-hour clock until they reach college age and are unlikely to reach levels of expertise until their third or fourth decade (Ericsson, 2008). There is a role, then, for instructional design researchers and practitioners in bridging from expertise studies to expertise training, especially in professions such as law, medicine, nursing, education, business, architecture, social work, counseling, physical therapy, law enforcement, pharmacy, accountancy, information technology, dietetics, public health, engineering, finance, and even instructional design.

As with efforts to find shared ground between the fields of instructional design (ID) and Human Performance Technology (Foshay, Villachia, & Stepich, 2013) as well as between ID and Learning Sciences (Lin & Spector, 2017), our challenge is to find insights that add to our ID knowledge base (Richey, Klein, & Tracey, 2011) without oversimplifying or cherry picking from another discipline. Of course, constructivist learning approaches such as cognitive apprenticeship (Collins, Brown, & Holum, 1991), problem-based learning (Hmelo-Silver, 2004), four-component instructional design (van Merriënboer, 1997), and first principles of instruction (Merrill, 2002) imbue educational environments with elements of professional work. However, constructivist learning approaches have not been as widely adopted in professional training contexts where ID practitioners value more systematic approaches (van Merriënboer & Boot, 2009). In addition, cognitive task analysis (CTA) methods that reveal expert knowledge and have improved professional education curricula (Clark, Feldon, van Merrienboër, Yates, & Early, 2008; Yates & Clark, 2012), are largely ignored by many ID practitioners because of the high level of skill and effort required to conduct CTA (Schraagen, 2009).

What we seek in this chapter, therefore, are ways to bridge from expertise research to ID practice in highly applicable ways. We first clarify these goals by unpacking the chapter's focal question. We then consider who can benefit from expertise training and what expert skills are appropriate to train. We conclude by describing four models that apply principles of expertise studies to designing expertise training.

> *Focal Question: How do we facilitate the development of expertise and expert performance through instructional design and technology?*

How alludes to our focus on practical application of expertise theories, research, and methods. Historically, with roots in World War II-era military training, ID has been highly successful in training to levels of certifiable competence (Molenda, 2010), but expertise is assumed to come with experience, mentorship, and non-instructional professional development activities such as reading journals and attending conferences (Richey et al., 2011). We contend that systematic ID approaches can expand to include expertise training.

We includes current and future ID professionals along with academic faculty in instructional design, learning design and technology, workforce education, cognitive psychology, and human factors engineering. Instructors and curriculum designers in college-based professional education programs also have particular interest in accelerating expertise and expert performance.

Facilitate suggests that we are assisting mature and motivated performers to accelerate the natural development of expertise and expert performance over a career spent in a domain. Facilitation of expertise may operate in a preparation stage, such as professional education, or during professional work. Ultimately, the goal is for performers to become self-regulated learners guiding their own development.

Development alludes to the focus of modern expertise studies on *individual development* in contrast with traditional interests in *individual differences* (Ericsson, 2017). Rather than talent or inherited attributes, expertise is primarily attributed to thousands of hours of *deliberate practice* under the direction of an instructor that is designed to improve performance by targeting specific deficiencies with activities that are at the edge of performers' abilities, offer timely feedback, and can be repeated to refine performance (Ericsson et al., 1993).

Expertise and *expert performance*, as individual terms, are associated with knowledge and skills, respectively. The combined phrase, though, emphasizes knowledge in the service of performance. While traditional expertise studies attempted to codify expert knowledge, the *expert-performance approach* aims to capture exceptional performance in naturally occurring events that can be recreated in controlled conditions in order to investigate the cognitive mechanisms of expert performance (Ericsson, 2008).

Instructional design and technology (IDT) refers to distinct, and often mediated, learning activities more than course-level curricula. Although training for expert performance is often associated with simulator-based training, the deliberate practice framework aligns well with long-established instructional methods such as drill-and-practice and technologies such as computer-based training (CBT) that can deliver measureable and repeatable learning activities.

Issues and Considerations in the Design of Expertise Training

Asking how we can facilitate expertise and expert performance leads to asking who can benefit from expertise training and what specific aspects of expertise to train.

Who Can Benefit from Expertise Training?

The most obvious beneficiaries of expertise training are performers in *Type 1* domains (Hoffman et al., 2014) that engage in direct competition (such as sports and performing arts) and have a culture of practice. *Type 2* domains that don't meet the criteria for *Type 1*, including most professions, are less familiar with deliberate practice. Figure 1 depicts a *culture of expertise* continuum that represents beliefs of various domains regarding how expertise is attained.

Chess, music, and sports represent classic *Type 1* domains that have direct competition, objective feedback on performance, and an established culture of practice. *Type 2* domains include academic domains, such as history and literature, which emphasize knowledge more than performance skills and can be characterized as having a *culture of study*. Although "performance" can include academic skills such as locating and synthesizing sources, these don't align with conceptions of drill-like deliberate practice associated with *Type 1* domains. Other *Type 2* domains have *cultures of experience* that place high value on holistic experience-based learning, such as student teaching and medical residencies. These domains can also be an unnatural fit for deliberate practice. Even when teacher education theorists (e.g., Berliner, 2000, 2001; Darling-Hammond, 2005; Dunn & Shriner, 1999) directly reference deliberate practice to develop teacher expertise, a typical sentiment is that:

> For most of us, the word "practice" elicits images of repeated performances aimed at refining and perfecting some skill, usually a motor skill. Teachers do not practice, they "teach." (Dunn & Shriner, 1999, p. 647)

Strong correlations have been shown between the amount of deliberate practice and the level of performance for the classic *Type 1* domains of chess, music, and sports (Baker & Young, 2014; Macnamara, Hambrick, & Oswald, 2014; Ward, Hodges, Starkes, & Williams, 2007), but only tenuous correlations between deliberate practice and level of performance have been shown for *Type 2* domains such as education and other professions (Hambrick et al., 2014). Indeed, the lack of competitions or rankings that clearly designate level of performance makes it difficult to apply the expert-performance approach in *Type 2* domains (Ericsson, 2015), for both research and training purposes. Translating to *Type 2* domains the expertise theories, research, and methods developed in *Type 1* domains requires teachers, trainers, and ID professionals to expand conceptions of deliberate practice. For example, analysis of expert performance in many domains shows that experts are

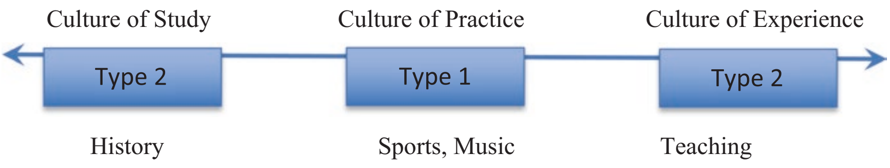


Fig. 1 Continuum depicting cultures of expertise in professional domains

better able to plan, execute, and monitor their own performance (Ericsson, 2015), suggesting that expertise training should address these metacognitive skills with deliberate practice activities that are focused and measureable, offer timely feedback, and can be repeated to refine performance.

