Chapter 4
The Interplay of Knowledge, Strategies, and the Interest in the Development of Expertise within Professions

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For the past quarter century, I have investigated the nature of expertise in specific domains, and the factors and forces that shape individuals' journeys from novice to expert in professional fields (Alexander, 1997, 2018b). Within this chapter, I will characterize the central role that knowledge plays in individuals' professional development and how knowledge interacts with strategic processing and interests throughout the journey toward expertise (Ackerman, 2003; Alexander, 2004; Chase & Simon, 1973; Chi, Glaser, & Farr, 1988). The framework I employ to capture the dynamic changes that individuals undergo in their professional development is the Model of Domain Learning or MDL (Alexander, 1997, 2003). I will make evident that knowledge is a centerpiece of the MDL and core to each stage in the journey toward expertise in any profession.

Conceptualizing Professions, Expertise, and Knowledge

One problem that has long plagued the social sciences is a lack of conceptual specificity (Alexander, Schallert, & Hare, 1991). Within the physical and life sciences, as well as certain more applied professions such as engineering, practitioners commonly and consistently define those concepts regarded as foundational to the field. A kilometer is denoted the same in Germany and New Zealand; a quark means the same to an astrophysicist working in a laboratory in Switzerland or in the United States. Regrettably, the same is not true for key concepts

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in the social sciences. Rather, practitioners of social science fields like education, psychology, and sociology, more often only poorly, variably, or loosely define core terms in professional discourse, or simply leave them unspecified (Murphy & Alexander, 2000). I thus begin this examination by explaining the meanings ascribed to the terms profession, expertise, and knowledge. I have also assembled a glossary of the italicized terms that appear in this chapter, along with illustrative examples, to further clarify their meaning (see Appendix).

Professions Characterized

For more than 100 years, the answer to the question of what constitutes a profession has remained elusive (Alexander, 1998). There is no shortage of characterizations or standards that have been proffered, often by communities of practice arguing for their recognition as professions (Cogan, 1955; Klass, 1961; Saks, 2012). Nonetheless, there are certain agreed-upon attributes of professions that distinguish them from related terms such as trade, vocation, or job. Specifically, *professions* are particular fields or domains that require formal preparation occurring over an extended time frame. This formal preparation time allows individuals to acquire the extensive body of specialized *knowledge* and *competencies* deemed essential to successful performance in that field. Further, membership into a profession is typically marked by degrees, examinations, or certifications intended to ensure that those requisite knowledge and competencies have been duly obtained. Within professions, there can also be monitoring of members to recertify their qualifications and a review of performance standards for the field to ensure the expected knowledge and competencies are current. Finally, members of professions often have an obligation to apply their specialized knowledge and competencies in service to others, such as clients, patients, or students.

According to Klass (1961), the earliest professions (i.e., divinity, law, and medicine) were directly aligned with the founding of the earliest universities. Even today, preparation for entry into professions remains largely the purview of higher education and professional schools. The domains of study within higher education—from economics to engineering—are the academic roots of professions. Thus, it is presumed that those who have successfully matriculated from universities and then completed their required studies in graduate or professional schools have achieved at least a foothold in their chosen professions.

The Nature of Expertise

As noted, the training that college students receive is an intended initial step toward entry into their chosen professions. However, this achievement represents only the first stage in the long journey toward expertise. *Experts*, as I will endeavor to establish, are those select few within a profession who are widely recognized for their exceptional body of knowledge, creative insights or innovations, and outstanding problem-solving abilities, which researchers now see as pivotal to expertise development. Yet, this was not always the case. Although the systematic study of expertise traces back to Sir Francis Galton (1874/1970), the characterization offered here represents a more contemporary perspective. What fascinated Galton was the relation between "eminence" and heredity. In effect, he wanted to determine what genetic traits accounted for exceptional achievements—a pattern he observed within families, from which he surmised that parents passed these traits down to their offspring.

By the mid-twentieth century, fascination with exceptional performance had largely moved away from a focus on heredity and into the realm of *cognition* or the operations of the human mind. Researchers directed their attention toward the nature of mental processes and abilities manifested by experts (Ericsson & Charness, 1994; Groen & Patel, 1988). A primary catalyst for the growing interest in cognitive factors and processes were the emergent domains of cognitive science and computer science, and particularly the nascent field of artificial intelligence (AI). Although analytical machines had been around since the late 1800s, it was not until the 1940s, when these machines became powerful enough to solve algorithmic problems, that they came to be called computers.

By the late 1950s and early 1960s, with the influence of such powerhouses as Nobel Prize winning economist Herbert Simon, his colleague William Chase (Chase & Simon, 1973), and others (e.g., Newell & Gregor, 1999), AI researchers dedicated themselves to unraveling the mysteries of the "black box" of the human mind. They wanted to determine what happens when humans go about solving problems and what distinguishes expert performers from novices (Ericsson & Charness, 1994). They aimed to use what they discovered to fashion intelligent machines capable of mimicking expert behaviors. These researchers needed to identify those who were "experts" at such tasks so that their computer models could approximate the thinking and behaviors of these high performers. Chess was a favorite arena of intense investigation: An ideal venue for such study due to the contained problem space (the chess board), the limited number of elements (the pieces), and the regulated movements for each piece. Yet, there were clearly those who excelled at the game, notably the Grandmasters. What researchers learned through these investigations was that expert players had studied masters of the past, had accumulated rich knowledge of prior games and exceptional tactics, and could envisioned the game as a series of coordinated moves.

In addition to chess, researchers investigated problem solving among experts and novices in medicine, waitressing, economics, law, typewriting, and computer programming (e.g., Gentner, 1988; Ericsson & Polson, 1988; Voss, Blais, Means, Greene, & Ahwesh, 1986). Along with problem-solving strategies and tactics, cognitive scientists became intrigued with the significant differences in the depth and structure of knowledge that experts displayed compared to novices (Schoenfeld & Herrmann, 1982). With their findings, this research generation firmly established the influential role that knowledge plays in expert performance and the effects on the implemented problem-solving strategies. However, there were constraints on what these researchers learned about the correspondence between knowledge and expertise development during this period, as they targeted task domains like waitressing or typewriting that do not require the extended training nor exhibit the intricacies ascribed to professions like medicine, economics, or computer science (Groen & Patel, 1988).

