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Making sense of adaptive expertise for frontline clinical educators: a scoping review of definitions and strategies

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Abstract

Adaptive expertise has been promoted as an emerging model of expertise in health professions education in response to the inherent complexities of patient care; however, as the concept increasingly influences the structure of professional training and practice, it creates the potential for misunderstandings of the definition and implications of adaptive expertise. To foster a common understanding of the concept, we conducted a scoping review to explore how adaptive expertise has been discussed within health professions education literature. Five databases—MedLine, PubMed, ERIC, CINAHL, and PsycINFO—were searched using the exact term "adaptive expertise", producing 212 unique articles. Fifty-eight articles met inclusion criteria. In the included articles, authors discussed the conceptual implications of adaptive expertise for health professions education, strategies for training for adaptive expertise, and research findings aimed at supporting the development of adaptive expertise or utilizing adaptive expertise as a theoretical framework. The goal of this scoping review is to establish a resource for frontline educators tasked with fostering the development of adaptive expertise in learners through education initiatives. A common understanding of adaptive expertise is essential to ensuring effective implementation in training programs.

Keywords Adaptive expertise · Adaptivity · Expertise · Health professions education · Scoping review

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Introduction

Taking care of the health of human beings and communities is complex and often unpredictable. Not only are physicians required to respond to the inherently complex needs of individual patients, but physicians also work and learn within dynamic networks of healthcare workers and interprofessional communities. Further, the astonishing speed of societal transformation resulting from technological advances and the information revolution (Thimbleby, 2013) has had a profound impact on how patients interact with their healthcare providers. Clinical research regularly results in the need to adjust previously standard ways of practice, and often produces new knowledge that must be mastered—which may also entail "unlearning" what was previously accepted as truth. All of these factors and more contribute to the need for healthcare practitioners to be able to be flexible and adaptable. So how can healthcare providers be prepared to effectively meet this challenge? How can training programs prepare their graduates with the tools and skills to be able to adapt as needed when faced with unfamiliar or new situations? A potential solution is to explicitly incorporate the concept of adaptive expertise into healthcare professions education (HPE).

Initially proposed by Hatano and Inagaki (1984) to explain differences in the development of skills in solving math problems, the concept of adaptive expertise proposes that there are two kinds of expertise: routine expertise, and adaptive expertise. As originally conceptualized, routine expertise requires mastery of skills, knowledge, and procedures so that carrying out the processes or actions (problem-solving) associated with those skills and knowledge is highly efficient and accurate. Adaptive expertise requires similar levels of mastery, but also incorporates deeper conceptual understanding and insight, so that the adaptive expert can solve new problems that are outside those assumed by routine expertise, or even develop new processes or procedures for problem-solving that differ from those learned/mastered in developing routine expertise (Fig. 1). It is important to note that this conceptualization of expertise does not assume that routine and adaptive expertise are two sides of a dichotomy – routine experts can demonstrate adaptive expertise, and adaptive expertise still requires the foundation of mastery needed for routine expertise.

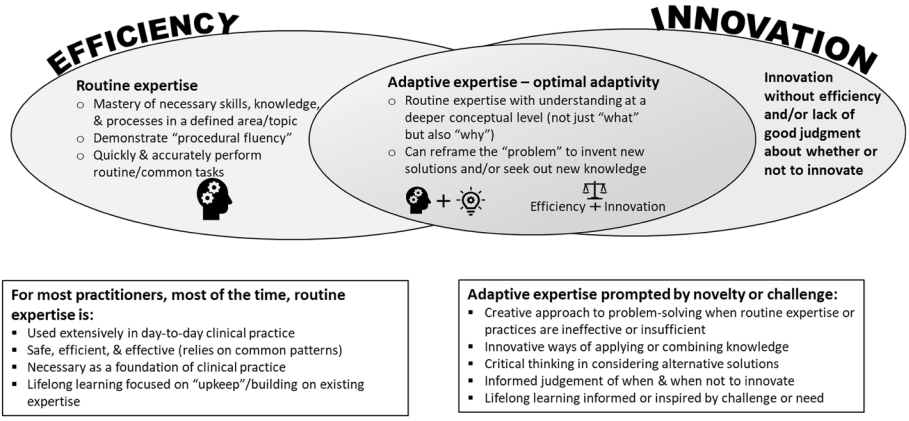

Fig. 1 The relationship between routine expertise and adaptive expertise is not a dichotomy. Rather, adaptive expertise is an extension of routine expertise characterized by a deeper conceptual understanding that facilitates innovation and creativity in problem-solving, balanced by efficiency and good judgement about when and when not to innovate. Both types of expertise are essential to health professionals

Much of the initial research and instructional interventions about adaptive expertise took place in the context of mathematics education, with a focus on understanding differences in how novices and experts approach arithmetical problem-solving (Baroody et al., 2013; Hatano & Oura, 2003; McMullen et al., 2020; Verschaffel et al., 2009). The applicability of the adaptive expertise concept applied to all areas of education — students often learn through problem-solving — which resulted in a sustained interest in adaptive expertise among researchers in teacher education (Crawford et al., 2005; Janssen et al., 2008; McDiarmid and Clevenger-Bright, 2008; Metz et al., 2020; Soslau, 2012; Tynjälä et al., 2006). Beyond the classroom, adaptive expertise research rapidly expanded as researchers explored the ways that experts approach problem-solving in challenging, novel, unfamiliar, or complex situations (Bransford et al., 2000; Carbonell et al., 2014; Schwartz et al., 2005; Wineburg, 1998). Other researchers wanted to examine and understand why some people were flexible in how they used their existing knowledge and skills, while others were unable to solve non-routine problems or adapt to changes in circumstances (Hutton et al., 2017; Newton et al., 2010; Spiro, 1988).

Understanding what processes underlie the ability to be flexible in response to challenge and to demonstrate appropriate application of knowledge in non-routine situations is the essential first step in developing educational interventions and strategies to support the development of adaptive expertise. Research into adaptive expertise has identified some of the key characteristics of people who demonstrate adaptive expertise (Carbonell et al., 2014): well-developed metacognitive skills such as monitoring one's own performance and learning, and assessing one's own level of knowledge (Bransford, 2007; Crawford et al., 2005; Lin et al., 2005; Janssen et al., 2008; Mees et al., 2020); flexibility (Baroody, 2003; Mees et al., 2020); and creativity (Gube & Lajoie, 2020). Given how closely these characteristics mirror many of the elements of self-regulated learning (SRL), it is not surprising that many authors have made the connection between fostering SRL behaviours and the development of adaptive expertise (Anthony et al., 2015; Lajoie & Gube, 2018; Vanasupa et al., 2010). As will be seen in the Results and Discussion, the connection between SRL and adaptive expertise is of interest in the HPE literature (e.g., Lajoie & Gube, 2018), where SRL serves as the basis for the Master Adaptive Learner model (Cutrer et al., 2018).

Adaptive expertise is particularly important for those working in professions or environments where complexity, challenge, and novelty occur regularly (Carbonell et al., 2014; Grenier, 2021). Researchers in professions that are characterized by the need to adapt in complex circumstances, such as engineering (Harris et al., 2002) and the military (Hutton et al., 2017), have embraced adaptive expertise as a useful way to frame the skills necessary for training professionals who are well-suited for challenging work. Findings from adaptive expertise research in other contexts have begun to inform the development of educational interventions that are intended to support the development of adaptive expertise, such as the "Coaching for Improved Ability to Handle Unforeseen Events" (CIAU) program for nuclear power plant operators in Norway (Skjerve and Holmgren 2018). Nuclear power plants are high-risk environments that have multiple levels of safety measures which include strict operational and procedural routines. Licensed operators must have high procedural fluency for carrying out these routines. However, it is possible for serious accidents to arise from unforeseen circumstances or series of events (David et al., 1996). The CIAU program leverages what is known about the metacognitive processes that underpin adaptive expertise in order to promote flexible thinking and adaptivity in nuclear power plan workers so that they can perform a high-risk profession safely, even when faced with challenge and non-routine circumstances.