What aspects of expertise and expert performance should be targeted for training?

The problem with training expertise and expert performance is that they seem to represent massive amounts of accumulated knowledge and skills. Fortunately, our focus is on what *differentiates* expert from near-expert performers rather than the totality of experts' knowledge and skills. This difference is the target of studies that adopt the expert-novice research paradigm introduced in pioneering chess studies (e.g., Simon & Chase, 1973). In their classic experiment, Simon and Chase (1973) compared an internationally ranked chess player with a skilled but unranked player on the representative task of reconstructing the arrangement of pieces on a chessboard after a brief look at the board. As would be expected, the expert performed much better, but only when the arrangement of pieces came from an actual chess match. When the arrangement of pieces was arbitrary, the expert's advantage largely disappeared. Simon and Chase concluded that the expert possessed chess-specific schema that permitted him to chunk meaningful information, thereby circumventing limits of working memory.

The assumption underlying expertise training is that acquiring skills that differentiate expert from near-expert performers will enable a near-expert performer to become an expert performer. While this assumption is not fully proven, it provides a starting point for expertise training. In the expert-performance approach, the first step of an expertise researcher, or an instructional designer who seeks to facilitate performers' advancement to expertise, is to identify specific knowledge or skills that demonstrate repeatable superior performance in natural settings (e.g., Ericsson, 2008). This goal is facilitated by models that represent stages of development, starting with novice and progressing to expert but with special attention to the transition points between near-expert and expert performance. The Dreyfus and Dreyfus (1980) five-stage model is particularly useful because it highlights specific mental functions associated with the transitions to expert level, which can potentially serve as appropriate targets for expertise training.

Table 1 shows that advancement from competent to proficient is associated with a change in the *recognition* function from decomposed to holistic, which is consistent with research showing that experts typically transition from decontextualized

Table 1 Mental functions at skill levels in Dreyfus and Dreyfus (1980) model

Skill level/mental function	Novice	Competent	Proficient	Expert	Master
Recollection	Non-situational	Situational	Situational	Situational	Situational
Recognition	Decomposed	Decomposed	Holistic	Holistic	Holistic
Decision	Analytical	Analytical	Analytical	Intuitive	Intuitive
Awareness	Monitoring	Monitoring	Monitoring	Monitoring	Absorbed

rule-based reasoning to context-rich instance-based reasoning (Gonzalez, Lerch, & Lebiere, 2003). Advancement from proficient to expert is associated with a change in the *decision* function from analytical to intuitive, which is consistent with research in the area of naturalistic decision-making (Klein & Wright, 2016).

While the model is theoretical rather than empirical, it provides potential starting points in narrowing the range of knowledge and skills that might be targeted for expertise research or training. In the next section, we look more closely at recognition and intuitive decision-making as targets for expertise training.

Mental Functions for Expertise Training

While covering all research addressing expertise is beyond the scope of this chapter, we find it important to the crafting of instruction to address mental functions that are important to training that aims to develop expertise, namely, pattern recognition and intuitive decision-making.

> The situation has provided a cue: This cue has given the expert access to information stored in memory, and the information provides the answer. Intuition is nothing more and nothing less than recognition. (Simon, 1992, as cited in Kahneman & Klein, 2009, p. 520)

The connection between recognition and intuitive decision-making is central to the *Recognition-Primed Decision-Making* (RPD) model, which proposes that experts apprehend a situation and, without conscious effort, a potential solution presents itself. The expert then mentally simulates the solution and, if the simulated outcome is acceptable, executes the solution (Klein, 1998). David Jonassen adapted RPD in his ontology of problem solving as *strategic performance problem solving* (Jonassen, 2011) and described it as a very high form of human cognition that requires extensive experience and training (Jonassen, 2012). However, Fadde (2009b) points to evidence from sports expertise research to argue that the recognition component of RPD is less complex and can be trained in isolation from the full RPD process as a strategy to accelerate expertise.

Training Recognition Skills

Since the early 1980s, sports expertise researchers have investigated pattern recognition in the form of perceptual-cognitive skills that allow expert athletes in many fast-action sports to read cues in the movements of an opponent and thereby anticipate outcomes and make faster responses (Müller & Abernethy, 2012). Meta-analysis has confirmed that perceptual-cognitive skills differentiate expert and less-skilled cricket batsmen, baseball hitters, tennis returners, and goalies in hockey, soccer, and field hockey (Mann, Williams, Ward, & Janelle, 2007). Making the crossover from research to training, methods used to measure perceptual-cognitive skills – especially video-based temporal occlusion – have also been used to train the same skills in intermediate and near-expert performers (Larkin, Mesagno, Spittle, & Berry, 2015).

In a typical video-occlusion task used for research or training purposes, participants or trainees watch a video display of an opponent, such as a tennis server, that shows the view of an on-court contestant. Video clips of opponent serves are cut to black (occluded) at various points before, at, or shortly after racquet-to-ball contact. The participant or trainee identifies the type of serve (e.g., flat, slice, or kick) and predicts the location of the serve (e.g., backhand or forehand side). Input is typically made verbally, by ticking a paper answer sheet, or by finger press or mouse click on a computer screen. Since the video image does not change in response to input by the participant or trainee, video occlusion is not a true simulation (Hubal & Parsons, 2017). Rather, video occlusion is designed specifically to test or train early recognition of serves (or pitches or shots on goal) as an attribute of expert performers (Ward, Williams, & Hancock, 2006).

The targeting of perceptual skills (rather than vision or reaction time) and the development of video-occlusion methods in sport science laboratories demonstrate the expert-performance approach (e.g., Ericsson, 2008) that starts with identifying an aspect of expert performance in natural settings, such as expert tennis players successfully returning 130-mile-per-hour serves. The performance is then reduced to a representative task that can be repeated and measured in controlled conditions. The task is then manipulated (e.g., occluded) to reveal mechanisms of expert performance, such as expert tennis players' use of advance visual cues to circumvent limitations on human reaction time. The assumption, which has been demonstrated in the sports setting (Larkin et al., 2015), is that training the same perceptual skills that differentiate expert performers using the same occlusion methods should improve performance of the full skill and thereby help a near-expert performer reach the next level.