Although the insights gained from the expertise research in the late 1970s and 1980s were quite informative, the study of expertise and expertise development specific to professional domains required significant transformations in research methods and approaches (Ackerman & Heggestad, 1997; Sternberg, 2003). Multidimensionality, developmental orientation, and the expansion of the novice-expert dichotomy characterize this newer phase of expertise research (Dreyfus & Dreyfus, 2005; Hatano & Oura, 2003). The Model of Domain Learning (Alexander, 2018b) reflects this altered characterization of expertise and the expanded role that knowledge plays in professional development.

Knowledge

As I have argued, many concepts central to professions and expertise are only loosely or poorly defined (Dinsmore, Alexander, & Loughlin, 2008; Murphy & Alexander, 2000). One plausible explanation for this occurrence may be the unwarranted assumption that these concepts are so basic or commonplace that one can take their meanings for granted. There is no better example of this misguided assumption than the concept of *knowledge*. Researchers from such diverse fields as educational psychology, information sciences, cognitive neuroscience, philosophy, and communications have also provided ample evidence that misconceptions about knowledge can be highly consequential for (a) what individuals come to understand or believe, and (b) the decisions and choices they make or the actions they take, either consciously or unconsciously (Alexander, 1996; Alexander, Winters, Loughlin, & Grossnickle, 2012). To the layperson, knowledge may appear to be a simple, straightforward notion that needs no further explication, but to those who investigate human learning, expertise, or professional development, its definition is far from simple or straightforward.

For one thing, the meaning of knowledge varies according to whether one adopts a philosophical or psychological perspective. Philosophers who expressly study knowledge or *epistemology* define the word as referring to beliefs that have been justified or shown to be true on the basis of evidence. Laypersons may attach no set meaning the notion of knowledge, and therefore easily supplant it with words like information, data, awareness, or facts. Yet, subtle differences in the meanings ascribed to knowledge may emerge in people's everyday discourse, as when someone claims: "I know *about*….;" "I know *of*…;" or "I know *that*…" This latter statement seems to be closest to the philosophical definition of knowledge as "justified true belief" (Grossnickle, List, & Alexander, 2015). Finally, for educational psychologists like me, knowledge signifies that information encountered in the external world that ultimately becomes part of individuals' internalized mental storehouse and, thus, their mental universe (Alexander, 2006). That internalized knowledge can consequently be accurate or inaccurate, significant or trivial, explicit or tacit. It is this cognitive perspective on knowledge and the process of knowing that I represent in my model of expertise.

One other aspect of this cognitive bases of knowledge that has bearing on the examination of expertise within the professions pertains to the forms of knowledge. Although a litany of knowledge forms exist that I could overview, three are particularly relevant to professional development: declarative, procedural, and conditional knowledge, or simply the *what*, *how*, and *when* of knowledge, respectively (Alexander, 2006; De Jong & Ferguson-Hessler, 1996). As the "what," *declarative knowledge* comprises the particulars, facts, descriptions, or statements individuals can offer about some object, idea, or event (e.g., "This is a dog"; "Dover is the capital of Delaware"; "Economics is my area of expertise"). On the other hand, *procedural knowledge*, the "how," pertains to knowing how to successfully exert some process, technique, or routine. As an educational psychologist, I am able to name and describe five strategies for improving memory (declarative), but procedural knowledge requires that I can actually implement those strategies effectively.

The final form of knowledge, *conditional knowledge*, is the one that receives far too little attention during K-12 education, despite the vital role it plays in expertise. Conditional knowledge is vital because it pertains to when and where existing knowledge or competencies are to be utilized. Let me explain its importance with an illustrative case. Some nursing students had successfully learned what vitals they needed check when patients first entered a hospital or clinic (declarative knowledge) and how to perform routine procedures such as taking blood pressure, administering a shot, or inserting an IV (procedural knowledge). What these nursing students found harder to grasp, however, were the conditions under which they should not perform these "routine" procedures, or should perform them in a non-routine way. It can be challenging for non-experts to understand precisely when they should activate their acquired declarative and procedural knowledge. Yet for those working in professional domains, all three of these knowledge forms must operate smoothly and interactively if they are to achieve successful performance.

A Model of Expertise Development

The driving question that sparked the formulation of the Model of Domain Learning or MDL (Alexander, 1997, 2018b) was: What is the nature of expertise development? Simply defined, *expertise development* refers to the systematic changes that take place in individuals from when they are first exposed to a particular field of study until they reach the highest level of proficiency in that field. My search for an empirically-grounded answer to that question ultimately led me to conceptualize the model I present here. However, before introducing the MDL, let me position it within a richer context that acknowledges both the larger or macro-forces and the more particularized or micro-factors that can propel or prohibit expertise development in any profession.

For that reason, I describe the MDL as a mid-level model of expertise development to acknowledge that there exist macro-forces—societal, cultural, political, and economic—that can alter the course of individuals' movement toward expertise. Likewise, individual difference factors such as memory, perception, attention, or spatial ability operate at the micro-level that can impede or facilitate professional growth. These macro-forces and micro-factors fall outside of the MDL's scope. In that sense, the MDL is not a complete model of expertise development; but then, no model of such a complex phenomenon is ever truly complete.

Unique Contributions

Despite these just-acknowledged limitations, the MDL's adopters sought to expand prevailing views of expertise and expertise development in several ways, including how knowledge is conceptualized and seen to interact with other essential components. Those contributions include the following:

- *They discounted the notion that individuals can be simply categorized as either novices or experts in any profession.*

Across the decades of expertise studies, researchers have treated expertise dichotomously. They have labeled individuals as experts or novices, with nothing in between. Yet, in reality, few individuals are true novices if they have been exposed to domains as part of their formal education. Nor are most individuals practicing in professional settings true experts according to the characterization forwarded in the MDL. This false novice/expert dichotomy complicates one's ability to position individuals accurately as they learn and develop within their professions. Thus, the MDL's developers set out to accurately describe those who fall between novice and expert in complex domains.