Given the relevance of adaptive expertise to effective performance of high-risk tasks in challenging, unpredictable, or complex circumstances (Feltovich et al., 1997), it is not

surprising that there has been intense interest in how the concept of adaptive expertise may apply in the health professions. Healthcare professionals and learners face complexity daily, both in navigating the healthcare system and in caring for patients (Woodruff, 2019). While HPE programs try to design instruction to prepare graduates for the complexity of healthcare, it is impossible to train for every eventuality. This is particularly true for clinical situations that are high in acuity but low in frequency, which often need to be taught using simulation scenarios (Brown & Mackinnon, 2016; Wheeler et al., 2013). Unfortunately, teaching specific high acuity/low frequency scenarios is generally not effective, as skills are lost without opportunities to practice (Hatchimonji et al., 2020). Incorporating adaptive expertise into HPE programs may provide a solution, by targeting how healthcare practitioners approach challenge and novelty in the clinical context, rather than training for specific scenarios (Mylopoulos et al., 2018a).

Adaptive expertise as a concept first appeared in the HPE literature when Mylopoulos and Regehr proposed adaptive expertise as an alternative or complement to some of the more traditional cognitive paradigms for thinking about expertise (Mylopoulos & Regehr, 2007). Mylopoulos and Regehr made the argument that a potential reason for some of the challenges inherent in researching the development of expertise may have been the result of limitations of the cognitive paradigms being used. Specifically, the authors argued that most research in medical expertise at the time focused on outputs from tasks (real or artificial) as proxies for how experts versus novices used knowledge, rather than on the creative processes that experts used to solve the task. In introducing the concept of adaptive expertise into HPE, Mylopoulos and Regehr contributed to a shift in thinking about expertise from comparing novice versus expert to considering how expertise continuously develops and how different experts solve problems or enact their expertise (Mylopoulos & Scardamalia, 2008; Mylopoulos & Woods, 2009; Sockalingam et al., 2016).

While the introduction of the concept of routine and adaptive expertise has opened up new ways of thinking about expertise, the rapidity with which this model has been embraced comes with some potential risks. As is the case any time that a construct, concept, theory, or model from one context is introduced into a novel context — especially a context as specialized as healthcare — it is essential to ensure there is consistency in how those ideas are understood as they are taken up by scholars in the new context. It is important to keep in mind that the concepts of routine and adaptive expertise were initially theorized in the context of math education and child development to explain differences in approaches to solving math problems. In this context, there are clear routines and sub-routines associated with mathematical functions and strategies for mathematical problem-solving (Carbonell & Dailey-Hebert, 2021), allowing for relative ease in identifying novel approaches in strategy use. Contrast this with the context of healthcare practice, where routines and sub-routines are not as distinct, nor even uniformly common across specialties and sub-specialties. Given the differences between the contexts of mathematical problem-solving and clinical care, it is not surprising that some of the nuances of the concepts of routine and adaptive expertise may be lost in translation. This issue may be further exacerbated by the rise in popularity of guidelines and the call for more standardization implicit in 'best practices' and quality improvement, which can make the case that healthcare is on the path of establishing what 'routine care' looks like. It is important to ensure that both learners and practitioners understand that adaptive expertise does not mean dispensing with or rejecting routine expertise and guidelines; rather, adaptive expertise is needed for recognizing when a guideline does not apply, or when the guideline needs to be applied for a specific patient in a specific way.

The potential for differing understandings of routine and adaptive expertise becomes concerning when considering the increasing call for incorporating adaptive expertise into

HPE (Edje & Price, 2021; Lajoie & Gube, 2018; Mylopoulos et al., 2018a; Steinert et al., 2021; Woods et al., 2021). While the scholars immersed in writing about adaptive expertise possess in-depth knowledge, those are not the frontline educators who will be tasked with implementing initiatives to support and foster the development of adaptive expertise in learners in HPE programs. Further, as more authors begin to contribute to the adaptive expertise literature, there is a concurrent increase in the potential for misunderstandings and differing conceptualizations in both academic and clinical audiences.

As health professions educators find themselves faced with expectations of teaching and assessing adaptive expertise, it is crucial to examine the ways in which adaptive expertise is defined and described in the HPE literature. Through exploring different authors' definitions and descriptions of adaptive expertise, we aimed to identify opportunities to foster a common understanding among frontline educators. Further, we sought out examples of recommendations for how training programs could support the development of adaptive expertise. Our overall goal was to consolidate information from disparate sources to provide frontline educators with a primer for understanding what adaptive expertise is and how development of adaptive expertise can be supported through teaching and assessment.

Methods

This scoping review follows the framework developed by Arksey and O'Malley (2005). Our goal in this study was not to appraise the quality of included studies, and so a systematic review approach was not appropriate. Rather, we were interested in creating a general overview of available knowledge about how adaptive expertise is defined in the HPE literature, and the ways in which authors have proposed or implemented interventions to support the development of adaptive expertise in health professions learners. Given this purpose, we determined that a scoping review would be appropriate as we were interested in rapidly examining the extent, range, and nature of research activity and available evidence underpinning the research area (Daudt et al., 2013; Levac et al., 2010; Peterson et al., 2017). The Arksey and O'Malley (2005) framework identifies five stages: (1) identifying the research question; (2) identifying relevant studies; (3) study selection; (4) charting the data; (5) collating, summarizing, and reporting the results. Following these stages, an optional consultation exercise to inform and validate findings is identified as an opportunity to enhance results. The use of this framework promotes transparency and replicability of study findings.

Stage 1 Identifying the research question

The research questions guiding this review were:

1.How is adaptive expertise defined within HPE literature?
2.How can HPE programs support the development of adaptive expertise?

Stage 2 Identifying relevant studies

The primary goal of this scoping review is to explore how the concept of adaptive expertise is defined and applied in HPE in order to consolidate this information for frontline health professions educators. We focused on published literature in HPE. In June 2021, we searched the following databases using the exact term "adaptive expertise" for the years 1984–2021: MedLine, PubMed, ERIC, CINAHL, and PsycINFO. Our start year reflects the year that the term adaptive expertise was first introduced by Hatano and Inagaki. We

intentionally used the databases above to capture a broad range of education literature, which we would then further narrow to HPE literature in the ensuing stages of the study, as described in the following section. Additionally, we reviewed references lists of included articles for any additional literature not captured in the initial search. However, as the purpose of this study was to provide a general overview of adaptive expertise in HPE, our secondary searching was not exhaustive, and was limited to publications in peer-reviewed journals. This was a deliberate decision made by the team, in recognition of the trade-off between breadth, comprehensiveness, and feasibility in conducting scoping reviews (Daudt et al., 2013; Levac et al., 2010), and we found that our initial search provided a comprehensive database of articles suitable for the purpose of this study.