The success of recognition-only training skills in sports has implications for training in other domains that have feature extremely rapid and visually based reactions, such as aviation, military, and law enforcement (Eccles, Ward, Janelle, Woodman, & LeScanff, 2008; Roca & Williams, 2016; Ward et al., 2008) as well as surgical education (Causer, Barach, & Williams, 2014). In many of these domains, authentic case images and video recording may be available for use in expertise training. Indeed, expertise researchers have suggested using case video to train expert-performance skills ranging from medical diagnosis (Ericsson, 2008, 2015) to backing 54-foot semi-tractor trailers (Fadde, 2009c) to sports coaching (Ford, Coughlan, & Williams, 2009).[2]

Obviously, the direct relevance of training perceptual-cognitive skills in sports is limited to other domains that involve fast psychomotor actions. However, it also serves to demonstrate how expertise theories, research findings, and laboratory methods can inspire the design of expertise training methods.

---

[2] Because few studies have been published that actually implement expertise training, we rely on hypothetical training designs, such as the ones described here, to illustrate the approach.

Training Intuitive Decision-Making and Reflection

Training intuitive decision-making skills is less well established than training recognition skills. It is also more controversial. While intuitive decision-making is increasingly recognized as a valuable component of expertise and expert performance in many domains (Klein & Wright, 2016), it is not always valid or even recommended. Indeed, Kahneman and Klein (2009) debated the merits of intuitive decision-making versus the risk for biases inherent in “trusting your gut” and concluded that intuitive decision-making is real, and valuable, but that it should be trusted (and trained) only in situations that offer regularity – so that patterns can be amassed – along with timely and valid feedback.

Ericsson (2008) maintains that intuitive decision-making relies on automatic cognitive processing that he links with arrested development where further experience makes performers work faster and with minimal or no errors but does not make them advance to higher levels of expertise. Advancing to expert requires deliberate practice that is, by definition, conscious and effortful. Ericsson (2015) suggests that experts’ ability to plan, execute, and monitor their own thinking – skills that are associated with reflection and self-regulated learning – are appropriate targets for expertise training. As noted earlier, *Type 2* domains that have a strong culture of experience, such as teaching, also value reflection as an attribute of expert performers. As such, deliberate practice may be better understood and more readily accepted in these domains when it targets reflection in systematic ways that meet criteria as deliberate practice. It may be that, as suggested in the Dreyfus and Dreyfus five-stage model of adult skill acquisition (see Table 1), the mental function of *awareness* continues in a mode of conscious monitoring until the highest stage of master, when awareness changes from monitoring to absorbed awareness that is automatic, but only after years of conscious reflection.

In the final section, we describe four models that can guide ID practitioners in designing expertise training. The models – which have emerged from cognitive psychology, sport science, workplace learning, and naturalistic decision-making – are appropriate for training different expertise skills, including recognition and reflection.

Instructional Design Models for Expertise Training

We describe four models below that adapt expertise research methods for expertise training purposes: (1) expertise-based training, (2) expert-performance-based training, (3) ShadowBox, and (4) integrative pedagogy. These training models highlight different aspect of expertise in various domains.

Expertise-Based Training (XBT)

As depicted in Fig. 2, XBT connects Naturalistic Decision-Making theory, particularly the Recognition-Primed Decision-Making model, with training tasks inspired by expert-novice studies in order to create CBT modules that target perceptual-cognitive skills such as situational awareness and pattern recognition. XBT uses drill-and-practice method to systematically build recognition skills implicitly through repetition with immediate feedback (Fadde, 2009a).

XBT tasks typically present research participants or trainees with still or video images and then prompt one of the interactions that are typical of representative research tasks (Chi, 2006). For example, an XBT task to train radiologists using case file images (as suggested by Ericsson, 2008, 2015) could require trainees to *recall* features from images, *detect* anomalies in images (such as mammograms), *categorize* images (e.g., the type of lesion), or *predict* the outcome (e.g., biopsy found to be malignant or benign). Since the outcome of "old" case images is known, trainees can be given immediate and reliable feedback.

XBT has primarily been applied in sports but is increasingly applied to workplace learning (Johnson & Proctor, 2017) and areas of professional education including teacher education (Sancar-Tokmak, 2016) and nursing education (Razer, 2016). An XBT-based study in nursing education involved nursing students viewing video clips of simulated hospital room patient care in which experienced nurses purposefully engaged in several non-optimal behaviors. Nursing students were tasked with viewing the videos and recognizing errors made by the nurses, filling

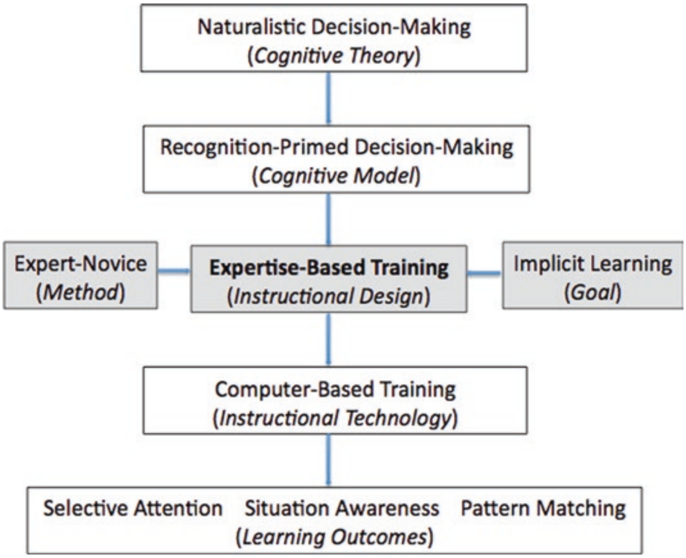


Fig. 2 Theoretical framework of expertise-based training (XBT) to train recognition skills. (Adapted with permission from Fadde, 2013)

out a computer form with their observations, and then checking their observations against the observations of three experienced nursing educators who viewed the same video clips (Razer, 2016).

