



When Automation Undermines Expertise: The Paradox of Human Capital Development in Intelligent Workplaces

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Abstract

Intelligent technologies increasingly improve the speed, consistency, and quality of professional work while simultaneously redistributing cognitive activities through which expertise is developed and maintained. This article develops Expertise Paradox Theory (EPT) to address the unresolved question of when AI-assisted performance improvement becomes decoupled from independently retained professional expertise. Drawing on and integrating human capital theory, experiential learning, automation–augmentation research, skill erosion, organizational learning, and work design, the article constructs a conditional developmental framework linking performance-oriented AI delegation to diagnostic practice displacement, feedback detachment, cognitive scaffolding, learning-oriented work design, and verification complexity. EPT advances existing literature by distinguishing assisted performance from independent expertise, conceptualizing performance–expertise decoupling as a longitudinal phenomenon, and specifying both erosion and augmentation pathways. The theory further identifies human capital overestimation and vulnerability during independent intervention as organizational consequences of sustained decoupling. Eight propositions and explicit boundary conditions establish an empirically testable research agenda for examining how intelligent work arrangements can improve productivity while preserving capabilities required for independent professional judgment.

Keywords

Expertise Paradox Theory; AI-assisted performance; independent professional expertise; human capital development; cognitive delegation; organizational learning

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1. Introduction

Professional expertise has traditionally developed through the performance of work itself. Diagnosing unfamiliar problems, evaluating competing explanations, correcting errors, and exercising judgment provide opportunities through which professionals acquire and maintain capabilities that organizations depend upon. This relationship between productive activity and capability development is becoming less straightforward as intelligent technologies assume increasingly substantial roles in professional work. Organizations can now achieve higher levels of productivity without requiring employees to perform all the cognitive activities that previously contributed to their expertise. The resulting challenge is whether improvements in organizational performance continue to reflect the development of the human capabilities on which future professional judgment depends.

The challenge is particularly consequential in knowledge-intensive settings. Intelligent systems increasingly assist with diagnosis, analysis, interpretation, and decision-making, allowing professionals to complete demanding tasks with greater speed and consistency. Evidence indicates that generative AI can improve productivity and task quality, although its benefits vary according to worker characteristics and task requirements (Brynjolfsson et al., 2025; Dell'Acqua et al., 2026). These improvements create considerable organizational value. They also complicate the interpretation of professional performance because observed outputs may increasingly reflect capabilities supplied by technology rather than expertise retained by individual employees.

A longstanding concern in automation research is that technological systems can improve routine operations while leaving human operators responsible for increasingly difficult exceptions. Bainbridge (1983) identified this tension as an irony of automation: the activities remaining for human intervention may require capabilities that routine automation provides fewer opportunities to exercise. Contemporary intelligent systems extend this problem into professional knowledge work, where diagnosis, evaluation, and judgment are not merely operational responsibilities but also important sources of experiential learning.

Existing research provides several explanations for the changing relationship between technology and professional work. The automation–augmentation perspective identifies tensions between substituting for human activity and complementing human capabilities (Raisch & Krakowski, 2021). Delegation theory explains how agentic information systems redistribute responsibilities between people and technological artifacts (Baird & Maruping, 2021). These perspectives establish why organizations reallocate tasks and how human–technology collaboration can improve performance. Their primary explanatory emphasis, however, does not fully resolve what happens to the professional expertise that previously developed through the activities being delegated.

Research on skill development and technological dependence addresses related concerns. Cognitive automation can contribute to self-reinforcing processes of skill erosion, while technology-mediated professional practice may restrict established opportunities for learning (Beane, 2019; Rinta-Kahila et al., 2023). Nevertheless, technological assistance does not invariably undermine expertise. Intelligent systems can provide guidance, examples, and corrective information that improve the quality of professional learning. A satisfactory explanation must therefore account for both the erosion and development of expertise under different arrangements of human–technology collaboration.

The unresolved theoretical problem concerns the relationship between performance and capability formation. Organizational learning research establishes that experience contributes to knowledge acquisition, transfer, and retention, but successful task completion

does not necessarily indicate that individuals have acquired the knowledge underlying that performance (Argote & Miron-Spektor, 2011). Professional expertise requires meaningful cognitive engagement and corrective feedback, conditions that may be altered when intelligent systems perform substantial portions of diagnostic work (Ericsson et al., 1993). Consequently, organizations may observe improving productivity while possessing insufficient evidence that employees' independent capabilities are developing at a comparable rate.

This distinction motivates Expertise Paradox Theory (EPT). The proposed theory explains how performance-oriented technological delegation can improve immediate task outcomes while weakening the processes through which independent professional expertise develops. Its explanatory mechanisms are diagnostic practice displacement, which reduces opportunities to exercise learning-relevant judgment, and feedback detachment, which weakens the connection between personal reasoning and corrective information. A countervailing mechanism, cognitive scaffolding, explains how technological assistance can preserve or strengthen expertise when it supports active reasoning, verification, and learning.

EPT contributes to human capital scholarship by distinguishing performance generated through human–technology collaboration from capabilities retained by individuals. It extends automation research by identifying the developmental consequences of delegating cognitively meaningful activities. It also advances organizational learning and work design perspectives by specifying the conditions under which productive arrangements preserve or constrain the reproduction of professional expertise.

The central research question is: Under what conditions does technologically assisted performance improvement undermine, preserve, or strengthen the development of independent professional expertise? Addressing this question requires a theory of how cognitive responsibilities, practice opportunities, and feedback processes interact over time. The proposed explanation is deliberately conditional: intelligent technologies may displace expertise-forming activities, but they may also support learning when organizational arrangements preserve meaningful human participation.

2. Theoretical Foundations and Domain Specification

2.1. Human Capital Theory and the Attribution of Professional Performance

The relationship between professional performance and human capital rests on the premise that individuals possess knowledge, skills, and judgment that contribute to productive activity. Human capital is not merely a record of prior training or accumulated occupational experience. Its organizational significance derives from capabilities that employees can deploy when confronting problems, interpreting information, and making decisions. Such capabilities also present managerial challenges because their development, retention, and productive application cannot be fully separated from the individuals who possess them (Coff, 1997).

Intelligent technologies complicate this relationship by allowing task performance to reflect capabilities distributed across human and technological resources. A professional may produce sophisticated analyses, accurate diagnoses, or defensible recommendations through access to an intelligent system without possessing equivalent capabilities for independent execution. The distinction does not diminish the productive value of technological assistance. It identifies a theoretical limitation in treating observed performance as a sufficient indicator of human capital development.

Research on technological change has long distinguished the substitution of particular tasks from the complementarity between technologies and human skills. Changes in task allocation can alter the productive value of different capabilities without necessarily establishing

whether those capabilities have strengthened or deteriorated (Autor et al., 2003). This distinction is important because reduced use of a skill may reflect either declining organizational demand or diminished opportunities to maintain a capability that remains necessary.

Expertise Paradox Theory (EPT) concerns the second possibility. Its central interest is not whether intelligent technologies change the economic value of professional skills, but whether their use alters the processes through which still-relevant expertise develops and persists. Human capital theory establishes the strategic importance of these capabilities, while EPT examines why their developmental trajectory may diverge from technologically assisted productivity.

2.2. Experiential Learning, Deliberate Practice, and the Developmental Value of Work

Experiential learning research establishes that productive activity can generate knowledge, but the conversion of experience into learning depends on the nature of the activity and the information available to the learner. Organizational knowledge develops through interactions among individuals, tasks, and tools rather than through task repetition alone (Argote & Miron-Spektor, 2011). Consequently, changes in the distribution of cognitive responsibilities can alter the learning value of work even when its observable outputs improve.

Deliberate practice provides a complementary explanation of expertise formation. Professional capabilities develop through engagement with appropriately challenging activities, opportunities to recognize deficiencies, and feedback that supports corrective adjustment (Ericsson et al., 1993). The relevant mechanism is not exposure to work in itself, but the exercise and refinement of capabilities required for competent performance.

This perspective requires an important qualification. The contribution of deliberate practice varies across activities, individuals, and domains; practice should not be treated as a sufficient explanation of expertise differences under all conditions (Macnamara & Maitra, 2019). EPT therefore does not assume that every reduction in independent task execution produces capability deterioration. Developmental consequences depend on whether displaced activities provide learning opportunities that are both meaningful and difficult to replace.

Research on situated learning reinforces this argument by emphasizing that knowledge development is embedded in particular activities and organizational contexts. Changes in work processes can therefore alter what individuals learn, how they learn, and which capabilities remain available for subsequent application (Tyre & von Hippel, 1997). Intelligent delegation becomes theoretically consequential when it changes not only the execution of tasks but also the professional experiences through which judgment is formed.

Evidence from technology-mediated professional work demonstrates the relevance of this concern. Beane (2019) identifies how robotic surgical arrangements can constrain established opportunities for skill development, prompting alternative forms of learning. Such findings establish that the introduction of advanced technology may redistribute access to expertise-forming activities. They do not, however, establish that technological assistance necessarily impairs learning.

EPT builds on this distinction by treating meaningful cognitive participation as a developmental resource. The theory proposes that the allocation of diagnostic reasoning, independent evaluation, and corrective feedback helps determine whether technologically assisted work contributes to expertise formation or merely produces successful outputs.

2.3. Automation, Augmentation, and the Limits of Task-Allocation Explanations

The automation–augmentation literature provides a central foundation for understanding the organizational consequences of intelligent technologies. Raisch & Krakowski (2021) conceptualize automation and augmentation as interdependent processes that create persistent tensions for management. Intelligent systems may replace human activities while simultaneously extending the capabilities of employees who remain involved in the work.