Stage 3 Study selection

Inclusion criteria for this study included articles which discussed adaptive expertise with specific reference to its role in HPE (Table 1). This included articles both discussing theoretical considerations of adaptive expertise, and research aimed at supporting the development of adaptive expertise in training. Although a previous scoping review explored adaptive expertise within education (Kua et al., 2020), we specifically limited our focus to HPE literature to ensure that any theoretical considerations or research that we identified were in our context of interest. Our context of interest included all populations of HPE learners and all levels (i.e. undergraduate, postgraduate, continuing profession development, etc.) of HPE in order to capture a breadth of available literature. One reviewer (NC) determined initial eligibility of articles, with frequent consultation with the full research team to verify appropriate inclusion or exclusion of articles.

Stage 4 Charting the data

For each article, data extraction included descriptive information such as authorship, year of publication, geographic location, and discipline. As inclusion criteria included non-research studies, specific data extracted from articles included definitions of adaptive expertise and strategies to promote its inclusion in HPE training and practice.

Stage 5 Collating, summarizing, and reporting the results

Summarizing and synthesizing the extracted data was done initially by NC, in consultation with SR and BH. The team adopted a subjectivist epistemology (Thomas et al., 2020) because the goal of this scoping review was to examine and summarize theoretical descriptions of the construct of adaptive expertise, as well as to describe strategies and interventions to support learners in developing adaptive expertise in the context of HPE, and all team members are HPE scholars. In examining the data each team member brought pre-existing knowledge of and experience with HPE, and interpretation of the data would be filtered through the team members' existing expertise (Brannick & Coghlan, 2007; Guba & Lincoln, 1994). In particular, the team members approached the data from a generalist physician perspective (i.e., family medicine), with experience across the continuum of education (undergraduate, postgraduate, and continuing professional education) (Thomas et al.,

Table 1 Inclusion and exclusion criteria for the scoping review

Element	Inclusion criteria	Exclusion criteria
Time period	1984 to present	Studies before 1984
Language	English	Language other than English
Type of articles	Original research, commentaries, dissertations/theses	Abstracts, conference proceedings
Focus of article/study	Adaptive expertise- theoretical or applied	Not directly about adaptive expertise
Population/context	Health professions education	Non-health professions education

2020). In discussing the initial synthesis of data, NC, SR, and BH acknowledged the prior knowledge and theoretical perspectives that they were bringing to interpretation of the data, as well as the specific generalism context in which SR and BH conduct their scholarly work (Feast & Melles, 2010). This process of acknowledging and reflecting on existing knowledge and expertise, including the generalist contextual lens which each team member was bringing to the interpretation and analysis of the data, was also followed in the Consultation exercise in Stage 6.

Stage 6 Consultation exercise

As synthesis progressed, two consultation sessions were held with the Certification Process and Assessment Committee (CPAC) of the College of Family Physicians of Canada. Previous CPAC work has considered the role of adaptability in family medicine practice and training. CPAC members reviewed the synthesis, and offered suggestions and comments on the relationship between adaptive expertise and HPE. Final synthesis was determined through agreement between CPAC and the research team.

In keeping with the subjective epistemology approach, the research team explicitly acknowledged that the synthesis and interpretation of the findings of this scoping review would be influenced by the subjective judgement of the research team (Brannick & Coghlan, 2007; Thomas et al., 2020). The research team brought a generalist, education-focused perspective to the synthesis and interpretation of the data, with additional contextual lens of summarizing the adaptive expertise literature for frontline clinical educators. As a result, the reporting of extracted data in the Results section attempts to position findings both with respect to the research questions guiding this review, as well as within historical conceptualizations of adaptive expertise. This latter consideration can help deepen our understanding of how adaptive expertise has been adopted within HPE, and further acknowledge strategies to support the development of adaptive expertise in education programs.

Results

Across the five databases, the search resulted in 212 unique articles. Upon abstract and full-text review of these articles, 58 met inclusion criteria (Fig. 2). The earliest included article is from 2007 — suggesting the influence of the aforementioned Mylopoulos and Regher article to the field of health profession education. Thirty articles were commentary-type articles that discussed the theoretical implications of adaptive expertise or its relationship to HPE; the remaining 28 articles reported research aimed at supporting the development of adaptive expertise or utilizing adaptive expertise as a theoretical framework (Table 2). The data extraction table is included as an Appendix.

How is adaptive expertise defined within HPE literature?

Definitions and descriptions of adaptive expertise in HPE are generally aligned with Hatano and Inagaki's (1984) original conceptualization, albeit with added dimensions of patient care and patient safety. Most authors define adaptive expertise as a model of expert development and performance that emphasizes a balance between efficiency and innovation (Cutrer et al., 2017; Lake et al., 2019; Mylopoulos & Woods, 2009, 2017; Pusic et al., 2018a, 2018b; Sockalingam et al., 2016, 2020).

Most authors describe adaptive expertise in the context of how adaptive experts respond to problems or challenges. Rather than viewing problems solely as an avenue to apply

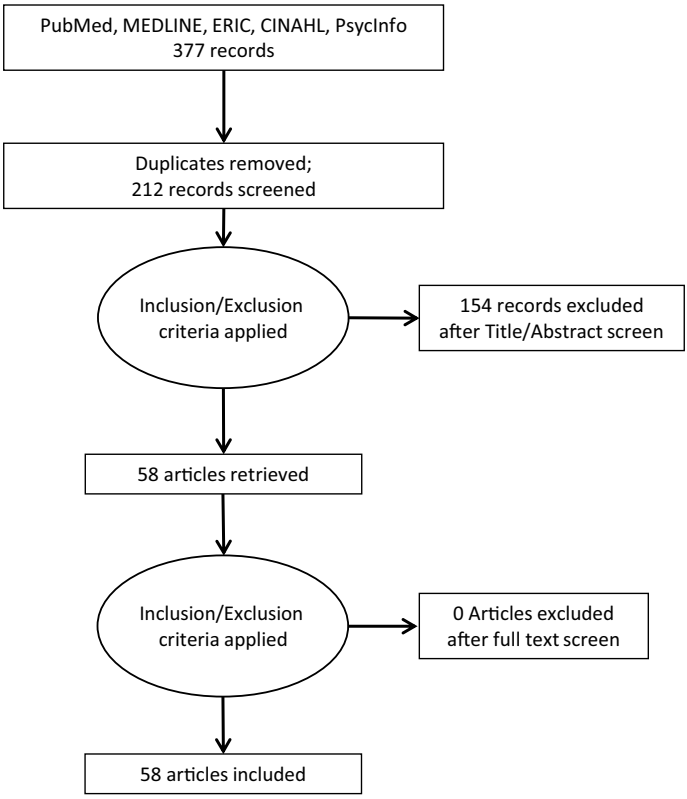

Fig. 2 PRISMA diagram for the scoping review search

Table 2 Characteristics of the 58 articles included in the scoping review

Country	Year	Type of article
Australia (N = 2)	2007–2009 (N = 7)	Case study (N = 2)
Canada (N = 31)	2010–2015 (N = 7)	Commentary (N = 31)
Germany (N = 1)	2016–2020 (N = 46)	Mixed methods (N = 3)
Singapore (N = 1)	2021 (N = 8)	Qualitative (N = 17)
United Kingdom (N = 4)		Quantitative (N = 3)
United States (N = 19)		Scoping review (N = 2)

previous knowledge, adaptive experts approach problems as opportunities to create new knowledge, for innovation and creativity, and to learn and improve practice (Mylopoulos & Scardamalia, 2008). Potential challenges identified in the examined articles include working with complex patient populations (Biro et al., 2021; Grossnickle et al., 2019; Kawamura et al., 2016), within dynamic team-based systems of care (Orsino & Ng, 2019; Salas et al., 2008) and interactions with novel healthcare technologies (Gegenfurtner et al., 2017; Guo et al., 2013; Varpio et al., 2009). Most articles described adaptive expertise as the capacity to recognize when a routine approach to problem solving is insufficient, and the

ability to reframe the problem in order to invent new solutions and learn new knowledge (Bleakley, 2021; Cutrer & Ehrenfeld, 2017; Mylopoulos & Woods, 2014; Mylopoulos et al., 2018a).