Expert-Performance-Based Training (ExPerT)

The *expert-performance-based training* (ExPerT) model expands the expert-performance approach to design larger-scale expertise training activities and programs (Ward, Suss, & Basevitch, 2009). As shown in Fig. 3, ExPerT is specifically designed to apply and also extend the expert-performance approach by: (1) identifying expert performers and representative tasks that capture the essence of expert performance in natural settings, (2) devising tasks to study under controlled conditions using process methods such as eye-tracking and think-aloud protocol to identify cognitive mechanisms of expert performance, (3) tracing the developmental history of experts to ascertain when and how they acquired mechanisms of expertise, (4) developing deliberate practice activities based on the representative tasks, and (5) reiteratively assessing training effectiveness and setting new performance goals.

Blair (2016) designed a training program intended to accelerate the expertise of undergraduate peer academic counselors by having the counselors adopt client questioning and observation techniques typically associated with more experienced and professional counselors. Two versions of the expertise training program were designed, implemented in an authentic training context, and compared using quantitative and qualitative methods. One version used the ExPerT framework, and one

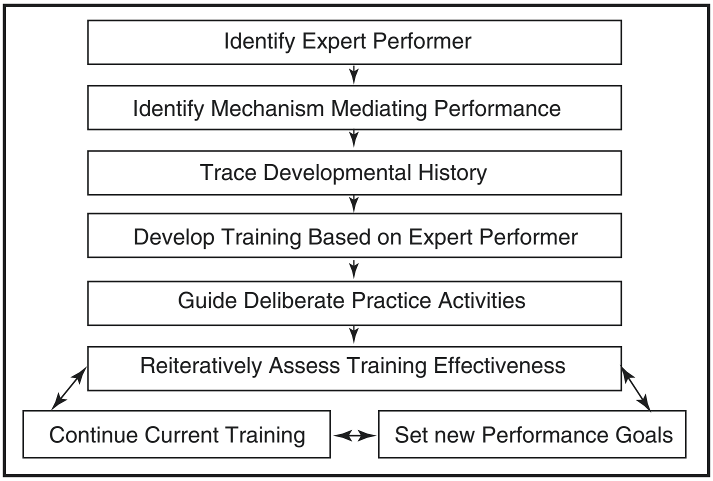


Fig. 3 Conceptual framework of the expert-performance-based training (ExPerT) model. (Adapted with permission from Harris, Eccles, Ward, & Whyte, 2013)

used XBT activities. The ExPerT version involved "live" simulation with experienced peer tutors role-playing student clients, while the XBT version tasked trainees with identifying suboptimal behaviors in videotaped role-plays between experienced peer counselors, one acting as a student client. Both versions were more effective than a control condition consisting of the established direct instruction peer tutoring curriculum. The ExPerT version produced the largest learning effects, albeit with higher instructional investment in the form of "live" role-playing that involved subject matter experts. The recognition-only XBT activities were less effective but, if delivered in CBT form, could be completed as web-based self-instruction. The researcher concluded that both methods have a place in an instructional designer's expertise training toolkit.

ShadowBox

Another approach to capturing and transmitting expert situational thinking is offered by the *ShadowBox* method developed by MacroCognition LLC and based on Klein's RPD model (Klein, 1998). As shown in Fig. 4, the ShadowBox process (MacroCognition, n.d.) starts with identifying training goals and conducting cognitive interviews with experts, similar to a cognitive task analysis process. Rather than generating curricular content, however, input from experts is used to create realistic scenarios. In ShadowBox training, trainees read a scenario, such as a public event security threat, that is presented on paper or computer. The scenario is stopped at various decision points. Trainees are presented with a list of decision options and tasked with prioritizing the options. After making their selections, trainees are shown the priorities made by a panel of experts completing the same scenario. Trainees are prompted to reflect on differences between themselves and the experts. Trainees also can read the experts' rationale for prioritization (Borders, Polander,

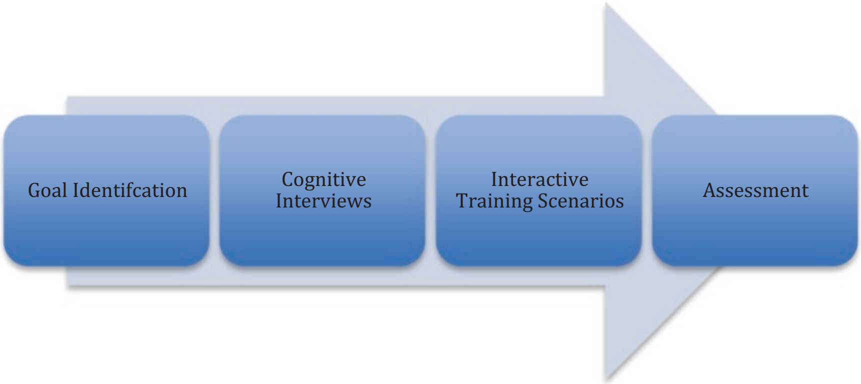


Fig. 4 ShadowBox process. (Adapted from MacroCognition LLC)

Klein, & Wright, 2015). ShadowBox has been employed in military, law enforcement, health care, and social services domains. A ShadowBox program to train Marines in “Good Strangers” interactions with civilians in conflict areas resulted in trainees aligning with experts 28% more than a comparison group (Borders et al., 2015). However, Klein (2015) points out that learning value comes less from matching the experts than from carefully considering the experts’ responses. ShadowBox targets recognition, reflection, and intuitive decision-making as cognitive skills associated with higher levels of expertise.

XBT, ExPerT, and ShadowBox provide frameworks for designing expertise training that is engaged in during formal training periods, be they pre-service professional education or in-service professional development. However, in many professional domains, performers’ progression from competence toward expertise will occur less through formal training and more through informal learning of tacit knowledge and skills embedded in everyday work (Klein & Hoffman, 1993). While implicit learning is assumed to come with extensive domain-specific experience, however, “mere experience” proves to be a poor predictor of expertise (Ericsson, 2008), suggesting that experiential learning needs to be scaffolded. The last model we describe aims to bridge from formal education to informal workplace learning, in large part through reflection.