Delegation research specifies how responsibilities can move between humans and agentic information systems. The allocation of tasks, authority, and control shapes the relationship between human actors and technological artifacts (Baird & Maruping, 2021). These perspectives explain how intelligent technologies become integrated into organizational activity and why the same system may support different forms of collaboration.

Their principal limitation for the present theoretical problem concerns the temporal distinction between task execution and capability development. An arrangement that effectively allocates responsibilities at one point in time may have different consequences for the expertise available at a later point. The efficiency of a human–technology configuration therefore cannot be assumed to indicate its developmental sustainability.

The distinction becomes clearer when considered alongside research on hybrid problem-solving. Human and artificial intelligence may contribute complementary capabilities to organizational decisions, creating opportunities for performance improvement through their interaction (Raisch & Fomina, 2025). EPT does not dispute the value of such complementarity. It asks whether repeated collaboration also preserves the human capabilities required to evaluate, contest, and independently interpret technological contributions.

This question separates the proposed theory from a general account of technological dependence. Appropriate reliance on automation may improve decision quality, while inappropriate reliance may create errors or weaken monitoring (Lee & See, 2004). Neither condition independently establishes the developmental trajectory of professional expertise. Reliance becomes relevant to EPT when it changes opportunities for learning-relevant reasoning and feedback across repeated work episodes.

The resulting theoretical extension is temporal and developmental. Task allocation explains who performs particular activities. EPT explains how that allocation influences the future distribution of professional capabilities.

2.4. Skill Erosion, Cognitive Offloading, and the Risk of Theoretical Redundancy

Research on automation-induced skill erosion presents the most direct challenge to the distinctiveness of EPT. Rinta-Kahila et al. (2023) identify self-reinforcing processes through which cognitive automation can contribute to declining human skills. Their analysis establishes that the consequences of automation may extend beyond immediate operational performance and become embedded in continuing patterns of technological reliance.

Macnamara et al. (2024) develop a related theoretical argument concerning the possibility that AI assistance accelerates skill decay among experienced performers and hinders skill acquisition among learners. They also identify the risk that users may not recognize these developmental consequences. This perspective substantially overlaps with the concern that favorable assisted performance can conceal weaknesses in independent competence.

These contributions make a simple claim that automation can erode expertise insufficient as a basis for a distinct theory. EPT must explain a phenomenon that cannot be adequately reduced to skill deterioration or unrecognized dependence. Its proposed contribution is the distinction between the trajectory of assisted performance and the trajectory of independently

retained expertise, together with the mechanisms that determine whether those trajectories converge or diverge.

Cognitive offloading provides a further qualification. Externalizing cognitive demands can reduce immediate processing requirements and support effective task execution (Risko & Gilbert, 2016). Offloading is therefore not inherently equivalent to deskilling. The developmental significance of delegation depends on whether it removes opportunities to exercise capabilities that remain necessary and whether alternative learning processes compensate for those opportunities.

EPT consequently distinguishes three outcomes that should not be conflated. Skill erosion involves an absolute deterioration of independent competence. Developmental stagnation involves little or no improvement in that competence despite continued professional demands. Performance–expertise decoupling involves a divergence between the development of assisted performance and independent expertise, which may occur with either erosion or stagnation.

This distinction does not eliminate overlap with existing scholarship. It narrows the proposed contribution to a conditional explanation of how performance improvement can coexist with inadequate capability formation, and why organizational arrangements may reinforce or mitigate that divergence.

2.5. Organizational Learning, Feedback, and the Aggregation–Learning Trade-off

Organizational learning research provides a particularly demanding comparison because it already recognizes that arrangements supporting immediate organizational performance may constrain individual learning. Piezunka et al. (2022) develop an aggregation–learning trade-off in which decision-making structures that aggregate information effectively may provide weaker opportunities for participants to learn. Their analysis distinguishes learning through participation in collective decisions from learning through direct individual action.

This insight substantially reduces the novelty of any general claim that organizational efficiency and individual learning can conflict. EPT therefore cannot establish its contribution merely by identifying a performance–learning trade-off. The proposed extension must concern the specific redistribution of diagnostic cognition between professionals and intelligent systems, the resulting separation of corrective feedback from personal judgment, and the measurement of independent expertise alongside assisted output.

The feedback distinction is particularly important. Organizational decisions may generate information about collective outcomes without revealing whether an individual professional could have reached or evaluated the same decision independently. In technologically mediated work, a similar separation can arise when AI produces a recommendation and the professional receives feedback primarily on the completed task rather than on an independently formulated judgment.

This mechanism is termed *feedback detachment*. It describes a reduction in the developmental information connecting personal reasoning, errors, and subsequent correction. Research on automation bias and verification complexity supports the relevance of difficulties in evaluating technological recommendations, although these findings should not be interpreted as direct evidence of longitudinal expertise loss (Lyell & Coiera, 2017).

The distinction between organizational knowledge and individual expertise introduces another theoretical boundary. Knowledge may be retained in organizational routines, technological systems, or shared practices without being equally available to every organizational member. Research on knowledge acquisition, transfer, and depreciation establishes that these processes depend on organizational conditions and may change over time (Darr et al., 1995).

More recent theorizing examines how machine learning systems may contribute to organizational knowledge depreciation through interactions involving model drift and human-led repair (Gerlach & Lange, 2026). This perspective addresses a related but different outcome: the depreciation of organizational knowledge within systems of technological use and maintenance. EPT concentrates on the independent professional expertise retained by individuals, particularly when technologically assisted outputs remain favorable.

The distinction is analytically important because organizational knowledge deterioration and individual expertise deterioration need not occur simultaneously. An organization may retain effective technological capabilities while individual professionals experience fewer opportunities to maintain judgment. Conversely, individuals may preserve expertise despite deficiencies in organizational knowledge systems. EPT explains the developmental relationship between assisted performance and individual competence rather than treating these forms of knowledge depreciation as interchangeable.

2.6. Work Design and the Possibility of Developmental Augmentation

A theory concerned exclusively with skill erosion would provide an incomplete explanation of intelligent professional work. Technological assistance can also supply explanations, comparative alternatives, and feedback that strengthen learning. The relevant question is which arrangements allow assistance to contribute to independent capability rather than replacing the cognitive activities required for its development.

Work design research provides the organizational basis for addressing this question. Task characteristics, autonomy, feedback, and social conditions influence employee experiences and outcomes (Humphrey et al., 2007; Morgeson & Humphrey, 2006). Within intelligent workplaces, these characteristics can be reconsidered in terms of the opportunities professionals retain to diagnose problems, evaluate recommendations, and reflect on corrective information.

EPT identifies *cognitive scaffolding* as a countervailing developmental mechanism. Assistance functions as scaffolding when it supports active reasoning, explanation, and verification rather than simply supplying completed outputs. Its contribution to expertise depends on whether professionals integrate the resulting information into capabilities they can subsequently exercise without immediate assistance.

This distinction is consistent with evidence that AI can improve task performance and with research examining its use in professional instruction. Such findings support the possibility of beneficial assistance but do not establish that all immediate gains persist as independent expertise (Brynjolfsson et al., 2025; Giglio et al., 2025).

Learning-oriented work design provides the organizational conditions under which scaffolding may become effective. Arrangements that preserve independent practice, structured comparison, and corrective reflection can maintain developmental opportunities despite substantial technological support. Psychological safety may further enable professionals to question recommendations, acknowledge uncertainty, and discuss errors (Edmondson, 1999).

The erosion and augmentation pathways should not be treated as mutually exclusive. A professional may gain conceptual understanding from AI-generated explanations while losing opportunities to practice particular diagnostic routines. Developmental outcomes depend on the cumulative balance between displaced practice, detached feedback, and effective scaffolding.

2.7. Integrative Synthesis and Domain Specification

The theoretical dialogue establishes four points. Human capital theory identifies the strategic relevance of independently retained competence. Experiential learning explains why

cognitive engagement and corrective feedback matter for capability development. Automation and delegation scholarship clarifies how intelligent systems redistribute work. Organizational learning and skill erosion research demonstrate that productive arrangements can have developmental consequences that are not captured by immediate performance indicators.

The proposed contribution of EPT lies in connecting these insights through a specific developmental explanation. Performance-oriented delegation can alter access to diagnostically meaningful practice. Reduced practice may constrain expertise formation, particularly when feedback becomes detached from personal reasoning. Cognitive scaffolding and learning-oriented work design can counteract these effects by preserving opportunities for active learning.

The theoretical foundations converge on a shared developmental concern, although each literature emphasizes different mechanisms, outcomes, and levels of analysis that leave the performance–expertise relationship only partially specified.

Table 1. Theoretical Foundations and Positioning of Expertise Paradox Theory

Theoretical Foundation	Primary Explanatory Focus	Limitation for the Focal Problem	Role within EPT
Human capital theory	Strategic value of individual knowledge, skills, and judgment	Observed performance may not reveal independently retained capability	Establishes independent expertise as a distinct developmental outcome
Experiential learning and deliberate practice	Capability development through meaningful practice and corrective feedback	Does not specify how AI delegation redistributes learning opportunities	Grounds diagnostic practice displacement and feedback detachment
Automation–augmentation and delegation	Redistribution of tasks, authority, and control between humans and technology	Emphasizes task allocation more than long-term capability formation	Connects technological delegation to developmental consequences
Skill erosion and cognitive offloading	Capability deterioration and reduced cognitive engagement	Skill loss does not capture stagnation or performance–expertise divergence	Clarifies erosion as one possible, not necessary, outcome
Organizational learning	Knowledge acquisition, retention, aggregation, and learning trade-offs	Collective performance and organizational knowledge may obscure individual expertise	Supports separation of organizational performance from individual capability
Work design	Effects of autonomy, feedback, and task characteristics on employee outcomes	Does not specifically theorize expertise preservation under AI delegation	Provides the basis for learning-oriented work design and scaffolding

Source: Authors' synthesis of the theoretical foundations reviews.