In describing adaptive expertise, all authors also describe routine expertise; however, the ways in which authors describe the relationship between routine and adaptive expertise can appear contradictory. For example, consider this statement from Kawamura et al., (2020):

> *"Adaptive experts are characterized by the procedural fluency of knowing how to complete tasks, as seen in routine experts, complemented by an understanding of why an approach works within a specific context. This explicit conceptual understanding is what sets adaptive experts apart from routine experts as it permits adaptation to variability."*

The notion of setting adaptive experts apart from routine experts might be inferred to suggest a dichotomy with routine expertise, but it is important to remember that adaptive experts still utilize routine expertise. Efficiency in practice — or routine expertise — is complemented by problem solving in novel, complex, or ambiguous situations. Rather, the key distinction emphasized in the above quotation is that routine expertise lacks the innovative capacity observed in adaptive expertise.

In one of the earliest publications introducing the concept of adaptive expertise to HPE, Mylopoulos and Regehr (2009) described the "optimal adaptability corridor" (OAC) (Schwartz et al., 2005). The OAC represents the balance between the efficiency and innovative dimensions of problem solving (Mylopoulos & Regehr, 2009; Mylopoulos & Woods, 2009). In more recent publications in the HPE literature (i.e., since 2017), there has been an increase in the number of authors who describe adaptive expertise as it relates to the OAC, likely due to a publication in *Academic Medicine* by Cutrer and colleagues in 2017 that included a figure of the OAC adapted from the original from Schwartz et al., (2005).

Most authors also describe the metacognitive processes, professional dispositions, and habits of inquiry that are incorporated into adaptive expertise (Mylopoulos & Woods, 2009; Valbuena et al., 2019) (Table 3). These factors are incorporated into the recommendations for how training programs can support the development of adaptive expertise that are described in the final section of the Results.

How can HPE programs support the development of adaptive expertise?

In almost all of the included papers, authors either explicitly or implicitly addressed the need to design training to support the development of adaptive expertise. A number of papers offered specific recommendations for training curriculum to support the development of adaptive expertise (Croskerry, 2018; Edje & Price, 2021; Fu, 2019; Hutchinson et al., 2019; Mylopoulos et al., 2018b; Quirk & Chumley, 2018; Valbuena et al., 2019). Many authors, especially in commentary or perspective articles, contrasted traditional educational approaches or strategies that emphasized solely routine expertise with the need for alternative approaches that emphasize adaptive expertise (Cutrer et al., 2017; Mylopoulos & Regehr, 2009; Mylopoulos & Woods, 2009; Rose, 2007). These authors point out that curricula and instructional approaches that focus on maximizing short-term performance through the acquisition and application of previous knowledge — as traditionally emphasized in training curriculum — is insufficient for long-term learning, and does not prepare learners to solve problems in novel situations (Mylopoulos et al., 2018b; Sockalingam

Table 3 Facilitating or enabling individual factors associated with adaptive expertise

Factor(s)	Source(s)
Maintaining an epistemic distance between prior knowledge and emerging representations of a current problem	Mylopoulos and Woods, (2009)
Capacity for self-regulated learning	Butler and Brydges, (2013); Cutrer et al., (2017); Cutrer et al., (2018); Lajoie and Gube, (2018); Mylopoulos and Woods, (2009)
"Thinking outside the box"	Croskerry, (2018)
An orientation towards novel content and unfamiliar situations	Mylopoulos and Woods, (2009)
Curiosity, motivation, growth mindset, and resilience	Cutrer et al., (2018)
Critical thinking	Cutrer et al., (2017)
Reflection	Cutrer et al., (2017); Grossnickle et al., (2019); Orsino and Ng, (2019)
Competence and confidence	Alderson, (2010); Dickinson et al., (2020)
Responsibility towards innovation in practice	Bell et al., (2012); Mylopoulos and Regehr, (2009); Mylopoulos and Scardamalia, (2008); Pusic et al., (2018a, 2018b)
Being sustainable, engaged, and accountable	Gisondi et al., (2021)
Finding complexity and being patient-centered	Mylopoulos and Woods (2014)
Tolerance for working with uncertainty	Royce et al., (2019); Steinert et al., (2021)
Positive inquiry attitude	Valbuena et al., (2019)

et al., 2016). The recommendations for educational approaches or strategies described by authors of the included papers all shared the aim of preparing learners to practice within the OAC, by moving beyond the acquisition and application of knowledge to demonstrating the capacity to learn and/or create new knowledge in order to adjust performance appropriately in the face of novel situations (Cutrer et al., 2017; Mylopoulos & Regehr, 2009). The recommendations are grouped under two prevalent conceptualizations: preparation for future learning and the Master Adaptive Learner model.

Preparation for future learning (PFL) is described as "the capacity to learn new information, to use resources effectively and innovatively, and to invent new strategies for learning and problem solving in practice" (Mylopoulos et al., 2016). Mylopoulos and colleagues (2018a) present three approaches to education that support PFL and, subsequently, adaptive expertise: emphasizing understanding rather than performance, emphasizing struggle and risk taking, and supporting meaningful variation. The integration of biomedical or basic science knowledge with clinical knowledge (Dickinson et al., 2020; Martimianakis et al., 2020; Mema et al., 2020; Mylopoulos et al., 2018b; Mylopoulos & Woods, 2014; Ravitz, et al., 2019; Sockalingam et al., 2020) and the use of contrasting cases in training has been promoted as a strategy to build conceptual understandings of knowledge (Mema et al., 2020; Mylopoulos & Woods, 2017; Mylopoulos et al., 2018b). Meanwhile, active learning strategies — and, more generally, learning environments in which risk-taking, creativity, and innovation are encouraged — can also support the development of PFL (Biro et al., 2021; Guo et al., 2013; Sockalingam et al., 2021; Steenhof et al., 2020; Steenhof et al., 2019). Finally, clinical educators can instil the belief that innovative problem solving is a core competency for healthcare professionals by role modeling and by making explicit efforts to provide learners with legitimate experiences in which they can meaningfully

engage in innovative problem-solving during training (Mylopoulos & Regehr, 2009; Mylopoulos & Scardamalia, 2008).

Similar recommendations were found in articles that cited the Master Adaptive Learner (MAL) model recently proposed by Cutrer and colleagues (Cutrer et al., 2017, 2018). The MAL combines aspects of the Plan-Do-Study-Act cycle of quality improvement with metacognitive aspects of the theory of self-regulated learning (SRL) (Butler & Brydges, 2013; Zimmerman, 2002). In the MAL model, there are four stages for effective learning: identify gaps in knowledge, engage in learning, evaluate what was learned, and incorporate this learning into practice. These stages do not occur in isolation: curiosity, motivation, mindset, and resilience promote and sustain the learner's ability to engage in the learning cycle, with support and guidance from coaching and the learning environment (Cutrer et al., 2018). The model stresses the importance of cognitive skills — specifically, critical thinking and reflection — as essential to learning (Cutrer et al., 2017). Several authors of the included studies referred to the MAL framework to help understand the development of adaptive expertise (Dickinson et al., 2020; Edje & Price, 2021; Gisondi et al., 2021; Regan et al., 2019).