- *They replaced the dichotomous models of the past with a three-stage model of expertise development.*

To represent the journey toward expertise more fully and more realistically, I have incorporated a stage of development between novice and expert, which I have labeled competence. With this label, I intend to convey that those within this intermediate stage are able to function adequately or competently within their professions, albeit to differing degrees. These competent individuals have oriented themselves to the profession and the knowledge and processes it entails, but they have yet to reach the point where they are performing at an expert level. The MDL is not the only multiple-stage model of expertise in the literature. With their Five-Stage Model (Dreyfus, 1982, 2004; Dreyfus & Dreyfus, 2005), the Dreyfus's also describe a developmental progression from beginner to expertise in complex domains. One critical difference between the MDL and the Dreyfus model is that the five stages of the five-stage model pertain only to skill acquisition and not to all facets of expertise considered in the MDL.

- *The MDL is predicated on the assumption that only a relatively few members of any professional community will achieve expert status.*

One of the vagaries of prevailing theories of expertise is whether any or all individuals can conceivably reach this pinnacle within professional domains. In contrast, does the confluence of factors and forces that must be achieved and maintained over years make it likely that only a relative few who begin the journey will cross the threshold into expertise? Although the reality may be hard to accept, only a small percent of any professional community is likely to achieve expertise as characterized in the MDL. Some stumble due to a lack of opportunities and experiences that would propel them forward. Some falter because the struggles to acquire increasingly complex knowledge and relevant competencies prove overwhelming. Still others choose to end their pursuit of expert status because the personal costs were too high or the personal gains were too low.

- *There was explicit recognition that non-cognitive factors, such as interest, influence expertise development.*

Another area of concern is the portrayal of expertise in theory and research as a "coldly cognitive" enterprise (Pintrich, Marx, & Boyle, 1993), attributable solely to such factors as knowledge, hours of deliberate practice, or problem-solving skills. However, it is inconceivable that expertise in any profession is achieved without individuals' deep, personal commitment to that pursuit. Therefore, unlike coldly cognitive models, the MDL's developers incorporated a motivational component in the form of interest as key to the attainment of expertise. With these unique contributions of the MDL overviewed, let me introduce its stages and principal components. I will also endeavor to illustrate how the interplay of those components over time shapes the journey toward expertise in professional domains and gives each of the model's stages its distinguishing characteristics.

MDL Stages

As previously stated, the development of expertise in the MDL unfolds in three stages: acclimation, competence, and proficiency or expertise (Fig. 4.1). Those familiar with the Dreyfus model (1982) will note certain similarities in the titles attached to stages. The initial stage of development for all individuals, whether they seek to become experts or not, is *acclimation*. I have chosen this label, acclimation, for this initial stage to communicate that these neophytes must first become oriented to a domain or a profession. For example, what does a neurobiologist do or what does a career in macroeconomics really involve? Whether exposure to a domain begins in primary, secondary, or tertiary school, students are unlikely to have formulated a rich picture of what practice in professions encompass (Twenge, 2017). Nonetheless, this early exposure to professional fields can plant the seeds for continued pursuit. For many, that continued pursuit occurs when tertiary students

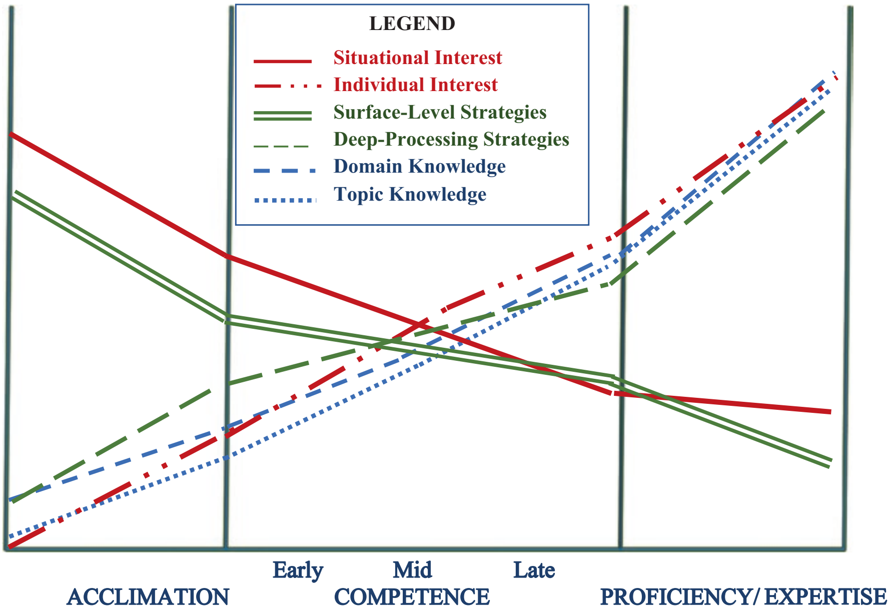

Fig. 4.1 The stages and components of the Model Of Domain Learning. Source: Design by author

declare a major or field of study and gain knowledge, problem-solving strategies, and interests needed to step over the threshold into competence.

As the intermediate stage in expertise development, *competence* occupies the greatest span in the journey from acclimation to proficiency. This is also the stage in expertise development where most individuals practicing in professional domains eventually settle. That is one reason I parsed this stage into three periods, early, mid, and late competence. This period is pivotal to professional development in that individuals will make significant career decisions during it. Specifically, when individuals reach early or mid-competence, they will likely have a better understanding of the domains in which they feel capable and personally interested. Based on those judgments, these individuals may consider subsequent educational or work experiences that could propel them deeper into competence.