Table 1 shows that EPT draws on established theoretical mechanisms without collapsing into any single literature. Human capital and learning perspectives clarify the developmental outcome, automation and delegation explain cognitive redistribution, skill erosion identifies potential losses, organizational learning distinguishes collective from individual capability, and work design specifies protective conditions. EPT integrates these insights around performance–expertise decoupling as the focal developmental problem.

The theory applies to knowledge-intensive professional activities in which independent judgment remains relevant despite substantial technological assistance. Its primary unit of analysis is the individual professional embedded within a human–technology work system. Assisted performance and independent expertise constitute separate outcomes that must be evaluated over time.

EPT does not explain general technological unemployment, occupational displacement, or the obsolescence of capabilities that no longer serve a professional purpose. Nor does it assume that all delegation reduces expertise. Its predictions concern settings in which delegated activities would otherwise contribute to the acquisition or maintenance of still-relevant capabilities.

The central theoretical problem can therefore be stated precisely: under which configurations of cognitive delegation, diagnostic practice, feedback, and work design do gains in assisted performance become separated from the development and retention of independent professional expertise? EPT addresses this problem through a conditional account of the expertise paradox rather than a general claim that intelligent technologies undermine human skills.

The preceding theoretical perspectives illuminate complementary dimensions of intelligent work, but their integration reveals a residual developmental problem concerning the relationship between technologically assisted performance and independently retained professional expertise.

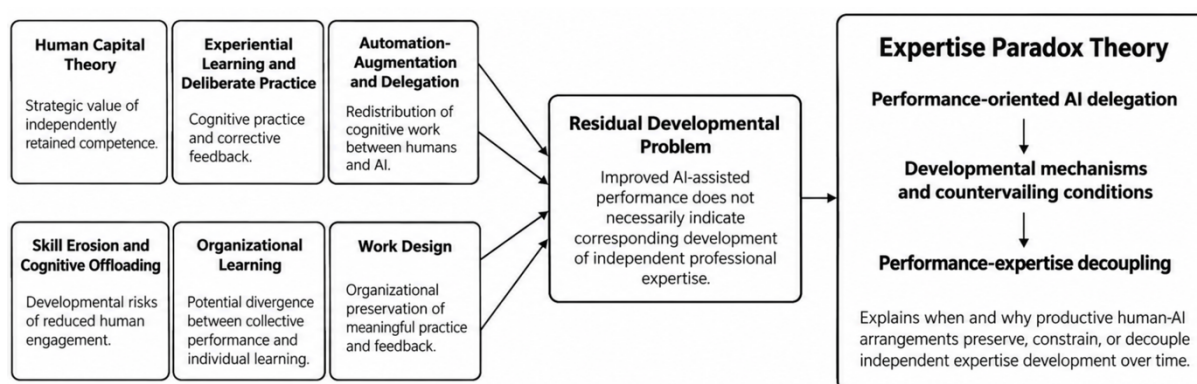


Figure 1. Theoretical Positioning of Expertise Paradox Theory
Source: Authors' conceptualization.

Figure 1 positions EPT at the intersection of established explanations of human capital, learning, technological delegation, skill erosion, organizational learning, and work design. Its distinctive focus is developmental rather than technological: EPT explains how the redistribution of cognitively meaningful work can separate improvements in assisted performance from the formation and retention of independently exercisable professional expertise over time.

3. Theory Building and Proposition Development

3.1. Core Constructs and Analytical Distinctions

Expertise Paradox Theory (EPT) explains how improvements in technologically assisted performance can become separated from the development and retention of independent professional expertise. Its central premise is that work produces two analytically distinct outcomes: the immediate accomplishment of tasks and the accumulation of capabilities that enable individuals to perform consequential work in the future. These outcomes may reinforce one another, but their relationship depends on how cognitive responsibilities and learning opportunities are distributed within the work process.

The distinction becomes consequential when intelligent systems undertake activities that previously required professionals to interpret evidence, formulate diagnoses, compare alternatives, or resolve uncertainty. Such arrangements may improve task efficiency while changing the experiences through which employees develop judgment. Research on human–AI delegation establishes that technological artifacts can assume responsibilities previously assigned to human actors, although the consequences of delegation depend on the nature of the activities and the resulting allocation of control (Baird & Maruping, 2021).

The antecedent of EPT is performance-oriented AI delegation, defined as the transfer of cognitively meaningful activities to intelligent systems primarily to improve the quality, speed, consistency, or efficiency of task execution. This construct differs from AI adoption, frequency of use, and technological sophistication. It concerns the specific professional responsibilities transferred to the system and their relevance to the development of human expertise.

Two developmental processes explain why such delegation may have adverse consequences. Diagnostic practice displacement occurs when AI performs activities that would otherwise require professionals to exercise independent diagnostic reasoning. Feedback detachment occurs when the connection between professionals' own judgments, observed outcomes, and corrective information becomes weaker. These processes are related but distinct. Professionals may lose opportunities for independent practice while continuing to receive meaningful feedback, or they may remain involved in task execution without obtaining feedback that clarifies the quality of their reasoning.

A countervailing process, cognitive scaffolding, arises when intelligent assistance supports active interpretation, explanation, verification, and corrective learning. It differs from providing completed recommendations because its developmental value depends on meaningful human engagement. Learning-oriented work design refers to organizational arrangements that preserve opportunities for independent practice, evaluation, and reflection despite extensive technological support.

The theory distinguishes assisted performance, defined as the quality and efficiency of work completed through human–AI collaboration, from independent expertise, defined as the retained capacity to exercise defensible professional judgment without immediate AI assistance. Performance–expertise decoupling describes divergence between their developmental trajectories. Decoupling does not necessarily imply absolute skill deterioration: independent expertise may improve, remain stable, or decline while assisted performance improves more rapidly.

Clarifying the conceptual status of each construct is necessary because EPT distinguishes task allocation, developmental mechanisms, moderators, outcomes, and the focal divergence through which the expertise paradox becomes theoretically observable.

Table 2 differentiates the constructs that constitute EPT and prevents conceptually adjacent phenomena from being conflated. Performance-oriented delegation functions as the antecedent; practice displacement and feedback detachment explain developmental risk; cognitive scaffolding and work design provide countervailing conditions; assisted performance and independent expertise remain distinct outcomes; and performance–expertise decoupling captures their relative divergence over time within AI-supported professional work arrangements.

Table 2. *Construct Definitions and Theoretical Functions in Expertise Paradox Theory*

Construct	Conceptual Definition	Theoretical Role	Analytical Distinction
Performance-oriented AI delegation	Transfer of cognitively meaningful work to AI to improve immediate task outcomes	Antecedent	Task allocation, not adoption intensity

Construct	Conceptual Definition	Theoretical Role	Analytical Distinction
Diagnostic practice displacement	Reduction in opportunities to exercise independent diagnostic reasoning	Primary developmental mechanism	Loss of learning-relevant practice, not simply reduced workload
Feedback detachment	Weakening of links between personal judgment, outcomes, and corrective information	Amplifying developmental mechanism	Feedback quality, not merely feedback frequency
Cognitive scaffolding	AI support that requires active interpretation, verification, and learning	Countervailing mechanism	Learning support, not answer provision
Learning-oriented work design	Organizational arrangements preserving meaningful practice and feedback	Organizational moderator	Structured learning opportunities, not general training expenditure
Verification complexity	Difficulty of independently evaluating AI recommendations	Boundary condition	Evaluation difficulty, not task complexity alone
Assisted performance	Quality and efficiency of human–AI task execution	Performance outcome	Joint system output
Independent expertise	Retained capability for professional judgment without immediate AI assistance	Developmental outcome	Individually exercisable competence
Performance–expertise decoupling	Divergence between assisted performance and independent expertise over time	Focal phenomenon	Relative developmental divergence, not necessarily absolute skill loss

Source: Authors' conceptualization based on the construct definitions.

3.2. Performance-Oriented Delegation and Diagnostic Practice Displacement

The first causal relationship concerns how technological delegation changes opportunities for professional learning. Knowledge-intensive work contains activities that simultaneously contribute to task accomplishment and capability development. Interpreting ambiguous evidence, constructing explanations, and evaluating competing solutions can generate immediate outputs while also refining the judgment required for subsequent decisions.

When these activities are delegated to intelligent systems, their productive contribution may be preserved or enhanced while their developmental contribution to individual professionals becomes less certain. A worker may remain accountable for a decision without independently performing the reasoning through which similar decisions were previously learned. Research on technology-mediated professional learning demonstrates that changes in work arrangements can restrict access to established routes of skill acquisition (Beane, 2019).

The developmental significance of delegation depends on the activities transferred. Automating repetitive work with limited learning value may release resources for more demanding professional engagement. Delegating diagnostically consequential work may instead reduce opportunities to exercise capabilities that remain necessary for independent judgment. Cognitive offloading research supports the distinction between reducing cognitive

demands and impairing learning; offloading does not inherently constitute a developmental loss (Risko & Gilbert, 2016).

Diagnostic practice displacement therefore depends on the learning relevance of delegated activities rather than the extent of technological use alone. The mechanism becomes stronger when AI assumes activities that would otherwise require substantive professional reasoning and when alternative opportunities for equivalent practice are unavailable.