Some authors report on qualitative research studies, including interviews, focus groups, or observational research to understand how students or teachers understand or define expertise, adaptiveness, or innovation in practice, and portfolios, journals, or similar assessments intended to stimulate critical reflection (Bradfield et al., 2019; Dickinson et al., 2020; Grossnickle et al., 2019; Kawamura et al., 2020; Kawamura et al., 2016; Mylopoulos et al., 2017; Mylopoulos & Woods, 2014; Mylopoulos & Farhat, 2015; Mylopoulos & Regehr, 2009; Mylopoulos & Scardamalia, 2008; Reed, 2018; Regan et al., 2019; Sockalingam et al., 2020; Sockalingam et al., 2021; Varpio et al., 2009). The findings from these studies provide insight into how clinical educators, practitioners, and learners think about expertise, and about how experiences in training and practice contribute to development of expertise. This information adds to understanding how PFL or MAL instructional recommendations may contribute to development of adaptive expertise.

While there was consistency among authors in the recommendations for instructional strategies or approaches to support development of adaptive expertise, few authors provided evaluation evidence. For PFL, research has focused on evidence of transfer: the extent to which students are able to transfer their knowledge from one problem-solving situation to a different, yet related, context (Croskerry, 2018; Gegenfurtner et al., 2017; Martin & Schwartz, 2009; Pusic et al., 2018a, 2018b). Case-based simulations provide some evidence (Guo et al., 2013; Mema et al., 2020). However, many transfer protocols, especially those that address future learning, have fairly effortful designs that are not easily or feasibly implemented in HPE programs, such as eye-tracking studies (Gegenfurtner et al., 2017) and double transfer protocols that endeavour to determine whether a PFL assessment can reveal differences in performance that would otherwise be undetected by traditional assessment methods (Mylopoulos & Woods, 2014; Steenhof, 2020; Steenhoff et al., 2019, 2020).

Discussion

The goal of this scoping review was to consolidate published information about what adaptive expertise is, and how educators can support development of adaptive expertise in their learners, specifically in the context of HPE. While there is a growing body of literature to support the adoption of adaptive expertise into HPE (Kua et al., 2021), much of that literature is more conceptual than applied, and many busy frontline educators may not have the

capacity to engage with that conversation. We wanted to provide a resource to promote a common understanding among frontline healthcare professions educators of how adaptive expertise is defined and can be applied in the HPE context. Holding a common understanding of the 'what' and 'how' of adaptive expertise will facilitate more effective uptake and implementation of strategies in clinical training programs and environments (Lane et al., 2015).

Our findings suggest that there is a fairly consistent description of adaptive expertise both within HPE as well as with respect to the conceptualization originally proposed by Hatano and Inagaki (1984). Adaptive expertise provides a model of expert development that incorporates both efficiency and innovation. Innovation is necessary to respond to the inherent complexity of healthcare; however, this is not to suggest that innovation replaces the necessity for efficiency in healthcare (Pusic et al., 2018a, 2018b). Just as an inability to be adaptive in a complex situation may result in poor patient care (Woodruff, 2019), being overly innovative in a situation which has a known solution may also result in poor patient care (Earl, 2019; Mylopoulos & Woods, 2017; Soni et al., 2016). While much of a healthcare provider's practice includes consistency in what clinical presentations are seen, alongside the expected can be the unexpected — the novelty, uncertainty, and ambiguity which can arise in many areas of clinical practice (Woodruff, 2019).

Both within and outside the HPE literature, adaptive expertise is often graphically depicted in the form of a simple four quadrant grid. The y-axis represents increasing innovation, while the x-axis depicts increasing efficiency (Cutrer et al., 2017; Schwartz et al., 2005). Routine expertise is thus high in efficiency and low in innovation; adaptive expertise is high in both efficiency and innovation. While this commonly repeated depiction is a useful visual to communicate a more complex concept, it can lead to misinterpretation of the relationship of routine and adaptive expertise, with routine expertise being "less than" adaptive expertise. This potential misinterpretation runs counter to what was originally proposed by Hatano and Inagaki (1984), and built upon by other scholars who discussed the interrelationship of routine and adaptive expertise. Routine expertise is both a necessary precursor to adaptive expertise and is often employed at the same time as adaptive expertise: adaptive expertise is not free of content knowledge, and rather builds off extensive domain-specific knowledge or else risks innovation without the necessary sufficient judgement (Martimianakis et al., 2020; Mylopoulos et al., 2018a, 2018b). Further, routine expertise can be seen as a way to maximize an individual's ability to be creative and innovate – the procedural fluency of routine expertise means that some of the routine subtasks of care can happen on "autopilot", freeing up cognitive capacity for innovative problem-solving in the face of challenge or novelty (Carbonell & Dailey-Hebert, 2021; Gube & Lajoie, 2020; Schneider & Stern, 2010).

In the Introduction to this paper, we present a figure that offers a different way of visualizing the relationship between routine and adaptive expertise (Fig. 1). In the health professions in particular, routine expertise is essential for many aspects of patient care. Adaptive expertise builds upon that routine expertise, and enables clinicians to adeptly respond to challenges, or problem-solve in the face of situations that are not routine or do not follow established patterns. In Fig. 3, we build upon this visualization of the continuum of expertise to depict the OAC in the context of HPE. This Figure explicitly shows how the recommendations for teaching strategies to support development of adaptive expertise fit into the conceptual model, which can be useful for faculty development as training programs implement those strategies. Moreover, Fig. 3 reflects how routine expertise can lead to the development of adaptive expertise through certain enabling factors presented in Table 3, further highlighting the relationship between adaptive and routine expertise. Importantly, evidence across the continuum of education has demonstrated that students who receive forms of instruction that have been shown to support the development of

adaptive expertise perform significantly better on PFL assessments with no detriment to knowledge acquisition and application — in other words, an explicit emphasis on innovation in training does not come at the cost of routine expertise (Mylopoulos & Woods, 2014; Mylopoulos et al., 2016; Steenhof et al., 2019).

In working with frontline educators, a useful approach could be to present adaptive expertise as a marker of competence (Edie & Price, 2021). As noted by Regehr (1994), true competence manifests in unfamiliar situations, and it is inevitable that physicians will encounter novel problems in practice. Emerging work suggests that adaptive expertise may be a mindset that is stimulated by the realities of the complexity of authentic clinical practice, where the limits of routine expertise become evident (Betinol et al., 2022). Programs can create situations that allow learners to try out and reflect upon adaptive expertise strategies during training. Assessment of both the reflections and the strategies used could then become part of programmatic assessment of competence. This integrates adaptive expertise into expectations of competence, preparing learners to work with and learn from novel problems in the future (Gisondi et al., 2021). Further, an explicit focus on PFL in training promotes expertise as a process of lifelong learning rather than an endpoint (Alderson, 2010; Brehaut & Eva, 2012; Mukherjee et al., 2019), and embeds knowledge production in daily practice (Mylopoulos & Scardamalia, 2008). Similarly, the SRL concepts that were adapted for the MAL model have strong research evidence from the non-HPE literature to support their effectiveness and importance to lifelong learning (Winne, 2017; Zimmerman, 2002)