Finally, the select few who continue to grow their declarative, procedural, or conditional knowledge, hone their strategic capabilities, and deepen their interest in a profession, may realize the final stage of *proficiency* or *expertise*. Yet simply stepping from competence into proficiency does not ensure that individuals will merit the designation of expert in perpetuity. The pursuit of expertise does not cease. It demands continued dedication because professional domains are not fixed or stagnant. Rather, professions undergo change—some more rapidly than others (e.g., computer technology versus philosophy).

MDL Components

In many ways, the specific components that comprise the MDL and the nature of their interactions over time set it apart as a model of expertise development. I have already been introduced one key component, *knowledge*, that is central to this chapter. Generally speaking, knowledge encompasses all the declarative, procedural, and conditional understandings that individuals have acquired, whether those understandings represent formal or informal, real or abstract, accurate or misleading information. However, when one focuses on a specialized field of study, as in the MDL, two forms of knowledge become significant to expertise development: domain and topic knowledge. *Domain knowledge* represents the scope or breadth of declarative, conceptual, and procedural knowledge associated with that field, whereas *topic knowledge* pertains to the depth of knowledge one possesses about particular objects, ideas, or experiences specific to the profession (Alexander et al., 1991).

Let me illustrate the distinction between domain and topic knowledge by drawing on an example of a meteorologist, Jackson, working with a local weather station. The scope of information that Jackson possesses about his field—including weather systems, humidity, climate changes, and extreme weather conditions—constitutes his domain knowledge. However, as a meteorologist in Oklahoma, Jackson has acquired far more topic knowledge related to tornadoes (common in this state) and seasonal temperature that are critical to farmers in his local area. As I show in Figure 4.1, both domain and topic knowledge are expected to grow incrementally across the stages of development. Qualitative changes, too, occur.

Specifically, domain and topic knowledge for those who have yet reached competence are often spotty or piecemeal and not well connected. This means that students learning about weather in school may have learned about tornadoes, but they do not understand how tornadoes are tied to other atmospheric or meteorological topics such as humidity, pressure cells, and more. Those approaching expertise or in the stage of proficiency, by comparison, have a wealth of both domain and topic knowledge about meteorology, but more importantly understand how all that knowledge is interconnected and mutually informative. What these experts possess, according to Gelman and Greeno (1989), is *principled knowledge*.

Along with knowledge, another component has long been a part of contemporary characterizations of expertise—strategic processing (Alexander, Graham, & Harris, 1998; Dinsmore, Fryer, & Parkinson, 2020). *Strategies* are a special class of procedural knowledge that individuals purposefully or intentionally employ when encountering problems that require solution or resolution (Dinsmore, 2017). When researchers report differences between novices' and experts' problem-solving abilities, approaches, and effectiveness, they are describing strategy differences. Researchers long presumed that experts employ more strategies during problem solving than non-experts. However, when I tested that presumption in the early 1980s, that relation between frequency of strategy use and level of expertise did not emerge (Alexander & Judy, 1988). This led me to delve deeper into the nature of strategies, which in turn resulted in a distinction between surface-level and deep-processing strategies (Fig. 4.1).

Surface-level strategies, as the name implies, are those with which one focuses on the surface or given elements of a problem or task (Dinsmore & Alexander, 2016). By comparison, *deep-processing strategies* involve the manipulation, transformation, reframing, or reformulation of given problems. Let me use an example to illustrate the differences in these two forms of strategies. Two doctoral students in a statistics course are given a dataset that was collected to test the effects of two writing interventions and a control condition on the quality of students' argumentative essay writing. Their task was to construct and to test a model with which one could assess the change from pre- to post-intervention. One student opens the software program he is familiar with and, together with the software manual, starts working step-by-step through a simple repeated measures ANOVA procedure to assess the change, simply feeding the data into the program.

The other student first inspects the dataset to ensure that she chooses a modeling approach that is compatible with the messy nature of classroom data while maximizing the likelihood that a real effect, if present, is detected. Then, she checks that her data meet all the assumptions for two completing theoretically plausible structural equation models (SEM) she intends to fit. Although both students are being strategic, the former is staying close to the problem given, whereas the second is delving more deeply into what successful task completion requires. Thus, the first student is demonstrating more surface-level strategies, whereas the second student is employing deep-processing strategies. Deep processing may also entail determining the most effective strategies needed to achieve success, along with the monitoring of performance (Dinsmore & Fryer, 2019). The second student's decision to test two competing models is illustrative of this type of reasoning and monitoring.

As I show in Figure 4.1, there is a heavy reliance on surface-level strategies in acclimation with that dependency decreasing during competence. In contrast to the trajectory of surface-level strategies, deep-processing strategies manifest infrequently in acclimation, with an increase during competence. Similarly, the reliance on deep-processing strategies takes a sharp upturn during proficiency because of experts' engagement in the generation of new knowledge. Although I have here drawn a sharp distinction between these two forms of strategy, it is critical to recognize that development in any professional domain requires the utilization of both surface-level and deep-processing strategies in an orchestrated fashion. Where the MDL and the Dreyfus model (1982, 2004), previously mentioned, seemingly converge is in the expectation that movement across stages of expertise are marked by the increased automaticity of common procedures, routines, or problem types—what Dreyfus calls intuition. This automaticity largely fuels the MDL's decreased reliance on surface-level strategies, permitting greater attention to deeper issues, questions, or concerns as signified by the rise in deeper-processing strategies.

The final component defining the MDL is the element that differentiates this expertise model from those that are entirely cognitive—*interest* (Hidi & Renninger, 2006; Schiefele, 1991). In general, interest signifies an object, idea, or event that draws persons' attention or has personal value to them (Garner, Alexander, Gillingham, Kulikowich, & Brown, 1991; Murphy & Alexander, 2000). Within the literature, authors have conceptualized and operationalized two forms of interest that are represented in the MDL: individual and situational interest. Like many other contemporary scholars, researchers' views on individual interest in the MDL have been greatly influenced by the writings of John Dewey (1903, 1913).