Proposition 1. *In knowledge-intensive professional work, greater performance-oriented delegation of diagnostically meaningful activities to AI increases diagnostic practice displacement when those activities would otherwise provide substantive opportunities for independent professional reasoning.*

3.3. Diagnostic Practice Displacement and Independent Expertise

The second relationship concerns the consequences of reduced practice for capability development and retention. Professional expertise depends partly on repeated engagement with challenging activities that require interpretation, judgment, and corrective adjustment. When meaningful practice opportunities diminish, individuals may have fewer occasions to strengthen existing capabilities or develop responses to unfamiliar problems.

Deliberate practice research identifies purposeful engagement and corrective feedback as important contributors to expertise development, although their explanatory significance varies across domains and individuals (Ericsson et al., 1993; Macnamara & Maitra, 2019). EPT draws on this conditional relationship rather than assuming that every instance of independent task execution produces learning.

Diagnostic practice displacement is expected to constrain expertise when the displaced activities are developmentally consequential and cannot be adequately replaced. Its effects may emerge through slower capability accumulation, reduced retention, or diminished readiness to address unfamiliar situations. These possibilities differ from the immediate accuracy of AI-assisted outputs, which may remain high despite fewer opportunities for independent practice.

Research on cognitive automation documents processes through which technological reliance can become associated with skill erosion (Rinta-Kahila et al., 2023). EPT extends this explanation by treating developmental stagnation and deterioration as distinct possible consequences of displaced practice. The relevant theoretical outcome is the trajectory of independently retained expertise, not technological reliance itself.

Proposition 2. *Diagnostic practice displacement negatively influences the development and retention of independent professional expertise, particularly when equivalent opportunities for meaningful practice are unavailable.*

3.4. Feedback Detachment as an Amplifying Mechanism

Reduced practice does not necessarily prevent learning if professionals retain opportunities to understand the reasoning underlying technological outputs, evaluate alternatives, and recognize errors. The developmental consequences of displacement therefore depend partly on the quality of feedback available within AI-assisted work.

Feedback detachment arises when professionals receive information about completed outputs without a sufficiently clear connection to their own reasoning. An accurate recommendation may resolve a task while providing limited insight into how an individual would have approached the problem independently. Similarly, feedback concerning the success of a technologically supported decision may not identify deficiencies in the professional's unaided judgment.

The distinction is consistent with research showing that automation can complicate human monitoring and that verification demands influence reliance on technological recommendations (Lyell & Coiera, 2017; Parasuraman & Manzey, 2010). These studies establish relevant limitations in evaluation and monitoring, although they do not independently demonstrate long-term expertise deterioration.

EPT proposes that feedback detachment amplifies the developmental consequences of diagnostic practice displacement. When professionals have fewer opportunities to reason independently and receive less information connecting their judgments to outcomes, both practice and correction become less effective. Where meaningful corrective feedback remains available, the consequences of reduced practice may be less severe.

Proposition 3. *Feedback detachment strengthens the negative relationship between diagnostic practice displacement and independent professional expertise development.*

3.5. Cognitive Scaffolding as a Countervailing Mechanism

An explanation centered exclusively on displaced practice would overlook the possibility that intelligent systems create alternative learning opportunities. AI can provide explanations, generate competing interpretations, identify inconsistencies, and support the examination of complex problems. These functions may strengthen professional reasoning when assistance requires active evaluation rather than passive acceptance.

Cognitive scaffolding refers to this learning-oriented form of assistance. Its defining feature is not the amount of information provided but the extent to which professionals must interpret, verify, and integrate that information into their own understanding. A system that supplies a completed answer may improve immediate performance without necessarily supporting expertise formation. A system that prompts comparison, explanation, and correction may contribute to both outcomes.

Evidence of productivity improvements under generative AI and research on AI-supported professional instruction establish the plausibility of beneficial assistance, although immediate performance gains do not establish durable independent learning (Brynjolfsson et al., 2025; Giglio et al., 2025).

Cognitive scaffolding is therefore proposed to weaken the adverse developmental consequences of performance-oriented delegation. Its effectiveness depends on the preservation of meaningful reasoning, verification, and feedback integration. This proposition does not require technological assistance to outperform independent practice in every context. It specifies the conditions under which delegation is less likely to undermine expertise development.

Proposition 4. *Cognitive scaffolding weakens the negative developmental consequences of performance-oriented AI delegation when assistance requires active reasoning, meaningful verification, and corrective feedback integration.*

3.6. Learning-Oriented Work Design and the Preservation of Practice

The consequences of delegation are shaped by organizational arrangements rather than technological capabilities alone. Similar systems can be integrated into work processes that differ substantially in their allocation of judgment, responsibility, and opportunities for learning. Work design research establishes that task characteristics, autonomy, and feedback are consequential features of organizational experience (Morgeson & Humphrey, 2006).

Learning-oriented work design preserves activities through which professionals exercise and refine judgment. Such arrangements may include initial independent diagnosis, structured comparison of human and AI recommendations, opportunities to explain disagreements, and

periodic tasks completed without immediate technological assistance. Their theoretical significance lies in retaining learning-relevant cognition within otherwise technologically supported work.

This distinction prevents learning-oriented work design from becoming a general label for favorable organizational conditions. In EPT, its specific function is to weaken the relationship between performance-oriented delegation and diagnostic practice displacement. Organizations may delegate substantial work to AI while deliberately preserving opportunities for independent reasoning.

Proposition 5. *Learning-oriented work design weakens the positive relationship between performance-oriented AI delegation and diagnostic practice displacement by preserving structured opportunities for independent practice.*

3.7. Verification Complexity and Feedback Detachment

The developmental value of AI-assisted work also depends on professionals' capacity to evaluate technological recommendations. Verification complexity refers to the difficulty of independently determining whether an AI-generated explanation, diagnosis, or proposed action is appropriate. It may arise from ambiguous evidence, specialized knowledge requirements, or the effort needed to reconstruct the reasoning underlying a recommendation.

Verification complexity differs from task complexity. A task may be difficult to perform but relatively straightforward to verify once a solution is available. Conversely, an apparently simple recommendation may be difficult to evaluate when the underlying evidence or decision process is inaccessible.

Research on trust in automation emphasizes the importance of appropriate reliance, while studies of automation bias identify verification demands as relevant to human evaluation of technological outputs (Lee & See, 2004; Lyell & Coiera, 2017). EPT extends these concerns by specifying a developmental consequence: difficult verification may prevent professionals from connecting AI-assisted outcomes to corrective information about their own judgment.

The relationship is conditional. Verification complexity should increase feedback detachment primarily when professionals lack the time, resources, expertise, or opportunities needed to evaluate recommendations independently. Where these resources remain available, demanding verification may itself provide meaningful cognitive engagement.

Proposition 6. *Greater verification complexity strengthens feedback detachment under AI-assisted decision-making when professionals lack sufficient resources or opportunities to independently evaluate system recommendations.*

3.8. Performance–Expertise Decoupling and Human Capital Overestimation

The preceding relationships explain why assisted performance and independent expertise may develop at different rates. Performance-oriented delegation can improve task execution while changing opportunities for practice and corrective learning. When the developmental benefits of cognitive scaffolding and learning-oriented work design are insufficient to compensate for these changes, assisted performance may improve more rapidly than independently retained competence.

This divergence constitutes performance–expertise decoupling. It is not an additional causal mechanism. It is the focal phenomenon emerging from the relationship between technologically supported productivity and individual capability development.

Decoupling creates an organizational evaluation problem. Performance systems that primarily assess completed outputs may have difficulty distinguishing individual expertise from capabilities supplied by intelligent technologies. The resulting assessments may

overestimate human capital development even when they accurately record the quality or efficiency of assisted work.

Research on artificial certainty raises related concerns about the appearance of expert authority in AI-supported decision-making (Leonardi & Leavell, 2026). EPT specifies a distinct mechanism of misattribution: improvements in joint human–AI output may be interpreted as evidence of individual capability development without corresponding assessments of independent expertise.

Proposition 7. *As the growth of AI-assisted task performance exceeds the growth of independent professional expertise, organizational evaluations that rely predominantly on assisted-performance indicators become more likely to overestimate individual human capital development.*

3.9. Decoupling and Vulnerability During Independent Intervention

The consequences of performance–expertise decoupling may become apparent when professionals must act without effective technological assistance. Intelligent systems may be unavailable, generate unreliable recommendations, or encounter circumstances outside their effective operating conditions. Under such conditions, independent professional judgment may remain essential.

The classic ironies of automation identify the difficulty of preserving human readiness for exceptional intervention when routine operations are increasingly automated (Bainbridge, 1983). EPT extends this concern by specifying a developmental pathway through which apparently successful AI-assisted work may coexist with insufficiently maintained independent expertise.

The predicted consequence is not universal organizational fragility. Vulnerability depends on whether the capabilities affected by decoupling remain necessary, whether alternative expertise is available, and whether professionals encounter circumstances requiring independent intervention. The mechanism is most consequential when assisted performance conceals a persistent gap between operational expectations and retained human capabilities.

Proposition 8. *Greater performance–expertise decoupling increases vulnerability to performance deterioration when professionals must operate without effective AI assistance, particularly in situations requiring exceptional judgment or independent intervention.*

3.10. Integrative Causal Logic

The propositions establish a developmental sequence linking technological delegation, learning opportunities, professional expertise, and organizational consequences. Performance-oriented delegation can displace diagnostic practice when it transfers activities that would otherwise support independent reasoning. Displacement may constrain expertise development, particularly when feedback becomes detached from professionals' own judgments.

Two countervailing conditions qualify this sequence. Cognitive scaffolding can preserve the developmental value of technological assistance through active reasoning and corrective learning. Learning-oriented work design can reduce practice displacement by retaining structured opportunities for independent professional engagement. Verification complexity may intensify feedback detachment when professionals cannot adequately evaluate AI-generated recommendations.