Integrative Pedagogy

Reflection on action is widely done as after-action review by teams in military, medical, and business settings. In addition, many teacher education programs promote the *reflective practitioner* (Schön, 1983) as an aspirational disposition. As shown in Fig. 5, reflection is an integral part of the *integrative pedagogy* model

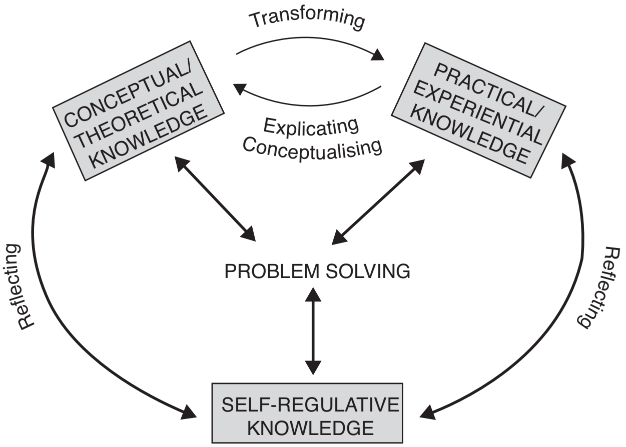


Fig. 5 Integrative pedagogy model. (Adapted with permission from Tynjälä, 2008)

(Tynjälä, 2008) of learning in the workplace that connects formal learning of theoretical knowledge gained in education with experiential knowledge gained at work.

Although the *integrative pedagogy* model is more descriptive than it is proscriptive, it does point out several cognitive activities that cultivate expertise: transforming, explicating, and conceptualizing between theoretical and experiential knowledge in the course of solving problems, along with reflection as a self-regulated learning strategy (Zimmerman, 2006) that can be consciously practiced by in-service professionals. The model provides a framework for overcoming the "arrested development" that can lead to performers remaining at a level of competent performance even after years of domain experience (Ericsson, 2008). Integrative pedagogy is especially appropriate for connecting professional education to professional work.

Professional education typically includes mastering an established body of declarative knowledge and requisite skills through college-based professional education that often leads to certification (Boshuizen, 2004) and an initial stage of professional competence. Whether self-directed by the performer or guided by a coach, progressing to stages beyond competence can be facilitated with a plan that includes reflection on action (Jung, Kim, & Reigeluth, 2015). With experience, some performers master *reflection-in-action* (Schön, 1983) that involves consciously experimenting with new approaches, monitoring situations even while performing, and anticipating outcomes of potential actions. Reflection-in-action shares much with intuitive decision-making and represents a very high level of expertise.

The expert training models described above are not comprehensive or definitive but rather demonstrate that specific elements of expert performance, such as recognition and reflection, can systematically be trained in ways that are inspired and guided by the deliberate practice framework and the expert-performance approach from modern expertise studies. Below we provide an example that uses the models to design expertise training in the context of classroom teaching (Fadde & Sullivan, 2013).

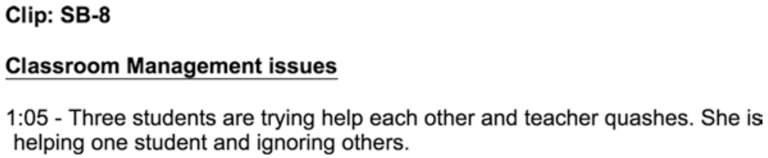
Example: Training Classroom Noticing Via Video

The participants in the study were preservice teachers who were near the end of the introductory course to a two-year Teacher Education Program (TEP). The course had covered several aspects of teacher-student interaction, including *classroom management* and *student questioning* to ascertain students' cognitive processes. Both topics included instruction on strategies for teachers to apply in various classroom management and student questioning situations. Teacher expertise research shows that experienced teachers are able to observe student behaviors and consider if, when, and how to apply strategies *while* delivering a lesson (Feldon, 2007). Novice teachers, however, are not able to observe, consider strategies, and deliver a lesson at the same time. Satisfying the first step of the ExPerT model, the ability to observe and consider while teaching represented a reliably reproducible superior performance of experienced teachers in the natural classroom setting. It is a combination of recognition and reflection-in-action skills.

Once identified, the target expert skill was theorized as *classroom noticing* (Rosaen, Lundeberg, Cooper, Fritzen, & Terpstra, 2008; Sherin & van Es, 2005). A representative task was devised using "old" case video of student teachers delivering lessons. The videos contained instances of classroom management and student questioning. A representative task then was structured so that it could be repeated in a controlled setting (step 2 of ExPerT). The videos were edited into 1–2-minute segments to facilitate timely feedback and repeated trials – both elements of deliberate practice. The video segments were not chosen to demonstrate particular behaviors but rather to depict routine classroom activity.

The students in the TEP class were tasked with watching for examples of either classroom management or student questioning behaviors by the classroom teacher. Since not all videos contained target behaviors, students needed to *detect* (an XBT task) target behaviors. They then needed to *categorize* (a second XBT task) behaviors as classroom management or student questioning. Students watched the video clips on a computer monitor in a computer lab. They typed their observations into an on-screen form (see Fig. 6). Once the form was submitted, the student was shown a similar form that contained the observations made by two experienced teacher educators when they viewed the same video clip (a repurposing of the expert-novice research paradigm). Students were instructed to compare their observations with those of the experts and to reflect on differences between what they noticed and what the experts noticed. Students, who had been instructed to try to match the experts, then selected the next video clip and repeated the observe/align/reflect process.

In this task, students were not asked to choose a classroom management or student questioning strategy, consistent with the XBT focus on recognition-only training that minimizes cognitive load (van Gog, Ericsson, Rikers, & Paas, 2005). Applying the ExPerT model, with iterative rounds of assessment and recalibration, would entail showing more challenging classroom videos or adding strategy selection tasks. A ShadowBox approach might show students a number of strategy options and ask them to rate or rank the options before showing them the experts' ratings or rankings. When these pre-service teachers reach student teaching, then they can apply the integrative pedagogy model to tie theoretical knowledge gained in the TEP to practical knowledge gained in the classroom. If a substantial amount of deliberate practice, such as the noticing activity, were completed during their time in the TEP, the preservice teachers would be positioned to take self-regulated



Clip: SB-8

Classroom Management issues

1:05 - Three students are trying help each other and teacher quashes. She is helping one student and ignoring others.

Fig. 6 Student observation entered in classroom noticing activity learning strategies and reflection as a habit of mind into their professional careers, thereby amplifying their critical early-career experience.

Conclusions

As with Learning Sciences (Lin & Spector, 2017) and Human Performance Improvement (Foshay et al., 2013), instructional design gains from exploring shared ground between ID and expertise studies (Lajoie, 2003). Teachers, trainers, and ID professionals, along with faculty in professional education programs, are able to facilitate the development of expertise and expert performance through instructional design and technology. To further bridge expertise studies to expertise training, expertise training research needs to move beyond short-form projects that demonstrate feasibility and onto transactional theory-to-practice research (Ericsson & Williams, 2007) that embeds longer-form training programs in authentic contexts and analyzes process and outcome results using mixed quantitative and qualitative measures (e.g., Fadde, 2016).