Individual interest, or what Dewey called true interest, is a driving force that originates from within persons and that reflects their values, personal investment, and self-identity (Hidi & Renninger, 2006; Schiefele, 1991). Individual interest in professional domains is unlikely to manifest during acclimation. However, individual interest in a profession may show signs of emergence in late acclimation and grow during competence as individuals are schooled in the academic domains that are the roots of professions (Fig. 4.1). A particular turning point in expertise development in the MDL is predicted to occur in mid-competence when individuals' individual interest can be a catalyst for their pursuit of additional educational or work experiences. Students who find that they enjoy mathematics, for instance, may elect to pursue more advanced mathematics courses in secondary school which, in turn, may lead them to contemplate careers that center around mathematics, such as economics, statistics, mechanical engineering, physics, or mathematics. Thus, from mid-competence onward, this strengthening personal interest may become tied to one's professional identity. For some individuals, personal and deep-seated investment in the profession continues to rise well into the proficiency stage, sustaining momentum for years.

Situational interest follows a very different path than individual interest over the stages of expertise development. In contrast to internally-driven and enduring individual interest, *situational interest* is short-lived or fleeting attraction that is bound to conditions within the immediate context that capture attention, prove fascinating, or pique curiosity (Garner, Gillingham, & White, 1989; Schiefele, 1991). Understandably, those in acclimation or early competence require an environment that is situationally interesting to draw their attention or pique their curiosity about domain-related ideas and processes. Moreover, although the influence of situationally-interesting content and contexts declines as individuals progress toward expertise, it never completely disappears. Humans are curious by nature and drawn to ideas, events, or experiences that they perceive as surprising, intriguing, or novel. Even those who are highly competent or proficient in their professions can find themselves fascinated by some anomalous or unexpected occurrence. Thus, although situational interest continues to play a role in professional development, its relative importance vis-à-vis individual interest declines dramatically over time (Fig. 4.1).

Characterizing the Interplay of Knowledge with Strategic Processing and Interest

Although I have described each of the MDL's components separately in the preceding discussion, it is critical to understand that it is the different ways knowledge, strategic processing, and interest interact across the stages of professional development that becomes more determinative. To make that point more clearly and emphatically, I want to return to the central focus of this chapter, knowledge, and illustrate how changes in individuals' knowledge are pivotal to the professions they pursue and how competent or even proficient they become in those professions. The approach I have taken is to posit claims about knowledge within the professions that I then explicate and illustrate.

- *A rudimentary level of knowledge is requisite to formulate realistic ideas about what a profession is and what would be expected of those working within that profession.*

Those reading this chapter may well have committed to and be currently engaged in a specific profession. As you reflect back on your personal path to that career pursuit, you may recollect the point in your life when you decided to follow this professional course. It would be rare, indeed, if that critical juncture occurred in childhood, when youngsters envision becoming pirates, princesses, doctors, or maybe astronauts. Instead, it may have been in college that you first gave serious thought to your future career. One reason for this chronology is that it takes time to acquire knowledge about what professions exist in the world and what precisely members of those professions do. People also require time to learn about their own capabilities and interests relative to the tasks and responsibilities aligned with a given profession. This *self-knowledge*, all the information individuals possess about themselves, can be academic in nature (e.g., "I am not particularly good at mathematics") or center on personality traits (e.g., "I do not have the patience or empathy to be a good therapist") or values (e.g., "I need a career that pays very well"). Chosen careers likely fall in the area where professional and personal attributes and values are most compatible—a determination that requires an adequate base of knowledge about professions and about the self.

- *A rich body of knowledge allows professionals to deeply analyze problems common to their fields and to select and execute appropriate strategies efficiently and elegantly.*

When it comes to the relations between knowledge and strategic processing, one can extrapolate from the earlier discussion of expert chess players to professions like medicine, engineering, psychology, or law. Those who are highly competent or proficient in their professions have accumulated a great deal of knowledge about problems or tasks that are commonplace in their fields. Consequently, they spend almost no time on surface-level strategies dedicated to understanding the nature or underlying structure of these rather routine problems or tasks. Instead, they can direct their cognitive energy toward more complex problems, devising alternative ways for attacking existing problems, or creating new problems that other members of the field have not yet addressed.

- *Although those in all stages of development continue to acquire new knowledge about their profession, experts are also expected to generate new knowledge or achieve new insights relevant to their field.*

One characteristic that sets experts apart from those in all the other stages is very directly related to knowledge. In effect, those who merit the designation of "expert" are required to contribute new knowledge, insights, or practices to the profession. When one is an acknowledged expert, it is no longer enough to acquire knowledge or procedures that others have contributed to the domain. Experts are agents of change within their professional communities. It is precisely because of this expectation that researchers hypothesized a spike in deep-processing strategies in proficiency, as these strategies are required to manipulate, transform, reframe, or reformulate existing knowledge and procedures in the domain (Dinsmore & Fryer, 2019).

- *Knowledge gained through in-school and out-of-school experiences can nurture one's interest in a profession.*

Within the interest literature, authors frequently ask: How do individual interests take shape; what are the seeds of such enduring commitments or fascinations? Dewey (1903) argued that those seeds are present in very young children. These "true interests" only need to be recognized and nurtured if they are to thrive. Others contend that situationally interesting experiences might take hold and transform into individual interests (Hidi & Renninger, 2006). Whether the source of such enduring interests is internal or external, there is no question that knowledge gained from in-school or out-of-school experiences is necessary to feed such interests if progress toward expertise is to be sustained or energized.

For those who have achieved competence in professional domains, common experiences they pursue as a result of abiding and enduring interests include continued education in the form of graduate programs or enrollment in professional schools. Internships or specialized on-the-job training are also valuable contributions to new knowledge that can serve to deepen interest directly or expand opportunities that can lead to increased interests. What is important to keep in mind is that individuals are choosing to pursue these professional experiences on their own—these experiences are not mandatory. The voluntary nature of these experiences that both nurture interest and propel individuals toward expertise serves as a reminder that primary-secondary-tertiary educational systems are not constructed to produce experts in any professional field. At best, these mandatory educational systems may be used to build a foundation of professional knowledge and to fan the sparks of individual interest. However, much more is required for individuals to progress deeper into competence or approach expertise (Rikers & Paas, 2005).