The resulting relationship between assisted performance and independent expertise determines the extent of performance–expertise decoupling. When divergence increases,

organizations may overestimate individual human capital development and become more vulnerable during situations requiring independent intervention.

The proposed relationships converge into a conditional developmental architecture linking AI delegation, displaced practice, feedback quality, protective learning mechanisms, performance–expertise decoupling, and subsequent organizational consequences across repeated professional work episodes.

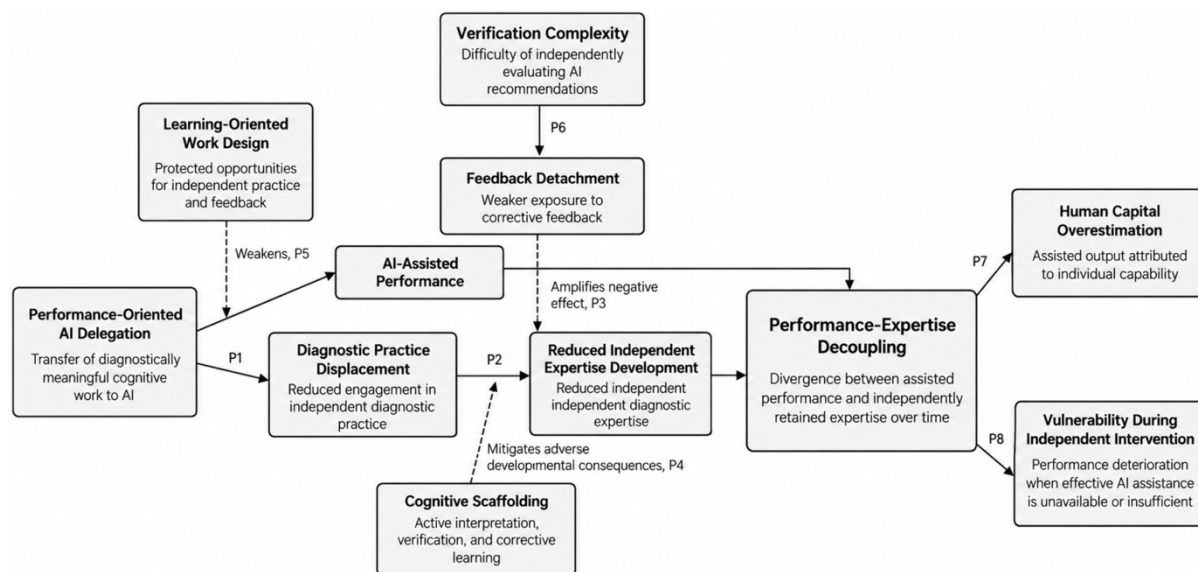


Figure 2. Causal Architecture of Expertise Paradox Theory
Source: Authors' conceptualization based on Propositions 1–8.

Figure 2 summarizes EPT as a conditional causal system rather than a direct automation-to-deskilling pathway. Performance-oriented AI delegation increases diagnostic practice displacement, while feedback detachment amplifies developmental loss. Cognitive scaffolding and learning-oriented work design counteract this pathway, whereas verification complexity heightens feedback detachment. Resulting performance–expertise decoupling may produce human capital overestimation and vulnerability during independent intervention under consequential operating conditions.

The proposed relationships form a coherent developmental architecture in which technological delegation initiates learning-related mechanisms, countervailing conditions alter their effects, and performance–expertise decoupling produces distinct organizational consequences over time.

Table 3. Proposition Summary and Explanatory Architecture of Expertise Paradox Theory

	Proposition & Theoretical relationship	Function within EPT
P1	Performance-oriented AI delegation → diagnostic practice displacement	Establishes the primary antecedent–mechanism link
P2	Diagnostic practice displacement → reduced independent expertise development	Specifies the core developmental consequence
P3	Feedback detachment strengthens the adverse effect of practice displacement	Identifies an amplifying mechanism
P4	Cognitive scaffolding mitigates adverse developmental consequences	Identifies a countervailing mechanism
P5	Learning-oriented work design weakens delegation- induced practice displacement	Specifies an organizational moderator
P6	Verification complexity increases feedback detachment under constrained evaluation	Specifies a conditional antecedent
P7	Performance–expertise decoupling → human capital overestimation	Establishes an assessment consequence

P8	Performance–expertise decoupling → vulnerability during independent intervention	Establishes an operational consequence
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Source: Authors' conceptualization.

Table 3 shows that EPT combines a primary developmental pathway with amplifying, countervailing, and conditional mechanisms. P1–P2 specify how delegation can reduce expertise-forming practice, P3–P6 qualify that pathway, and P7–P8 identify downstream consequences of sustained decoupling. The propositions therefore constitute a conditional causal architecture rather than a deterministic sequence from AI delegation to professional skill deterioration.

EPT therefore proposes neither a universal trade-off between technological productivity and professional learning nor an inevitable progression toward skill erosion. Its explanatory contribution is a conditional account of how the allocation of cognitive work changes the relationship between immediate performance and the development of independently retained expertise. The proposed relationships provide a basis for empirical testing across professional settings where technological assistance is extensive but independent human judgment remains consequential.

4. Expertise Paradox Theory

4.1. The Expertise Paradox: When Productive Work No Longer Reproduces Expertise

Professional work has traditionally served two interconnected functions. It generates outputs that contribute to organizational performance and provides experiences through which individuals acquire, refine, and retain professional expertise. The relationship between these functions is not automatic, but their connection has been central to understanding how productive activity contributes to human capital development. Intelligent technologies introduce conditions under which the two functions can become increasingly separated.

Expertise Paradox Theory (EPT) explains this separation. Its central proposition is that organizational arrangements designed to improve immediate performance through intelligent delegation may simultaneously reduce the opportunities through which professionals develop and maintain the expertise required for independent judgment. The paradox arises not because productivity improvements are inherently detrimental, but because the activities removed from human work may also be activities through which professional capabilities are reproduced.

This explanation extends the automation–augmentation paradox by introducing a developmental distinction. Raisch & Krakowski (2021) establish that intelligent technologies create persistent tensions between substituting for human activities and complementing human capabilities. EPT addresses a related but analytically different problem: whether technologically supported performance arrangements preserve the human expertise required for future professional work. The allocation of tasks may be effective for immediate production without being equally effective for capability formation.

The distinction is important because the consequences of delegation cannot be inferred from observed productivity alone. Improvements in assisted task performance indicate that a human–technology configuration has become more effective under particular conditions. They do not necessarily establish that individual professionals have developed an equivalent capacity to perform the same activities independently.

Research on skill erosion provides evidence that cognitive automation can have adverse developmental consequences. Rinta-Kahila et al. (2023) identify self-reinforcing processes through which skill deterioration may emerge in technologically mediated work. EPT incorporates this concern but does not equate the expertise paradox with absolute skill loss.

Independent competence may decline, remain stable, or improve more slowly than assisted performance. Each possibility can produce divergence between what a professional accomplishes with intelligent assistance and what the professional remains capable of accomplishing independently.

The theoretical problem therefore concerns the changing relationship between performance generation and expertise reproduction. EPT proposes that this relationship depends on the distribution of diagnostically meaningful activities, the availability of corrective feedback, and organizational arrangements that preserve active learning.

4.2. Foundational Assumptions and Developmental Logic

EPT rests on four assumptions that delimit its explanatory claims.

The first assumption is that professional expertise depends partly on meaningful cognitive practice and corrective feedback. Expertise is not simply accumulated through time spent at work. Its development requires engagement with activities that challenge existing understanding and provide opportunities to recognize and correct deficiencies. Research on deliberate practice supports the importance of purposeful engagement while also demonstrating that practice alone cannot explain all differences in expert performance (Ericsson et al., 1993; Macnamara & Maitra, 2019).

The second assumption is that assisted performance and independent expertise are distinct outcomes. Assisted performance reflects the combined contributions of professionals and intelligent systems. Independent expertise reflects capabilities retained by individuals and available for application without immediate technological assistance. These outcomes may be positively related, but their development need not follow identical trajectories.

The third assumption is that technological delegation redistributes opportunities for learning as well as responsibilities for task execution. When intelligent systems undertake diagnosis, interpretation, or evaluation, they may change which cognitive activities professionals perform and which experiences remain available for capability development. Delegation therefore has potential developmental consequences beyond its immediate effects on task efficiency.

The fourth assumption is that these consequences are conditional. Intelligent systems may displace opportunities for independent reasoning, but they may also provide explanations, alternatives, and feedback that support learning. Organizational work design influences whether professionals remain cognitively engaged and whether technologically assisted experiences contribute to retained competence.

Together, these assumptions establish the central developmental logic of EPT. Performance-oriented delegation can increase the effectiveness of task execution while reducing access to expertise-forming activities. Whether this produces a sustained divergence between assisted performance and independent expertise depends on the balance between developmental displacement and learning support.

4.3. The Erosion Pathway: Displaced Practice and Detached Feedback

The first pathway explains how performance-oriented delegation can constrain expertise development. It begins when intelligent systems assume activities that would otherwise require professionals to interpret evidence, formulate explanations, and evaluate competing judgments. Such delegation may improve immediate performance while reducing opportunities for independent diagnostic practice.

Diagnostic practice displacement is developmentally consequential because professional judgment depends partly on repeated engagement with uncertain and demanding problems. When individuals participate primarily in reviewing completed recommendations, they may

encounter fewer opportunities to construct their own interpretations or identify weaknesses in their reasoning. Research on technology-mediated professional learning demonstrates that changes in work arrangements can restrict established routes to skill acquisition (Beane, 2019).