As shown in Fig. 7, typical and accelerated trajectories to expertise may end up at a similar level of achievement. However, individual performers, along with their

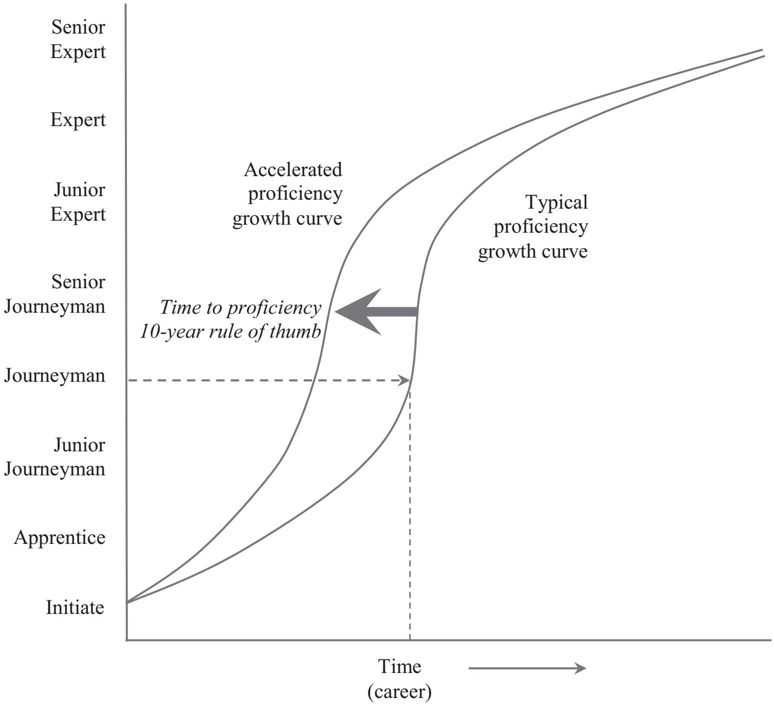


Fig. 7 "S" curve of expertise. (Adapted with permission from Hoffman et al., 2014)

customers, students, and patients, all benefit from performers reaching expert stages earlier in their careers and thereby amplifying their productive output. Although expertise and expert performance are considered to be highly domain specific (Ericsson, 2006), it may be that expert learning (Williams, Fawver, & Hodges, 2017) is the shared road to excellence and the role of ID researchers and practitioners is to provide the "expertise to make expertise" (Bransford & Schwartz, 2009, p. 432).

In line with this volume's applied focus, we conclude by offering several suggestions for designing expertise training:

- Start working on pieces of expertise early: Performers don't need to be proficient, or even competent, to start working on a "piece of expertise" such as classroom noticing.
- Devise deliberate practice activities that are guided by a coach (including a self-coach), target specific subskills to improve performance, require concentrated effort, and provide timely feedback with opportunities to repeat and refine skills.
- Resist unnecessary realism in simulations: Part-task training of recognition skills can be efficient as well as effective.
- Locate academic research or conduct informal research in a domain of interest to ascertain how experts are defined and what they do differently.
- Leverage workplace events for reflection, individually and as a team – before, during, and after work events.
- Use problem-centered, problem-solving, scenario-based, and other task-based instruction methods during formal education, especially professional education.
- Design content and activities based on what experts actually think and do (e.g., cognitive task analysis) rather than what they, or others, say they should do.
- Design representative tasks to practice recall, detection, categorization, or prediction.
- Appreciate the wonder of expert performance, wherever it is encountered.

References

Baker, J., & Young, B. (2014). 20 years later: Deliberate practice and the development of expertise in sport. *International Review of Sport and Exercise Psychology, 7*(1), 135–157.

Berliner, D. C. (2000). A personal response to those who bash teacher education. *Journal of Teacher Education, 51*(5), 358–371.

Berliner, D. C. (2001). Learning about and learning from expert teachers. *International Journal of Educational Research, 35*(5), 463–482.

Blair, L. (2016). *Implementing expertise-based training methods to accelerate the development of peer academic coaches* (Unpublished doctoral dissertation). Southern Illinois University, Carbondale, IL.

Borders, J., Polander, N., Klein, G., & Wright, C. (2015). ShadowBox: Flexible training to impart the expert mindset. *Proceedings of the 6th International Conference on Applied Human Factors and Ergonomics, Procedia Manufacturing, 3*, 1574–1579. https://doi.org/10.1016/j.promfg.2015.07.444

Boshuizen, H. P. A. (2004). Does practice make perfect? In H. P. A. Boshuizen, R. Bromme, & H. Gruber (Eds.), *Professional learning: Gaps and transitions on the way from novice to expert*. New York: Kluwer Academic Press.

Bransford, J. D., & Schwartz, K. L. (2009). It takes expertise to make expertise: Some thoughts about why and how and reflections on the themes in chapters 15-18. In K. A. Ericsson (Ed.), *Development of professional expertise* (pp. 432–448). New York: Cambridge University Press.

Causer, J., Barach, P., & Williams, A. M. (2014). Expertise in medicine: Using the expert performance approach to improve simulation training. *Medical Education, 48*(2), 115–123. https://doi.org/10.1111/medu.12306

Chi, M. T. H. (2006). Laboratory methods for assessing experts' and novices' knowledge. In K. A. Ericsson, N. Charness, P. J. Feltovich, & R. R. Hoffman (Eds.), *Cambridge handbook of expertise and expert performance* (pp. 167–184). New York: Cambridge University Press.

Clark, R. E., Feldon, D., van Merrienboër, J. J. C., Yates, K., & Early, S. (2008). Cognitive task analysis. In J. M. Spector, M. D. Merrill, J. J. G. van Merrienboër, & M. P. Driscoll (Eds.), *Handbook of research on educational communications and technology* (3rd ed., pp. 577–593). Mahwah, NJ: Lawrence Erlbaum Associates.

Collins, A., Brown, J. S., & Holum, A. (1991). Cognitive apprenticeship: Making thinking visible. *American Educator, 15*(3), 6–11, 38–46.

Colvin, G. (2008). *Talent is overrated: What really separates world-class performers from everybody else*. New York: Portfolio.

Coyle, D. (2009). *The talent code: Greatness isn't born it's grown, here's how* (p. 2009). New York: Bantam Books.

Darling-Hammond, L. (2005). *Instructional leadership for systemic change: The story of San Diego's reform*. Lanham, MD: Scarecrow Education.