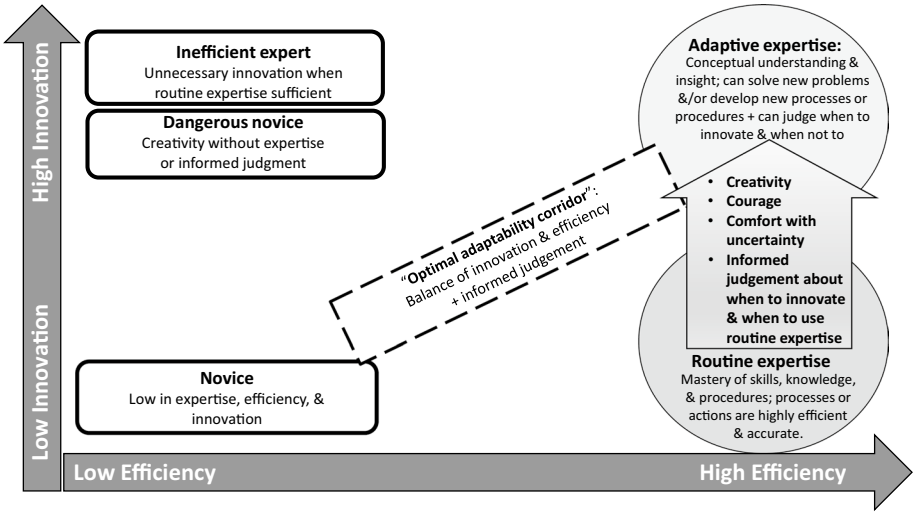

Fig. 3 The optimal adaptability corridor in health professions education (HPE) expanding on Bransford's original proposition in 2005. Routine expertise is appropriate in most clinical situations, and is characterized by high efficiency and accuracy. However, when novel or challenging situations are encountered, innovation and creativity are needed to problem-solve — i.e., adaptive expertise. The arrow between routine expertise and adaptive expertise captures the key elements necessary to go from routine expertise to adaptive expertise. HPE programs can implement strategies to target the "optimal adaptability corridor" — the balance between being efficient and being innovative — to help learners to the necessary knowledge, skills, and procedures of routine expertise, while providing safe challenges to facilitate innovation and creativity in problem-solving, and the skill to balance efficiency and innovation appropriately (i.e., judgement to know when and when not to innovate) to support development of adaptive expertise

and adaptive expertise (Anthony et al., 2015; Vanasupa et al., 2010), which is highly suggestive that using the MAL model in training will have similar benefits.

Given the emphasis on novelty, challenge, and uncertainty that are core to adaptive expertise, it is not surprising that this concept has rapidly gained traction among generalists. Kelly et al., (2021) identify six key concepts to inform the praxis of generalist care: comprehensive care, complexity, context, continuity of care, communication, and collaboration. The authors identify adaptive expertise as integral to the response to variability of context in practice; however, through this model, we can see the potential for adaptive expertise to further underpin some of the core components of generalism: managing complexity, uncertainty, and ambiguity in practice, responding to the needs of individual patients while negotiating personal and professional and even cultural boundaries, and participating within complex networks of care. Kvern (2021) also defines generalism both in relation to commitment to patients and the implied capability for problem solving in unexpected situations. Within the context of family medicine, Woods et al., (2021) propose adaptive expertise as a theoretical framework to support the practice and training of the "specialist generalist", enabling resourcefulness when faced with ambiguity, the ability to balance innovation and efficiency, and acknowledges the different ways family physicians may conceptualize practice.

Medical education often teaches through ideal cases in order to present concepts with clarity and build procedural fluency (Bekdache et al., 2019). Acknowledging the different settings and populations in which generalists provide care, it is important to consider how uncertainty and complexity might be incorporated into workplace-based learning environments; moreover, it is essential that a greater emphasis on uncertainty and ambiguity in training does not come at the cost of comprehensive, patient-centered care. While certain strategies have been presented in this review that support the development of adaptive expertise in training, careful consideration must be given to how they may be implemented judiciously within a training program.

This last point relates to the two gaps we identified in this scoping review that must be addressed as programs begin to implement strategies to support development of adaptive expertise. First, evaluation evidence is sparse for many of the recommended teaching strategies — particularly evidence from HPE contexts, although this need for more evaluation evidence has also been noted in the non-HPE literature (Axelsson & Jansson, 2018; Carbonell et al., 2016). As described in the Results, evaluation of adaptive expertise tends to focus on evidence of transfer which often requires onerous designs (Mylopoulos et al., 2016). Evaluation approaches that are better suited to the unique contexts in which healthcare professions education takes place will need to be developed. Collecting evaluation evidence can occur in conjunction with implementation, as long as deliberate planning is done to pair implementation and evaluation (Hamza et al., 2020).

The second gap identified is the challenge of assessment of adaptive expertise in HPE programs. Workplace-based assessment of adaptive expertise requires prolonged engagement with students through frequent, formative, dynamic assessment (Orsino & Ng, 2019; Quirk & Chumley, 2018). Such an assessment system requires extensive data collection and analysis, and proper alignment with training curriculum (Sachdeva, 2020). Most healthcare education programs are not internally structured to allow for the prolonged and continuous relationships needed, and/or they are situated within healthcare system contexts that create potentially insurmountable barriers to such time-intensive assessment. Moreover, an increased appreciation of the contextual nature of problem solving potentially requires greater attention to the integration of competencies and context in learner assessment (Mylopoulos & Farhat, 2015; Mylopoulos & Woods, 2014; Orsino & Ng, 2019). Given that both learners and practitioners provide care in dynamic, team-based environments, Orsino and Ng (2019) advocate for the importance of collective competence and social awareness in assessments, and to not just think of assessment on the level of the individual.

This review has limitations. Due to the inclusion criteria and scope of the study, our findings only reflect literature exploring adaptive expertise specifically within HPE. While this strategy was essential for the goal of this review to establish a common understanding of adaptive expertise for frontline healthcare educators, it represents a subset of potential theorizations, applications, and strategies for the development of adaptive expertise in the wider education literature. Additionally, the search strategies for this scoping review were intentionally restrictive as far as the type of literature included. Our goal in carrying out this review was to develop a resource for frontline clinical educators that summarizes the primary literature about adaptive expertise, specifically how adaptive expertise is defined and how it may apply in the context of HPE contexts. As such, we included only publications in indexed peer-reviewed journals in English, which is a notable limitation to our data. Finally, reflecting the adoption of a subjectivist epistemology (Thomas et al., 2020), it is important to recognize the research team's affiliation with family medicine and the influence this perspective may have had on the interpretation of results.

While this review is intended to serve as a general overview of definitions and applications of adaptive expertise in the HPE literature, it may also prompt thinking and discussion of potential future directions for research. An important next step in this research would be to examine adaptive expertise from a systems thinking approach, and expand the current analysis of the literature to consider the individual, organizational, and systems-level factors that influence or affect adaptive expertise. Another direction for future research would be to examine adaptive expertise through a specialist discipline lens; as mentioned in the Limitations section, all of the authors of this manuscript come from a generalist discipline background, which the authors acknowledge may have influenced the interpretation of the literature. Future research could also build upon this general overview by analyzing the adaptive expertise literature with a more critical lens, as this review reports on what has been published about adaptive expertise, but does not offer judgement of the approaches and assumptions within the individual publications that were included. Additionally, given the acknowledged narrowness of the search strategies for this study, future research should include an examination of the literature that includes a broader range of articles and more exhaustive search strategies.