The consequences of displacement are not uniform. Delegating repetitive activities with limited learning value may release time for more demanding work. Developmental risk is greater when the delegated activities contribute to capabilities that remain necessary for professional judgment and when equivalent opportunities for practice are unavailable.

Feedback detachment can amplify this risk. It occurs when professionals receive information about completed tasks without a sufficiently clear connection between outcomes and their own reasoning. Accurate AI recommendations may support effective task completion while providing limited opportunities to evaluate independently formulated judgments.

The distinction between practice and feedback matters because they represent different aspects of expertise formation. A professional may receive extensive information about task outcomes without exercising independent diagnostic reasoning. Another may continue performing demanding activities but receive insufficient feedback to recognize and correct errors. EPT predicts that developmental losses become more pronounced when reduced practice and detached feedback occur together.

Research on automation-related complacency and verification complexity identifies conditions under which technological assistance can complicate active monitoring and evaluation (Lyell & Coiera, 2017; Parasuraman & Manzey, 2010). EPT extends these concerns to the longitudinal development of expertise. The proposed relationship concerns whether repeated experiences provide sufficient opportunities to maintain independent judgment, not merely whether professionals detect an error in a particular assisted decision.

The erosion pathway consequently links performance-oriented delegation to reduced diagnostic practice, weakened corrective learning, and constrained expertise development. It does not require immediate declines in assisted output. The central concern is that favorable performance may persist while the developmental foundations of independent competence become weaker.

4.4. The Augmentation Pathway: Scaffolding and Protected Learning Opportunities

The second pathway explains how intelligent assistance may strengthen rather than constrain professional expertise. Technological systems can provide explanations, generate alternatives, identify inconsistencies, and support the examination of unfamiliar problems. These capabilities may improve immediate performance while creating opportunities for learning.

EPT identifies cognitive scaffolding as the mechanism through which such assistance can contribute to independent expertise. Scaffolding requires more than presenting accurate recommendations. It involves technological support that encourages professionals to interpret information, evaluate alternatives, verify conclusions, and integrate corrective feedback into their own understanding.

This distinction separates developmental augmentation from improved task execution alone. A professional who accepts a completed recommendation may achieve a high-quality outcome without acquiring the reasoning required to reproduce it independently. A professional who compares an initial judgment with alternative explanations, evaluates discrepancies, and incorporates corrective information may derive greater developmental value from the same technological system.

Research on generative AI at work demonstrates the potential for productivity improvements, while experimental work on AI-supported professional instruction indicates that technological assistance can contribute to training performance (Brynjolfsson et al., 2025; Giglio et al., 2025). These findings establish the plausibility of beneficial assistance but do not imply that immediate gains necessarily persist as independent expertise.

Learning-oriented work design provides the organizational conditions under which scaffolding may become effective. Such arrangements preserve opportunities for independent diagnosis, structured verification, corrective reflection, and periodic unaided practice. Their significance lies in ensuring that the use of intelligent systems does not eliminate the activities required for human capability development.

The augmentation pathway is not the absence of delegation. Professionals may rely extensively on intelligent systems while retaining meaningful opportunities to reason, evaluate, and learn. Delegation and scaffolding can therefore coexist within the same work arrangement.

This coexistence is central to EPT. The developmental consequences of intelligent technologies cannot be inferred from their intensity of use alone. They depend on whether the resulting work process preserves the cognitive participation through which independent expertise is developed and maintained.

4.5. Performance–Expertise Decoupling as the Focal Phenomenon

The two pathways explain why assisted performance and independent expertise may develop at different rates. The erosion pathway constrains capability formation through displaced practice and detached feedback. The augmentation pathway supports learning through cognitive scaffolding and preserved opportunities for independent engagement.

EPT defines performance–expertise decoupling as a divergence between the developmental trajectories of assisted task performance and independent professional expertise. The concept is relational and longitudinal. It cannot be established solely from a high level of technological reliance or from a single observation of successful assisted work.

Decoupling may arise through absolute expertise deterioration, but deterioration is not necessary. Independent competence may remain stable while assisted performance improves substantially. Alternatively, both outcomes may improve, but independent expertise may develop more slowly. These configurations differ in their developmental implications and should not be treated as equivalent evidence of skill erosion.

The distinction addresses a limitation in accounts that focus primarily on technological dependence or capability loss. Research on cognitive automation identifies processes of skill deterioration, while recent theoretical work raises concerns about skill decay and the possibility that performers may not recognize it (Macnamara et al., 2024; Rinta-Kahila et al., 2023). EPT specifies the broader relationship between assisted performance and independent expertise, allowing divergence to be examined without presuming that absolute deterioration has occurred.

The concept also differs from the aggregation–learning trade-off. Piezunka et al. (2022) explain how arrangements that aggregate information effectively may limit opportunities for individual learning. EPT concentrates on a particular configuration in which intelligent systems assume diagnostically meaningful professional activities and alter the feedback available for expertise formation. Its distinctive contribution lies in specifying the cognitive mechanisms and independently retained capabilities involved in that relationship.

Performance–expertise decoupling is therefore an outcome to be explained, not an additional mechanism. Its emergence depends on the cumulative consequences of delegation, practice displacement, feedback detachment, scaffolding, and work design.

4.6. Developmental Configurations of the Expertise Paradox

EPT distinguishes four configurations based on changes in assisted performance and independent expertise.

Productive erosion occurs when assisted performance improves while independent expertise deteriorates. This configuration represents the strongest manifestation of the expertise paradox because organizational performance gains coincide with declining retained competence. It may arise when cognitively meaningful activities are repeatedly delegated without sufficient opportunities for independent practice and corrective learning.

Stagnant dependence occurs when assisted performance improves while independent expertise remains relatively unchanged. Although this configuration does not demonstrate skill loss, it indicates that productivity improvements are not accompanied by corresponding capability development. Its developmental significance depends on whether professional demands continue to require growth in independent expertise.

Learning augmentation occurs when assisted performance and independent expertise improve together. This configuration is more likely when technological assistance provides meaningful cognitive scaffolding and work arrangements preserve opportunities for independent reasoning, verification, and feedback integration.

Failed integration occurs when technological assistance produces limited performance improvement and does not strengthen independent expertise. It reflects the absence of meaningful gains in either outcome rather than the paradoxical divergence central to EPT.

These configurations are analytical predictions rather than empirically established categories. They distinguish different developmental outcomes that may otherwise be grouped together under broad labels such as technological dependence, augmentation, or deskilling.

The configurations also clarify that EPT does not predict inevitable expertise erosion. Productive erosion and stagnant dependence represent forms of developmental divergence, while learning augmentation demonstrates that intelligent assistance can improve performance and expertise simultaneously.

The predicted developmental consequences of intelligent assistance vary according to the relative trajectories of AI-assisted performance and independently retained expertise, producing distinct configurations rather than a uniform pattern of deskilling.

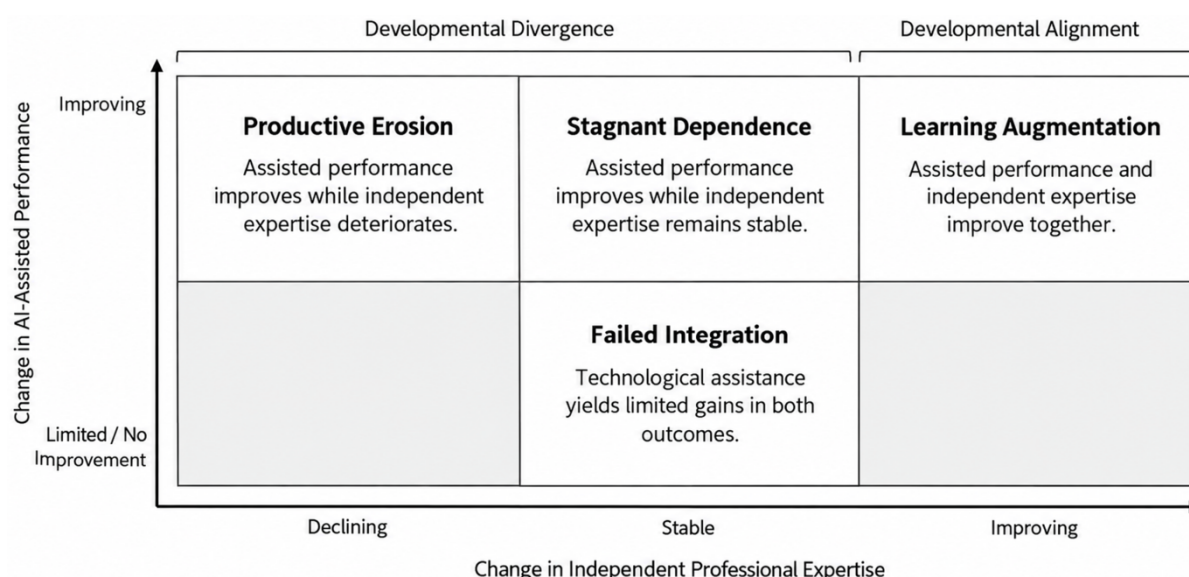


Figure 3. Developmental Configurations of AI-Assisted Performance and Independent Professional Expertise

Source: Authors' conceptualization based on the developmental configurations proposed in Expertise Paradox Theory.

Figure 3 clarifies that EPT does not equate technological assistance with inevitable expertise erosion. Productive erosion represents declining expertise despite improved assisted performance, whereas stagnant dependence reflects performance gains without corresponding capability development. Learning augmentation occurs when both trajectories improve, while failed integration captures limited gains in either outcome. The framework therefore distinguishes developmental divergence from absolute skill deterioration.

4.7. Boundary Conditions and Organizational Consequences

The strength of the expertise paradox depends on characteristics of professionals, tasks, and organizational arrangements.