Dunn, T. G., & Shriner, C. (1999). Deliberate practice in teaching: What teachers do for self-improvement. *Teaching and Teacher Education, 15*, 631–651. https://doi.org/10.1016/S0742-051X(98)00068-7

Dreyfus, H., & Dreyfus, S. (1980). *A five-stage model of mental activities involved in directed skill acquisition.* Supported by the U.S. Air Force, Office of Scientific research (AFSC) under contract F49620-C-0063 with the University of California, Berkeley.

Eccles, D. W., Ward, P., Janelle, C. M., Woodman, T., & LeScanff, C. (2008). Shared interests in solving common problems: How sport psychology might inform human factors and ergonomics. *Proceedings of the Human Factors and Ergonomics Society 52nd Annual Meeting, 52*, 743–747.

Ericsson, K. A. (2006). The influence of experience and deliberate practice on the development of superior expert performance. In K. A. Ericsson, N. Charness, P. Feltovich, & R. R. Hoffman (Eds.), *Cambridge handbook of expertise and expert performance* (pp. 685–706). Cambridge, UK: Cambridge University Press.

Ericsson, K. A. (2008). Deliberate practice and acquisition of expert performance: A general overview. *Academic Emergency Medicine, 15*, 988–994. https://doi.org/10.1111/j.1553-2712.2008.00227.x

Ericsson, K. A. (2015). Acquisition and maintenance of medical expertise: A perspective from the expert-performance approach with deliberate practice. *Academic Medicine, 90*(11), 1471–1485rc.

Ericsson, K. A. (2017). Expertise and individual differences: The search for the structure and acquisition of experts' superior performance. *WIREs Cognitive Science, 8*(1–2), 1–6. https://doi.org/10.1002/wcs.1382

Ericsson, K. A., Krampe, R. T., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review, 100*(3), 363–406. https://doi.org/10.1037/0033-295X.100.3.363

Ericsson, K. A., & Pool, R. (2016). *Peak: Secrets from the new science of expertise*. Boston: Houghton Mifflin Harcourt.

Ericsson, K. A., & Williams, A. M. (2007). Capturing the naturally occurring superior performance of experts in the laboratory: Translational research on expert performance. *Journal of Experimental Psychology: Applied, 13*(3), 115–123.

Fadde, P., & Sullivan, P. (2013). Using interactive video to develop preservice teachers' classroom awareness. *Contemporary Issues in Technology and Teacher Education, 13*(2), 156–174.

Fadde, P. J. (2009a). Expertise-based training: Getting more learners over the bar in less time. *Technology, Instruction, Cognition and Learning, 7*(2), 171–197.

Fadde, P. J. (2009b). Instructional design for advanced learners: Training recognition skills to hasten expertise. *Educational Technology Research and Development, 57*(3), 359–376.

Fadde, P. J. (2009c). Training complex psychomotor performance skills: A part-task approach. In K. H. Silber & R. Foshay (Eds.), *Handbook of training and improving workplace performance. Volume 1: Instructional design and training delivery* (pp. 468–507). San Francisco: Pfeiffer (International Society for Performance Improvement).

Fadde, P. J. (2013). Accelerating the acquisition of intuitive decision-making through expertise-based training (XBT). *Proceedings of the Inter-service/Industry Simulation, Training, and Education Conference*.

Fadde, P. J. (2016). Instructional design for accelerated macrocognitive expertise in the baseball workplace. *Frontiers in Psychology, 7*(292), 1–16. https://doi.org/10.3389/fpsyg.2016.00292/full

Feldon, D. F. (2007). Cognitive load and classroom teaching: The double-edged sword of automaticity. *Educational Psychologist, 42*(3), 123–127.

Ford, P., Coughlan, E., & Williams, M. (2009). The expert-performance approach as a framework for understanding and enhancing coaching performance, expertise and learning. *International Journal of Sports Science & Coaching, 4*(3), 451–463.

Foshay, W. R., Villachia, S. W., & Stepich, D. A. (2013). Cousins but not twins: Instructional design and human performance technology in the workplace. In J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), *Handbook of research on educational communications and technology* (4th ed., pp. 39–49). New York: Springer-Verlag. https://doi.org/10.1007/978-1-4614-3185-5_4

Gladwell, M. (2008). *Outliers: The story of success*. New York: Little, Brown and Company.

Gonzalez, C., Lerch, J. F., & Lebiere, C. (2003). Instance-based learning in dynamic decision making. *Cognitive Science, 27*(4), 591–635.

Hambrick, D. Z., Oswald, F. L., Altmann, E. M., Meinz, E. J., Gobet, F., & Campitelli, G. (2014). Deliberate practice: Is that all it takes to become an expert? *Intelligence, 45*, 34–45.

Harris, K. R., Eccles, D. W., Ward, P., & Whyte, J. (2013). A theoretical framework for simulation in nursing: Answering Schiavenato's call. *Journal of Nursing Education, 52*(1), 6–16. https://doi.org/10.3928/01484834-20121107-02

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review, 16*(3), 235–266.

Hoffman, R. R., Ward, P., Feltovich, P. J., DiBello, L., Fiore, S. M., & Andrews, D. H. (2014). *Accelerated learning: Training for high proficiency in a complex world*. New York: Psychology Press.

Hubal, R., & Parsons, T. (2017). Synthetic environments for skills training and practice. In L. Lin & J. M. Spector (Eds.), *The sciences of learning and instructional design: Constructive articulation between communities* (pp. 1–22). New York: Taylor-Francis/Routledge.

Johnson, A., & Proctor, R. W. (2017). *Skill acquisition and training: Achieving expertise in simple and complex tasks*. New York: Routledge.

Jonassen, D. (2011). *Learning to solve problems: A handbook for designing problem-solving learning environments*. New York: Routledge.

Jonassen, D. (2012). Designing for decision making. *Educational Technology Research and Development, 60*, 341–359. https://doi.org/10.1007/s11423-011-9230-5

Jung, E., Kim, M., & Reigeluth, C. M. (2015). Learning in action: How competent professionals learn. *Performance Improvement Quarterly, 28*(4), 55–69. https://doi.org/10.1002/piq.21209

Kahneman, D., & Klein, G. (2009). Conditions for intuitive expertise: A failure to disagree. *American Psychologist, 64*(6), 515–526. https://doi.org/10.1037/a0016755

Klein, G. (1998). *Sources of power: How people make decisions*. Cambridge, MA: MIT Press.

Klein, G. (2015). A naturalistic decision making perspective on studying intuitive decision making. *Journal of Applied Research in Memory and Cognition, 4*, 164–168.