Conclusions

Despite the challenges and limitations discussed above, the results of this scoping review highlight the potential for adaptive expertise as a guiding concept in HPE. Our goal was to consolidate information from across the HPE literature to help define adaptive expertise for frontline educators and present how the development of adaptive expertise can be supported through teaching and assessment. Although uncertainty is inevitable in the context of healthcare, it should not result in a diminished quality of patient care. Adaptive expertise can enable future healthcare professionals to continue to work and learn in these unfamiliar situations, while also promoting the efficient and effective response to well-established problems. As adaptive expertise continues to be adopted in HPE, this review will hopefully play a role in the deliberate pedagogical considerations towards training the next generation of expert healthcare professionals.

Appendix 1

See Table 4

Table 4 Data extraction table for adaptive expertise scoping review

First author	Title	Year	Country	Population	Type of article or method	Purpose of the article/how is adaptive expertise discussed within the article?
Alderson, D	Developing expertise in surgery	2010	United Kingdom	Surgery	Commentary	As an example of an expert approach to learning in surgical education
Bell, E	Climate change: could it help develop 'adaptive expertise'?	2012	Australia	Public health	Commentary	To respond to wide-ranging direct and indirect consequences of climate change
Biro, L	First year medical student experiences with a clinical skills seminar emphasizing sexual and gender minority population complexity	2021	Canada	Medical students	Qualitative: Focus groups	To understand students' experiences in a sexual and gender minority (SGM) clinical skills seminar with complex standardized patient scenarios
Bleakley, A	Re-visioning clinical reasoning, or stepping out from the skull	2021	United Kingdom	Medical education	Commentary	To promote a model of clinical reasoning that extends beyond cognition to include social and environmental contexts
Bradfield, Z	Urgency to build a connection: midwives' experiences of being 'with woman' in a model where midwives are unknown	2019	Australia	Midwifery	Qualitative: Interviews	To explore midwives' experiences of being "with women" in the context of an unknown midwife model
Brehaut, J. C	Building theories of knowledge translation interventions: use the entire menu of constructs	2012	Canada	Knowledge translation	Commentary	As a model for continuous efforts at quality improvement to inform the development of knowledge translation interventions

Table 4 (continued)

First author	Title	Year	Country	Population	Type of article or method	Purpose of the article/how is adaptive expertise discussed within the article?
Butler, D	Learning in the health professions: what does self- regulation have to do with it?	2013	Canada	Medical education	Commentary	As an outcome of interest for self-regulated learning in medical education
Croskerry, P	Adaptive expertise in medical decision making	2018	Canada	Medical education	Commentary	To effectively handle complexity in medical decision-making
Cutrer, W. B	Exploring the characteristics and context that allow Master Adaptive Learners to thrive	2018	United States	Medical education	Commentary	To facilitate the development of the Master Adaptive Learner in training
Cutrer, W. B	Protocolization, standardization and the need for adaptive expertise in our medical systems	2017	United States	Medical Education	Commentary	As a response to standardization when making clinical decisions in novel situations
Cutrer, W. B	Fostering the development of Master Adaptive Learners: a conceptual model to guide skill acquisition in medical education	2017	United States	Medical education	Commentary	To facilitate the development of the Master Adaptive Learner in training
Dickinson, B. L	"It is this very knowledge that makes us doctors": an applied thematic analysis of how medical students perceive the relevance of biomedical science knowledge to clinical medicine	2020	United States	Medical Students	Qualitative: Thematic analysis	To understand the perceived relevance of biomedical science to clinical practice for medical students

Table 4 (continued)

First author	Title	Year	Country	Population	Type of article or method	Purpose of the article/how is adaptive expertise discussed within the article?
Edje, L	Training future family physicians to become Master Adaptive Learners	2021	United States	Family Medicine	Commentary	To structure family medicine training curriculum according to the Master Adaptive Learner model to promote career-long learning
Fu, B	Common ground: frameworks for teaching improvisational ability in medical education	2019	United States	Medical education	Commentary	To teach the skill of improvisation as a strategy for "dealing with surprise"
Gegenfurtner, A	Effects of eye movement modeling examples on adaptive expertise in medical image diagnosis	2017	Germany	Radiology	Mixed-methods study	To explore whether technology utilizing eye movement modeling can promote adaptive expertise in medical image diagnosis
Gisondi, M. A	Sustainable engaged accountable learners	2021	United States	Emergency medicine	Commentary	To optimize educational experiences and learning opportunities for the development of lifelong learning in emergency medicine training
Grossnickle, K. E. H	Experiences of physical therapists working with women with chronic pelvic pain: a phenomenological qualitative study	2019	United States	Physical therapy	Qualitative: phenomenological Study (Questionnaires; Resumes; Interviews)	As a major component of the patient management process for working with women with chronic pelvic pain (WWCPP)

Table 4 (continued)

First author	Title	Year	Country	Population	Type of article or method	Purpose of the article/how is adaptive expertise discussed within the article?
Guo, Y	A case study on a capsule robot in the gastrointestinal tract to teach robot programming and navigation	2014	United States	Biomedical engineering	Case study	To support challenge-based learning through robotic technologies which support adaptive expertise through knowledge building and innovation
Hutchinson, T	Applying adaptive expertise for students' clinical decision making	2019	Canada	Medical students	Qualitative: interactive role-play; group discussion	To promote clinical judgement as an opportunity to take risks in order to learn how to make better judgements through a group activity
Kawamura, A	Exploring how pediatric residents develop adaptive expertise in communication: the importance of "shifts" in understanding patient and family perspectives	2020	Canada	Pediatric residents	Qualitative: observations; interviews	To explore how pediatric residents developed adaptive expertise in their communication with patients in daily practice
Kawamura, A	Promoting the development of adaptive expertise: exploring a simulation model for sharing a diagnosis of autism with parents	2016	Canada	Pediatric residents	Qualitative: simulation-based case study; observations; interviews	To explore how a simulation model promoted the development of integrated competencies associated with adaptive expertise in senior health professions trainees
Kua, J	A scoping review of adaptive expertise in education	2020	Singapore	Medical education	Scoping review	To verify the definition of adaptive expertise in education literature

Table 4 (continued)

First author	Title	Year	Country	Population	Type of article or method	Purpose of the article/how is adaptive expertise discussed within the article?
Lajoie, S. P	Adaptive expertise in medical education: accelerating learning trajectories by fostering self- regulated learning	2018	Canada	Medical education	Commentary	To examine how medical students can be supported in acquiring the skills they need to become adaptive experts
Lake, J. C. W	Case reports of diagnostic error: liposarcoma mistaken for hematoma in an obese female with concurrent ipsilateral thrombosis on rivaroxaban	2019	United States	Continuing medical education	Case report	To combat biases to achieve diagnostic success in a case report
Martimianakis, M. A	Developing experts in health professions education research: knowledge politics and adaptive expertise	2020	Canada	Health professions education research	Commentary	As an emphasis in health professions education research graduate training curricula
Martin, L	Prospective adaptation in the use of external representations	2009	United States	Medical education	Qualitative: observational study of a diagnostic reasoning task	To investigate routine and adaptive expertise in problem-solving patterns as non-medical experts worked through a complex medical diagnosis task
Mema, B	Using learning curves to identify and explain growth patterns of learners in bronchoscopy simulation: a mixed-methods study	2020	Canada	Pediatric residents	Mixed-methods study	To lead to faster growth trajectories for trainees while practicing on a bronchoscopy virtual reality (VR) simulator

Table 4 (continued)