Prior expertise may influence the ability to interpret and evaluate technological recommendations. Professionals with stronger conceptual foundations may be better positioned to identify inconsistencies and integrate corrective information. Prior competence, however, does not eliminate the need for continued engagement with activities through which expertise is maintained.

Task complexity affects the developmental significance of delegation. Removing opportunities for nonroutine diagnosis may have greater consequences than automating activities with limited learning value. Verification complexity introduces a related but distinct condition: even when professionals remain responsible for evaluating AI recommendations, the information or resources required for meaningful verification may be insufficient.

Learning-oriented work design moderates these relationships by preserving independent practice and corrective feedback. Organizational arrangements can therefore influence whether similar technological capabilities produce developmental erosion, stagnation, or augmentation.

EPT also identifies two organizational consequences of sustained decoupling.

The first is human capital overestimation. When employee evaluations rely predominantly on assisted performance indicators, capabilities supplied by intelligent systems may be attributed to individual professionals. Research on artificial certainty and expert authority raises related concerns about the interpretation of competence in AI-supported decision-making (Leonardi & Leavell, 2026). EPT specifies a developmental explanation for such misattribution: observed productivity may improve without corresponding growth in independently retained expertise.

The second consequence is vulnerability during independent intervention. Organizations may depend on professionals to address exceptional circumstances, evaluate unreliable recommendations, or continue operating when intelligent systems are unavailable. If independent expertise has developed more slowly than operational demands require, these situations may expose a gap between assisted performance and retained human capability.

This possibility extends the longstanding ironies of automation, particularly the difficulty of maintaining human readiness when automated systems assume routine responsibilities (Bainbridge, 1983). The predicted vulnerability is conditional rather than universal. It depends on whether independent judgment remains necessary, whether alternative expertise is available, and whether exceptional situations require capabilities affected by decoupling.

The expertise paradox is expected to vary across professional and organizational contexts because developmental risk depends on delegated task relevance, verification demands, compensatory learning opportunities, and continuing requirements for independent judgment.

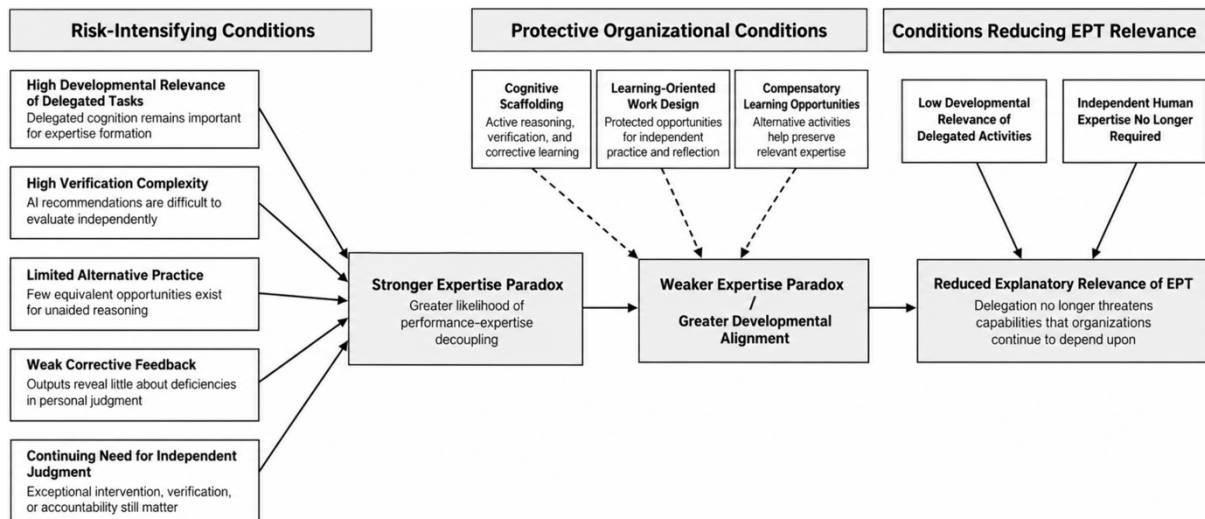


Figure 4. Boundary Conditions of Expertise Paradox Theory

Source: Authors' conceptualization based on the boundary conditions specified in Expertise Paradox Theory.

Figure 4 delineates the conditions under which EPT should exhibit greater or weaker explanatory relevance. Developmental risk increases when delegated activities remain expertise-forming, verification is difficult, alternative practice is limited, and independent judgment remains necessary. Cognitive scaffolding and learning-oriented work design can reduce decoupling, whereas EPT becomes less relevant when delegated capabilities have little developmental value or are no longer required.

4.8. Formal Theory Statement and Theoretical Distinctiveness

Expertise Paradox Theory proposes that, in knowledge-intensive professional work, performance-oriented delegation of cognitively meaningful activities to intelligent systems can improve assisted task performance while constraining the development and retention of independent professional expertise. This divergence arises when delegation displaces diagnostic practice and when feedback becomes detached from professionals' own reasoning. Its developmental consequences are weakened when cognitive scaffolding and learning-oriented work design preserve active interpretation, verification, corrective feedback, and meaningful practice. The extent and organizational consequences of the resulting performance–expertise decoupling depend on prior expertise, task complexity, verification demands, and the continuing need for independent human judgment.

The theory makes three distinct explanatory claims.

First, assisted performance and independent expertise are separate outcomes whose developmental trajectories may diverge. This distinction prevents improvements in joint human–AI output from being treated as sufficient evidence of individual capability development.

Second, the relationship between these outcomes depends on identifiable learning mechanisms. Diagnostic practice displacement and feedback detachment explain how productive delegation can constrain expertise, while cognitive scaffolding and learning-oriented work design explain how technologically assisted work may preserve or strengthen it.

Third, sustained divergence may have organizational consequences that remain difficult to detect through assisted-performance indicators alone. Human capital overestimation and vulnerability during independent intervention follow from the distinction between capabilities demonstrated through technological collaboration and capabilities retained by individual professionals.

EPT differs from the automation–augmentation paradox by specifying the developmental consequences of technological task allocation. It extends skill erosion research by explaining divergence that may occur without absolute capability deterioration. It also builds on organizational learning scholarship by identifying how delegation of diagnostic cognition and detachment of corrective feedback can separate immediate productivity from expertise formation.

The proposed theory remains conditional and requires empirical evaluation. Its contribution is not a universal prediction that intelligent technologies undermine professional competence, but an explanation of when and why technologically assisted performance may cease to provide reliable evidence of the development and retention of independent expertise.

5. Discussion and Future Research Agenda

5.1. Theoretical Implications: Reconsidering the Relationship Between Performance and Expertise

Expertise Paradox Theory (EPT) advances an explanation of how technologically assisted productivity and independently retained professional expertise may develop along different trajectories. Its central contribution is to distinguish the immediate effectiveness of human–AI task execution from the developmental processes through which individuals acquire and maintain professional judgment. This distinction challenges the assumption that improvements in observed performance necessarily indicate corresponding increases in individual human capital.

The contribution is particularly relevant to human capital scholarship. The strategic value of professional expertise depends on capabilities that individuals can apply to consequential organizational problems. Although these capabilities contribute to productive outcomes, the increasing involvement of intelligent systems makes it more difficult to attribute observed performance to individual competence. Coff (1997) identifies the managerial challenges associated with human assets, while EPT specifies a developmental problem that emerges when productive outputs are generated through technologically distributed capabilities. Organizations may improve their capacity to complete tasks without developing the independent expertise required to perform those tasks under different technological conditions.

EPT also extends the automation–augmentation perspective. Raisch & Krakowski (2021) explain the persistent tension between technological substitution and human complementarity. Their framework clarifies why organizations face competing demands when integrating intelligent systems into work. EPT introduces a distinct temporal dimension by examining whether the allocation of cognitive responsibilities preserves the processes through which professional expertise is reproduced. An arrangement may achieve an effective balance between automation and augmentation in immediate task execution while providing insufficient opportunities for independent capability development.

This distinction does not imply that augmentation is developmentally ineffective. It indicates that performance augmentation and expertise augmentation should not be treated as equivalent. The former concerns the effectiveness of technologically supported activity; the latter concerns changes in capabilities retained by individual professionals. The relationship between these outcomes depends on whether assistance preserves active reasoning, meaningful verification, and corrective learning.

The theory further develops research on cognitive automation and skill erosion. Rinta-Kahila et al. (2023) identify self-reinforcing processes through which technological dependence can contribute to skill deterioration. Macnamara et al. (2024) raise related concerns about the

possibility that AI assistance accelerates skill decay or constrains skill acquisition without users recognizing these consequences. EPT shares the developmental concern but distinguishes absolute capability deterioration from performance–expertise decoupling. Independent expertise may remain stable or improve more slowly than assisted performance without necessarily declining. This distinction broadens the range of developmental outcomes requiring explanation.

The proposed theory also contributes to organizational learning research by specifying how technologically mediated work can separate productive accomplishment from individual learning. Organizational learning scholarship establishes that knowledge develops through experience, while the aggregation–learning trade-off demonstrates that arrangements supporting effective collective decisions may constrain opportunities for individual learning (Argote & Miron-Spektor, 2011; Piezunka et al., 2022). EPT identifies a particular mechanism within this broader tension: delegation of diagnostically meaningful cognition can reduce independent practice, while feedback detachment limits the developmental value of completed tasks.

The distinction between individual and organizational knowledge is equally important. Organizational knowledge may remain available through technological systems, routines, and collective practices even when individual professionals exercise fewer opportunities for independent judgment. Research on organizational knowledge depreciation examines how technological arrangements may affect the persistence and renewal of organizational knowledge (Gerlach & Lange, 2026). EPT addresses a different level of analysis by focusing on independently retained professional expertise and its relationship to assisted performance. These outcomes may be related, but they are not conceptually interchangeable.