Klein, G., & Wright, C. (2016). Macrocognition: From theory to toolbox. *Frontiers in Psychology, 7*(54), 1–5. https://doi.org/10.3389/fpsyh.2016.00054

Klein, G. A., & Hoffman, R. (1993). Seeing the invisible: Perceptual/cognitive aspects of expertise. In M. Rabinowitz (Ed.), *Cognitive science foundations of instruction* (pp. 203–226). Mahwah, NJ: Lawrence Erlbaum.

Lajoie, S. P. (2003). Transitions and trajectories for studies of expertise. *Educational Researcher, 32*(8), 21–25.

Larkin, P., Mesagno, C., Spittle, M., & Berry, J. (2015). An evaluation of video-based training programs for perceptual-cognitive skill development: A systematic review of current sport-based knowledge. *International Journal of Sport Psychology, 46*, 555–586. https://doi.org/10.7352/IJSP2015.46.555

Lin, L., & Spector, J. M. (Eds.). (2017). *The sciences of learning and instructional design: Constructive articulation between communities*. New York: Taylor-Francis/Routledge.

Macnamara, B. N., Hambrick, D. Z., & Oswald, F. L. (2014). Deliberate practice and performance in music, games, sports, education, and professions: A meta-analysis. *Psychological Science, 25*(8), 1608–1618.

MacroCognition LLC. (n.d.). *ShadowBox Approach*. Retrieved from https://www.shadowbox-training.com/the-shadowbox-approach

Mann, D. T. Y., Williams, A. M., Ward, P., & Janelle, C. M. (2007). Perceptual cognitive expertise in sport: A meta-analysis. *Journal of Sport & Exercise Psychology, 29*, 457–478.

Merrill, M. D. (2002). First principles of instruction. *Educational Technology Research and Development, 50*(3), 43–59.

Molenda, M. (2010). Origins and evolution of instructional systems design. In K. H. Silber & W. R. Foshay (Eds.), *Handbook of improving workplace performance* (Instructional design and training delivery) (Vol. 1, pp. 53–92). San Francisco: Jossey-Bass/Pfeiffer.

Müller, S., & Abernethy, B. (2012). Expert anticipatory skill in striking sports: A review and a model. *Research Quarterly for Exercise and Sport, 83*(2), 175–187.

Razer, A. (2016). *Accelerating the noticing skills of nursing and medical students using staged video simulation* (Unpublished doctoral dissertation), Southern Illinois University, Carbondale, IL.

Richey, R. C., Klein, J. D., & Tracey, M. W. (2011). *The instructional design knowledge base: Theory, research, and practice*. New York: Routledge.

Roca, A., & Williams, A. M. (2016). Expertise and the interaction between different perceptual-cognitive skills: Implications for testing and training. *Frontiers in Psychology, 7*, 792. https://doi.org/10.3389/fpsyg.2016.00792

Rosaen, C. L., Lundeberg, M., Cooper, M., Fritzen, A., & Terpstra, M. (2008). Noticing noticing: How does investigation of video records change how teachers reflect on their experiences? *Journal of Teacher Education, 59*, 347–360. https://doi.org/10.1177/0022487108322128

Sancar-Tokmak, H. (2016). Videos as tools of expertise-based training (XBT) for the development of professional development of teachers: XBT videos for teacher development. In P. G. Rossi & L. Fedeli (Eds.), *Integrating video into pre-service and in-service teacher training* (pp. 254–270). Hershey, PA: IGI Global. https://doi.org/10.4018/978-1-5225-0711-6.ch013

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.

Schraagen, J. M. (2009). Designing training for professionals based on subject matter experts and cognitive task analysis. In K. A. Ericsson (Ed.), *Development of professional expertise* (pp. 157–179). New York: Cambridge University Press.

Sherin, M. G., & van Es, E. A. (2005). Using video to support teachers' ability to notice classroom interactions. *Journal of Technology and Teacher Education, 13*(3), 475–491.

Simon, H. A., & Chase, W. G. (1973). Skill in chess. *American Scientist, 61*, 394–403.

Syed, M. (2010). *Bounce : Mozart, Federer, Picasso, Beckham, and the science of success*. New York: Harper.

Tynjälä, P. (2008). Perspectives into learning at the workplace. *Educational Research Review, 3*(2), 130–154.

van Gog, T., Ericsson, K. A., Rikers, R. M. J. P., & Paas, F. (2005). Instructional design for advanced learners: Establishing connections between the theoretical frameworks of cognitive load and deliberate practice. *Educational Technology Research and Development, 53*(3), 73–81.

Van Merriënboer, J. J. G. (1997). *Training complex cognitive skills: A four-component instructional design model for technical training*. Englewood Cliffs, NJ: Educational Technology Publications.

van Merriënboer, J. J. G., & Boot, E. W. (2009). Research on past and current training in professional domains: The emerging need for a paradigm shift. In K. A. Ericsson (Ed.), *Development of professional expertise* (pp. 131–156). New York: Cambridge University Press.

Ward, P., Farrow, D., Harris, K. R., Williams, A. M., Eccles, D. W., & Ericsson, K. A. (2008). Training perceptual-cognitive skills: Can sport psychology research inform military decision training? *Military Psychology, 20*, S71–S102.

Ward, P., Hodges, N. J., Starkes, J. L., & Williams, M. A. (2007). The road to excellence: Deliberate practice and the development of expertise. *High Ability Studies, 18*(2), 119–153.

Ward, P., Suss, J., & Basevitch, I. (2009). Expertise and expert performance-based training (ExPerT) in complex domains. *Technology, Instruction, Cognition and Learning, 7*, 121–146.

Ward, P., Williams, A. M., & Hancock, P. A. (2006). Simulation for performance and training. In K. A. Ericsson, N. Charness, P. J. Feltovich, & R. R. Hoffman (Eds.), *Cambridge handbook of expertise and expert performance* (pp. 243–262). New York: Cambridge University Press.

Williams, A. M., Fawver, B., & Hodges, N. (2017). Using the 'expert performance approach' as a framework for improving understanding of expert learning. *Frontline Learning Research, 5*(3), 64–69.

Yates, K. A., & Clark, R. E. (2012). *Cognitive task analysis*. New York: Routledge.

Zimmerman, B. J. (2006). Development and adaptation of expertise: The role of self-regulatory processes and beliefs. In K. A. Ericsson, N. Charness, P. J. Feltovich, & R. R. Hoffman (Eds.), *Cambridge handbook of expertise and expert performance* (pp. 705–722). New York: Cambridge University Press.