The Changing Societal Landscape and Expertise Development

At an invitational conference on the subject of Knowledge and the Professions (Alexander, 2019), I spoke about several significant trends within society at large that are impacting views of knowledge, experts, and expertise development. The growing presence and power of the internet and social media are already shaping perceptions of knowledge, professional domains, and experts. Indeed, it would be impossible to move through the world and not recognize the influence that digital technologies are having in every corner of our lives. From mobile phones, self-driving cars, and Smart boards to GPS devises, e-commerce, and virtual reality, digital technologies are omnipresent. Moreover, their pervasiveness has found its way into educational institutions at all academic levels. Digital technologies have altered how knowledge is generated, transmitted, acquired, and evaluated, including the knowledge associated with professional domains (Alexander, 2018c; Ferguson, Bråten, & Strømsø, 2012). Likewise, this pervasiveness of digital technologies has dramatically affected the valuing of knowledge, which is a centerpiece of the MDL and key to problem identification and strategic processing (Alexander, 2018b; Rapp, Donovan, & Salovich, 2020). Finally, this global change has created new professional domains, while rendering others less relevant, and has allowed for a less mediated path for communicating new knowledge and insights to a wider and more diverse audience (Frey & Osborne, 2017). Let me briefly expand on these transformations and their implications for reframing expertise.

Learners and Learning

As an educational psychologist, I am especially concerned with how the changing "connected" landscape affects how students learn, how instructors teach, and what school leaders and policymakers value as foundational knowledge and skills. Although the internet has been around for generations, it is only recently that research on the effects of technology has come to the forefront (Anderson & Jiang, 2018; Rosen, 2012). Previously, researchers had focused on how to guarantee that students from all socioeconomic strata had access to the technology they would require for success; how to infuse technology into classrooms and into instructional and assessment routines; and, how to ensure that students were digitally literate (Greene, Seung, & Copeland, 2014; Warschauer, 2003). The few naysayers who dared to wave red flags, like Larry Cuban (1986, 2018) and Neil Postman (1992), were treated as alarmists or luddites. However, the tide has turned—at least to some extent. A burgeoning body of researchers has begun to ask the tough questions about technological effects on learners and learning, such as: What are the long-term effects of children's and youths' dependence on their digital devices? How is social media impacting reasoning and decision making? And what can be done to prevent the weaponization of misinformation? (Sinatra & Lombardi, 2020; Singer & Alexander, 2017a)

What this expanding literature has revealed is that digital technologies have significant implications for expertise development. These implications include students' waning attention and declining self-regulatory abilities, which are requisite for acquiring essential content and for using it appropriately (Richtel, 2010). In addition, researchers have reported that a quarter of 18- to 29-year-olds are almost constantly online (Anderson & Rainie, 2018) and are often spending their time passively in ways that do not promote deeper learner (Rideout, Foehr, & Roberts, 2010). It is worth noting that these papers and reports predated the year-long pandemic, which sparked forced quarantines and online learning. Conceivably, the picture of technology use and learning has only darkened.

Further, there is an increasing tendency for those who have grown up in this digitally-obsessed world—the iGeneration (Twenge, 2017)—to mistakenly assume that they do not need to build a knowledge base, as they can easily and almost instantaneously find everything online. Yet, the ability to navigate the flood of online data to find accurate information is tied directly to individuals' existing knowledge and their skills at distinguishing credible information from misleading content (Alexander, 2018a; Sinatra & Lombardi, 2020). There is also ample evidence that many individuals lack the ability to accurately judge their understanding or the quality and accuracy of their performance (i.e., calibration), especially when working in online environments (Singer & Alexander, 2017b). Yet the concerns are not solely cognitive. Researchers have reported an increased sense of isolation among the iGeneration; a rise in reported cases of depression and even suicide; a decline in basic human interaction skills; and struggle to carry on face-to-face conversations (Rosen, Whaling, Rab, Carrier, & Cheever, 2013; Twenge, 2017). Again, these are now likely conservative estimates, given the potential effects of forced isolation during the COVID-19 pandemic (Pfefferbaum & North, 2020).

What lines can one draw between these shifting characteristics of learners and the learning process and the MDL? For one thing, many within the iGeneration have an overly simplistic view of knowledge. They believe that knowledge entails simple answers they can quickly and rather effortlessly find online (e.g., "Hey Siri"). They do not necessarily regard knowledge as a valued commodity to be actively pursued. That bodes poorly for these individuals' ability to acquire the extensive and principled knowledge essential for professional development (Grossnickle et al., 2015). Relatedly, the ease of locating information with little mental effort and without critical analysis of its legitimacy or validity works against the development of deeper-processing strategies (List, Grossnickle, & Alexander, 2016). Unless learners put themselves in positions to struggle cognitively with an issue, and unless they have occasions to transform or reframe problems, their likelihood of progressing into competence in any profession is jeopardized. Finally, as I noted, there is an intricate and reciprocal relation between knowledge and individual interest (Alexander, Jetton, & Kulikowich, 1995; Hidi & Renninger, 2006). In essence, the more learners forge principled knowledge in a professional domain, the greater their reported interest in and identity with that field. Therefore, without the active pursuit of knowledge, these individuals' interest in professional development may wane and their progress toward expertise may stall.

The Nature of Professions

I grant that the picture I have painted seems cheerless and decidedly one-sided. I acknowledge that there are untold advantages accrued from living, learning, and working within today's technology-rich, interconnected world. Yet, my task in this chapter was to consider the implications of current and future conditions for those who may set out to become proficient in professional domains. Toward that end, there is one more formidable trend that must be examined—the automation occurring within professions. Interestingly, those in AI who played a significant role in sparking contemporary interest in expertise have assumed a rather paradoxical position in recent years. Specifically, AI researchers who started out studying the performance of experts in order to program intelligent machines that could approximate human thinking are now striving to build machines that can surpass human performance. This goal reversal was epitomized by the historic chess matches between Deep Blue, the IBM computer, and Garry Kasparov, the world chess champion, in the late 1990s. It was unthinkable that the #1 chess champion in the world would lose to a computer, which is precisely what happened in their second match in 1997. Today, such outcomes for man-versus-machine match-ups would surprise few. That is due to the continued investment in building smarter machines capable of undertaking increasingly more complex, more sophisticated tasks and of performing those tasks faster and more efficiently than humans.