First author	Title	Year	Country	Population	Type of article or method	Purpose of the article/how is adaptive expertise discussed within the article?
Mukherjee, S	Is surgery more about doing than thinking?	2019	United Kingdom	Surgery	Commentary	To ensure the preparedness for future learning for surgical trainees upon independent practice
Mylopoulos, M	Exploring integration in action: competencies as building blocks of expertise	2017	Canada	Postgraduate medicine	Qualitative: cognitive ethnography	To support the premise that CanMEDS roles and competencies may be structured to support the development of adaptive expertise
Mylopoulos, M	"I can do better": exploring purposeful improvement in daily clinical work	2015	Canada	Surgery	Qualitative: cognitive ethnography	As a core competency of the purposeful improvement of clinicians in daily practice
Mylopoulos, M	Developing the experts we need: fostering adaptive expertise through education	2018	Canada	Medical education	Commentary	To outline key educational approaches that have been shown to foster the development of adaptive expertise
Mylopoulos, M	How student models of expertise and innovation impact the development of adaptive expertise in medicine	2009	Canada	Medical students	Qualitative: interviews	An exploration of how students understand the role of adaptive expertise in their training experiences and requirements
Mylopoulos, M	Doctors' perspectives on their innovations in daily practice: implications for knowledge building in health care	2008	Canada	Practicing physicians	Qualitative: interviews	To understand how innovation is defined and identified by doctors in their daily practice

Table 4 (continued)

First author	Title	Year	Country	Population	Type of article or method	Purpose of the article/how is adaptive expertise discussed within the article?
Mylopoulos, M	Twelve tips for designing curricula that support the development of adaptive expertise	2018	Canada	Medical education	Commentary	To identify key educational strategies to support the development of adaptive expertise in training
Mylopoulos, M	Preparing medical students for future learning using basic science instruction	2014	Canada	Medical students	Quantitative: double transfer design	To compare basic science instruction and clinically focused instruction on performance on a preparation for future learning (PFL) assessment
Mylopoulos, M	Having our cake and eating it too: seeking the best of both worlds in expertise research	2009	Canada	Medical education	Commentary	To critically examine how expertise has been defined within medical education, and the underlying assumptions and implications of different conceptualizations of expertise
Mylopoulos, M	When I say…adaptive expertise	2017	Canada	Medical education	Commentary	To provide a definition of adaptive expertise for researchers and clinical educators
Nourallah Bekdache, G	Pedagogical strategies in teaching invasive prenatal procedures: a scoping review protocol	2019	Canada	Maternal–Fetal Medicine	Scoping review protocol	As a framework to complement CBD in training to prepare for complexity and novelty

Table 4 (continued)

First author	Title	Year	Country	Population	Type of article or method	Purpose of the article/how is adaptive expertise discussed within the article?
Orsino, A	Can adaptive expertise, reflective practice, and activity theory help achieve systems-based practice and collective competence?	2019	Canada	Pediatrics	Commentary	To prepare learners to function as members of complex systems of care in order to support the health of patients
Pusic, M. V	Learning to balance efficiency and innovation for optimal adaptive expertise	2018	United States	Medical education	Commentary	To highlight the capacity to balance efficiency and innovation as a key aspect of education and practice
Quirk, M	The adaptive medical curriculum: a model for continuous improvement	2018	United States	Medical education	Commentary	To outline a medical school curriculum structured to foster adaptive expertise
Ravitz, P	Integrating evidence-supported psychotherapy principles in mental health case management: a capacity-building pilot	2019	Canada	Mental health	Qualitative: focus groups; interviews	To explore how weekly case-based consultations and training can support the development of adaptive expertise for mental health case managers
Reed, F	Exploring the relationship between innovation in nursing education and clinical practice	2018	United States	Nursing	Mixed methods: dissertation (document reviews; surveys; journaling; focus groups)	As a theoretical framework to explore the perspectives of students in a nursing college regarding innovation
Regan, L	Learning to learn: a qualitative study to uncover strategies used by Master Adaptive Learners in the planning of learning	2019	United States	Postgraduate medical education	Qualitative: focus groups	To identify essential skills, habits, traits, and strategies utilized by Master Adaptive Learners in their planning of learning

Table 4 (continued)

First author	Title	Year	Country	Population	Type of article or method	Purpose of the article/how is adaptive expertise discussed within the article?
Rose, N	Review of The Cambridge handbook of the learning sciences	2007	United Kingdom	Psychiatry	Commentary	To highlight the ability to learn in a knowledge-rich environment in psychiatry training
Royce, C. S	Teaching critical thinking: a case for instruction in cognitive biases to reduce diagnostic errors and improve patient safety	2019	United States	Medical education	Commentary	To examine the role of clinical reasoning and cognitive bias in diagnostic error
Sachdeva, A. K	Acquiring and maintaining lifelong expertise in surgery	2020	United States	Surgery	Commentary	To support the development of the expertise in surgical training programs
Salas, E	Communicating, coordinating, and cooperating when lives depend on it: tips for teamwork	2008	United States	Medical education	Commentary	To provide guidelines intended to enable teams in healthcare to provide safe and reliable patient care
Sockalingam, S	Developing a framework of integrated competencies for adaptive expertise in integrated physical and mental health care	2020	Canada	Psychiatry	Qualitative: facilitated discussions; interviews	To establish integrated care competencies to support health needs of patients with both physical and mental illness
Sockalingam, S	Beyond integrated care competencies: the imperative for adaptive expertise	2016	Canada	Psychiatry	Commentary	As an educational framework to structure integrated care education programs to optimize the care of patients with comorbid physical and mental illness

Table 4 (continued)

First author	Title	Year	Country	Population	Type of article or method	Purpose of the article/how is adaptive expertise discussed within the article?
Sockalingam, S	Building mental health capacity: exploring the role of adaptive expertise in the ECHO virtual learning model	2021	Canada	Mental health	Qualitative: audio transcribed data, constant comparative methodology	To explore how learning experiences within the ECHO mental health care program can support the development of adaptive expertise in primary care providers
Steenhof, N	Adaptive expertise in continuing pharmacy professional development	2020	Canada	Pharmacy	Commentary	To highlight educational approaches to support the development of adaptive expertise in pharmacy continuing professional development
Steenhof, N	Exploring why we learn from productive failure: insights from the cognitive and learning sciences	2020	Canada	Pharmacy	Quantitative	To explore the effectiveness of productive failure as a teaching strategy to deepen conceptual understanding
Steenhof, N	Productive failure as an instructional approach to promote future learning	2019	Canada	Pharmacy	Quantitative	To explore the effectiveness of productive failure as an instructional intervention for preparation for future learning
Steinert, Y	Reframing faculty development practice and research through the lens of adaptive expertise	2021	Canada	Medical education	Commentary	To reframe faculty development through the lens of adaptive expertise
Valbuena, G	Inquiry in the medical curriculum: a pedagogical conundrum and a proposed solution	2021	United States	Medical education	Commentary	To support the development of adaptive expertise through a focus on habits of inquiry in education curriculum

Table 4 (continued)

First author	Title	Year	Country	Population	Type of article or method	Purpose of the article/how is adaptive expertise discussed within the article?
Varpio, L	Routine and adaptive expert strategies for resolving ICT mediated communication problems in the team setting	2009	Canada	Interprofessional teams	Qualitative: observations; interviews	To explore how technologies can mediate interprofessional communication strategies and networks
Woods, N	Defining the specialist generalist: the imperative for adaptive expertise in family medicine	2021	Canada	Family medicine	Commentary	To prepare family medicine residents for the inherent variability that results from generalist care

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