In what way does this push for smarter machines impact the development of expertise? What does the rise of more intelligence machines have to do with the nature and pursuit of proficiency or expertise? To capture that potential influence, there is one more thread that needs to be unraveled—the movement toward more automated jobs (e.g., Lake, Ullman, Tenenbaum, & Gershman, 2017). For example, AI economists Huang and Rust (2018) recently argued that there are four levels of "intelligence" into which jobs and professions can be placed: mechanical (precise, routine, little adaptation required); analytical (algorithmic or rule-based processing, minimal learning involved); intuitive (holistic or integrated thinking necessary); and empathetic (social and emotional awareness and responsiveness critical). Based on their extensive analysis of labor markets, Huang and Rust contended that intelligent machines already have the capacity to perform service jobs that are mechanical in nature as efficiently, effectively, and perhaps even better than humans (call center agents, self-driving vehicles, food ordering/delivery). They also stated that this automation is expanding into more analytical or rule-based jobs, such as those required to diagnosis a car problem or prepare tax forms. Even more prophetically, these AI researchers posited that in the not-too-distant future, machines would render many human workers obsolete in all four areas of intelligence.

Even though I personally find efforts to supplant human workers with smart machines seriously troubling, the deeper concern for the future of expertise development in the professions arises when those efforts come face-to-face with the less desirable habits that today's learners are forming, such as their non-smart use of smart technologies, that make them more vulnerable for replacement. Of course, those in certain professions may find themselves more at risk than others. But the big question is: which professions? Which current professions will survive in generations to come, what new fields will emerge, and which ones will go the way of switchboard operators, milkmen, elevator attendants, or video store clerks? What professions will continue to rely principally on human rather than artificial experts? Or will expertise in complex domains require some purposeful union of human and machine intelligences, as Huang and Rust (2018) concluded?

Although these critical questions remain to be answered, the claims that AI researchers are making about the expanding presence of intelligent machines into the world of professional domains and the decreasing need for certain forms of human intelligence are more likely to become a reality if today's students continue to forego their active pursuit of expertise. On the other hand, if members of the iGeneration:

- refuse to be lulled into accepting a role as passive consumers of information, striving instead to be active producers of knowledge;
- probe and critically analyze information they encounter online and offline, rather than accepting quick, simple answers;
- forge a meaningful interest in professions and personal connections to members of professional communities, instead of relying on moment-by-moment stimulation and superficial relationships;

then these individuals are more likely to make significant progress toward expertise, and to experience greater pleasure and enjoyment in the journey as well. That is a future those invested in the study of expertise and expertise development envision for all who set out in pursuit of proficiency in professional domains. Further, it is a worthy end for all those with the mind, heart, and spirit to undertake this journey toward expertise in any professional domain.

Appendix: Glossary of Key Terms

Term	Definition	Illustrative example
Acclimation	Acclimation is the initial stage in the Model of Domain Learning. During this period of expertise development, individuals become oriented to a field of study and what that field may involve.	The first grader who is introduced to a range of school subjects, from reading to mathematics and science, begins to form a very primitive idea of what these subjects represent and whether she enjoys one or another.
Cognition	Cognition is a term for all the mental processes in which the mind engages, including perception, thinking, comprehending, remembering, reasoning, and decision-making.	As you are reading this definition, you are engaged in cognitive activities such as pronouncing the words, encoding their individual and collective meanings, and perhaps relating what you comprehended to the subject of expertise.

(continued)

Term	Definition	Illustrative example
Competence	The middle stage in the Model of Domain Learning, competence is the period in expertise development when individuals have acquired an adequate base of knowledge, a workable inventory of strategies, and at least a passing interest in a particular profession.	By the time Markus graduated from secondary school, he was quite skilled in mathematics—particularly calculus—and found physics well suited to his interests and abilities. He had decided to pursue a master's degree in physics, for which calculus is vital. These characteristics would place him at mid-competence in the Model of Domain Learning.
Competencies	Within the expertise literature, one can understand competencies as particular skills or capabilities that individuals can demonstrate. Professions typically require their members to possess the competencies deemed foundational to successful performance.	Before Julianne can practice law, she must pass the bar exam. The bar exam is an assessment meant to determine if Julianne has acquired the competencies needed to perform adequately as a contracts lawyer. These basic competencies include functional knowledge of the precedents and principles key to contract law.
Conditional Knowledge	For individuals to draw on their knowledge successfully, they must be aware of when and where that knowledge is best used. This is the conditional form of knowledge.	Mechanical engineers trying to fix a flaw in the city's streetlights must determine which of the possible design procedures would work best for this setting.
Declarative Knowledge	Declarative knowledge is that portion of one's knowledge base that deals with particular details, facts, or state-able content; the "whats" of knowledge.	When a geologist explains the different forms of soil deposits in a region and the natural forces that result in such social deposits, she is sharing declarative knowledge.
Deep-Processing Strategies	When the strategies that individuals implement to aid their learning involve the manipulation, transformation, reframing, or reformulation of the given problem or task, one describes these as deep-processing strategies.	A sixth grader working on math word problems finds the wording of a problem confusing. She decides to recast the problem as a mathematical formula. This ensured that she was focusing on the deep structure of the problem and not the confusing words.
Domain Knowledge	The scope of individuals' knowledge that is related to a particular field of study or a specific profession is called domain knowledge.	As a professor of European History with identified expertise in the Renaissance Period, Dr. Kuhn has a wealth of knowledge about key persons, events, as well as monarchical and religious institutions of this era. He also has extensive knowledge of the conflicts, political alliances, art, music, and traditions across Europe that defined this period.

(continued)

Term	Definition	Illustrative example
Epistemology	Epistemology is the branch of philosophy that deals with knowledge and what it means to know.	To philosophers, knowledge represents “justified true beliefs,” which means that there is sufficient evidence or reason to hold that something is, in fact, true.
Expertise	Expertise refers to the specialized and extensive knowledge and associated competencies or skills that those who are experts in a profession are presumed to have acquired.	In the field of theoretical physics, expertise not only entails the scientific and mathematical knowledge and competencies held by experts in physics, but also requires an ability to devise alternative theoretical notions or envision plausible explanations for phenomena never directly tested.
Expertise Development	Expertise development describes the process of change individuals undergo as they gain knowledge and competencies in a specific domain or field of study.	Jackson was always good at science and decided to major in genetics in college. He went on to earn his master’s and then doctorate in molecular biology. He now holds the position of leading research scientist for a national institute of health. These events describe the course of his expertise development.
Experts	Experts are those select few within any profession who are widely recognized for their wealth of knowledge and consistently exceptional problem-solving abilities, as well as for their creative insights and innovations that advance the field.	K. Anders Ericsson has been acknowledged as an expert in psychology for his groundbreaking theories and research on expertise. He set forth the notion that 10,000 h of deliberate practice are required to achieve expertise in any domain or profession.
Individual Interest	There are those ideas, topics, or experiences that are consistently and deeply intriguing to people and with which they self-identify. These are called individual interests. These individual interests are evident in the activities in which people voluntarily engage and the professions they choose to pursue.	Even as a young child, Adolph was fascinated by how things worked. His parents remarked how he would dismantle every toy he was given. Over the years, Adolph’s fascination became centered on mechanical engineering and the ability to build things that operated effectively on both a large (turbines) and small scale (solar powered toys).
Interest	Interest is a motivation construct that encompasses the attraction, allure, fascination, or value an object, idea, or event holds for a person, whether that sensation is momentary or persistent.	Researchers have demonstrated that humans are predictably draw to surprising, scary, or shocking events, and any references to sex, death, and money. These are described as universally “interesting” stimuli.

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Term	Definition	Illustrative example
Knowledge	When data encountered in the external world is internalized and personalized, becoming part of a person's mental store of information, it is called knowledge.	Referred to as "prior knowledge," when people recall, remember, or reflect they are using their store of knowledge, which colors or shapes what they will subsequently learn.
Principled Knowledge	There are several key concepts or principles that are central to every domain or profession and to which many other concepts, processes, or competencies pertinent to that field are related. When individuals integrate their professional knowledge around these key concepts or principles, they are said to have principled knowledge.	Within biology, two core principles that must be understood are that (a) all living organisms are composed of cells; and (b) the genetic code that determines the nature of that living organism is carried within those cells. A multitude of information learned in biology is tied to these two principles. Those individuals with principled biology knowledge recognize how so much information in their field clusters around these and other core ideas.
Procedural Knowledge	Some knowledge takes the form of processes or an executable sequence of steps; this "how to" knowledge is procedural.	When cognitive scientists conduct experiments, they adhere to the scientific method. Knowing how to carry out this method successfully represents procedural knowledge.
Professions	Professions are particular occupations that require years of preparation in order to acquire the specialized body of *knowledge* and performance *competencies* that have been established as essential to successful practice. Evidence of the attainment of the core knowledge and competences is often required.	Medicine and law as professions required individuals to be accepted into professional programs where they spend years acquiring the mandatory knowledge and competencies. Before individuals are permitted to practice, they must also pass exams that result in licensure.
Proficiency	Proficiency or expertise is the final stage in the Model of Domain Learning. It is at this stage that an individual manifests the characteristics of an expert: extensive domain and topic knowledge; heavy reliance on deep-processing strategies; an enduring interest in the profession; strong identity as a member of that professional community; and the contribution of new knowledge to the field.	After having devoted more than 20 years to the study of writing, Dr. Graham is widely recognized as a leading authority in this field. He has dedicated his research to devising specific techniques or strategies that can be taught to novice writers to significantly improve their writing ability.

(continued)

Term	Definition	Illustrative example
Self-Knowledge	Self-knowledge can be described as persons' awareness of themselves as cognitive, social, emotional, and behavioral beings. As such, self-knowledge can relate to individuals' beliefs, values, and motives; their preferences and interests; and their judgments about their knowledge and competencies in specific domains and professions.	When asked to judge where they are in the journey toward expertise in the majors, undergraduates will justify their position in the Model of Domain Learning by sharing self-knowledge. They will discuss how much domain and topic knowledge they have in their major, how interested and committed to that major they are, and in what way they operate strategically when working on problems in their majors. All these descriptions rely on their self-knowledge.
Situational Interest	Whenever there is something within the immediate environment that draws an individual's attention or that they find fascinating, intriguing, salacious, or confounding, they are manifesting situational interest.	Traffic will always back up when there is an accident on the highway. People just have to look. Also, when reading a history text that mentions Horatio Nelson's affairs, individuals recall such a seductive detail without trying. These are cases of situational interest.
Strategies	Strategies are a special class of procedural knowledge that individuals purposefully or intentionally use when encountering problems that require solution or resolution.	While writing code for a new app she was designing, Sofie kept encountering an error. She therefore decided to try an alternative approach. She broke the task into three subcomponents and then wrote the codes for these separately. Finally, she created codes to link the subroutine.
Surface-Level Strategies	When trying to deal with a problem or task at hand, individuals may need to focus their cognitive energies on specific elements or features of the problem or task that are available. The procedures or actions they take represent surface-level strategies.	When a graduate student in psychology is first exposed to structural equation modeling, she may need to read and re-read the steps in the manual just to be sure that she understands what she is supposed to do to set up her data to run SEM correctly.
Topic Knowledge	Some of the knowledge that individuals possess in a domain or a profession is very concentrated on certain topics rather than widely distributed across the field. This more focused information is labeled topic knowledge	Jess is a computer scientist who has been fascinated by volcanoes since he was young. He still reads whatever he finds on the subject and has visited several active volcano sites in Europe and New Zealand. Such experiences have increased his topic knowledge of volcanoes.

Note. Source: Design by author

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