A further contribution concerns the conditions under which technological assistance supports learning. EPT does not assume that delegation necessarily constrains capability development. Cognitive scaffolding provides a countervailing mechanism through which explanations, alternatives, verification, and corrective feedback can support the internalization of knowledge. Learning-oriented work design determines whether professionals retain meaningful opportunities to exercise and refine judgment. The theory therefore specifies conditions under which assisted performance and independent expertise may improve together.

Taken together, these contributions establish EPT as a conditional developmental explanation rather than a general theory of technological deskilling. Its distinctive proposition is that the relationship between productivity and expertise depends on how intelligent systems redistribute cognitive practice and corrective feedback. The theory explains why favorable performance indicators may coexist with inadequate human capital development and identifies the organizational conditions under which this divergence may be reduced.

5.2. Managerial Implications: Managing Productivity Without Neglecting Capability Formation

EPT suggests that organizations integrating intelligent systems should distinguish the management of immediate performance from the development of professional expertise. These objectives are related but require different forms of assessment. Indicators of assisted output can establish whether a human–AI work arrangement produces desirable results. They do not independently establish whether employees retain the capabilities needed to evaluate, reproduce, or adapt those results without technological support.

Performance assessment should therefore distinguish proficiency in using intelligent systems from independently exercisable professional judgment. The distinction is particularly

relevant where employees remain responsible for evaluating recommendations, managing exceptional circumstances, or intervening when automated assistance is unavailable. Independent assessments can provide information that technologically assisted performance indicators may not capture.

The theory also directs attention to the developmental significance of task allocation. Organizations may benefit from identifying which activities provide meaningful opportunities for diagnosis, interpretation, and corrective learning before delegating them to intelligent systems. Activities with limited developmental value may be suitable for extensive automation, while diagnostically consequential activities may require arrangements that preserve professional engagement.

Learning-oriented work design offers a mechanism for reconciling productivity and capability development. Structured opportunities for initial independent judgment, comparison with AI-generated recommendations, explanation of discrepancies, and periodic unaided practice may preserve expertise-forming experiences within technologically supported work. Such arrangements are consistent with the broader importance of task characteristics and feedback in work design (Morgeson & Humphrey, 2006).

Cognitive scaffolding provides a complementary implication. Organizations should distinguish assistance that supplies completed outputs from assistance that supports professional reasoning. Explanations and alternatives are developmentally valuable only when employees engage with them in ways that contribute to understanding and retained competence. Increasing the volume of information presented by intelligent systems does not necessarily improve learning.

EPT also highlights the potential limitations of productivity-centered evaluation systems. When assisted performance becomes the dominant indicator of professional competence, organizations may overestimate the development of individual human capital. This concern is particularly consequential when employees retain accountability for judgments that require capabilities not routinely exercised during AI-assisted work.

These implications do not support a general restriction on technological assistance. They suggest that decisions concerning automation should consider both the immediate value of delegated activities and their contribution to the development of still-relevant professional expertise.

5.3. Professional Governance and Institutional Implications

The expertise paradox has implications for professional governance where independent judgment remains necessary for accountability, verification, or intervention. Intelligent systems may improve the consistency and efficiency of professional work while changing the opportunities through which practitioners maintain competence. Governance arrangements concerned with professional capability therefore face a distinction between effective use of technological systems and the continued ability to exercise independent judgment.

This distinction is particularly relevant in settings where professionals remain responsible for evaluating consequential recommendations. The difficulty of verifying automated outputs can affect the quality of human oversight, especially when recommendations require specialized knowledge or substantial effort to assess (Lyell & Coiera, 2017). Maintaining meaningful verification capabilities may therefore require attention to the developmental opportunities available within routine work.

Professional competence assessment may need to consider both assisted and unaided performance when independent intervention remains part of the occupational role. The appropriate balance depends on the nature of professional responsibilities and the consequences of inadequate judgment. EPT does not imply that unaided execution should replace technologically supported practice as the primary mode of work. It suggests that

retained independent competence should remain visible when it is necessary for professional accountability.

Governance responses should also distinguish skill erosion from skill obsolescence. A capability that is no longer required does not necessarily warrant continued investment solely because it was historically important. The theoretical concern arises when organizations continue to depend on independent human judgment while work arrangements provide insufficient opportunities to maintain it.

The resulting implication is proportional rather than universal. Professional and organizational governance should consider whether the capabilities required for consequential human intervention remain adequately developed and assessed under prevailing arrangements of intelligent assistance.

5.4. Boundary Conditions and Theoretical Limitations

EPT is a conceptual theory whose mechanisms and propositions require empirical evaluation. Its explanatory claims should not be interpreted as established causal effects of AI adoption. The proposed relationships concern developmental consequences that may emerge over repeated work episodes and are therefore not adequately evaluated through immediate performance comparisons alone.

The theory is most applicable to knowledge-intensive professional activities involving diagnosis, interpretation, evaluation, and consequential judgment. Its relevance is limited where delegated activities have little developmental significance or where independent human competence is no longer required. It does not explain general technological unemployment, occupational displacement, or changes in the market value of obsolete skills.

A central limitation concerns the measurement of independent expertise. Unaided task performance may provide useful evidence of retained competence, but assessments must account for prior expertise, task difficulty, changes in professional requirements, and the comparability of evaluation conditions. Without such controls, observed differences between assisted and unaided performance may be misinterpreted as evidence of developmental deterioration.

The temporal dimension presents an additional challenge. A short-term reduction in independent practice may not produce measurable expertise loss, particularly when professionals possess substantial prior experience or obtain equivalent learning opportunities elsewhere. Conversely, apparent stability in independent competence may conceal slower development relative to changing professional demands. Longitudinal assessment is therefore necessary to distinguish temporary variation from sustained developmental divergence.

EPT also recognizes that diagnostic practice displacement and feedback detachment may coexist with compensatory learning. Professionals may acquire new capabilities through interpreting AI-generated explanations, examining alternative solutions, or engaging in learning activities outside routine task execution. The developmental effects of delegation consequently depend on the balance between displaced and newly created learning opportunities.

Finally, the theory distinguishes individual expertise from collective and technologically embedded knowledge. Organizational performance may remain strong because intelligent systems preserve capabilities no longer exercised by particular employees. Such arrangements do not necessarily represent organizational failure. The concern arises when organizations continue to require independent human judgment but do not adequately preserve the expertise needed to exercise it.

5.5. Future Research Agenda

The proposed theory requires empirical research capable of distinguishing improvements in assisted performance from changes in independently retained expertise. The first priority is to establish whether these outcomes develop at different rates. Longitudinal studies could assess professionals under assisted and unaided conditions across repeated periods, allowing researchers to distinguish expertise growth, stagnation, and deterioration. Research on knowledge acquisition and depreciation provides a foundation for examining how capabilities change over time (Darr et al., 1995).

A second priority is to test the causal mechanisms. Field experiments could manipulate the extent of performance-oriented delegation while preserving comparable task demands. Such designs could examine whether the transfer of diagnostically meaningful activities reduces independent practice and whether this reduction predicts subsequent changes in expertise. Mediation analyses would help determine whether diagnostic practice displacement explains developmental outcomes beyond the immediate effects of technological assistance.

Feedback detachment requires separate investigation. Experiments could compare arrangements in which professionals receive completed AI recommendations with those requiring an initial independent judgment, structured discrepancy analysis, and corrective reflection. These designs would clarify whether the developmental consequences of delegation depend on the connection between personal reasoning and feedback.

Research should also examine cognitive scaffolding as a countervailing mechanism. Comparative interventions could evaluate explanation-based assistance, structured verification, and guided reflection. Delayed retention assessments and transfer tasks would be particularly important because improvements observed during assisted activity do not necessarily establish durable independent learning. Research on deliberate practice provides a basis for distinguishing immediate task accomplishment from capability development (Ericsson et al., 1993).

A fourth priority concerns learning-oriented work design. Multisite studies could compare organizations that preserve structured opportunities for independent diagnosis and feedback with those that emphasize assisted output efficiency. Such research could determine whether organizational arrangements moderate the relationship between technological delegation and diagnostic practice displacement.

Boundary-condition research should examine prior expertise, task complexity, verification demands, and professional accountability. These characteristics may influence both the developmental significance of delegated activities and the ability of professionals to learn from technological recommendations. Cross-domain studies could establish whether the proposed mechanisms operate similarly across clinical, financial, engineering, and advisory work.

The organizational consequences of decoupling require further investigation. Studies could compare assisted-output evaluations with independent competence assessments to determine whether productivity-centered performance systems overestimate individual human capital development. Simulations and longitudinal field research could also examine whether sustained decoupling increases vulnerability when intelligent systems fail or exceptional circumstances require unaided intervention.

These research directions would allow EPT to be supported, refined, or rejected through evidence concerning its mechanisms, boundary conditions, and predicted outcomes. The objective is not to demonstrate that intelligent technologies necessarily undermine professional expertise, but to establish when productive technological integration preserves or constrains the capabilities required for independent professional judgment.

The proposed mechanisms and boundary conditions generate a research agenda requiring longitudinal, experimental, comparative, and multilevel designs capable of distinguishing assisted performance from changes in independently retained professional expertise.

Table 4. Future Research Agenda for Expertise Paradox Theory

Research Stream	Central Question	Suggested Methodology	Proposition Linkage
Developmental divergence	Do assisted performance and independent expertise develop at different rates?	Longitudinal assisted and unaided assessments	Focal phenomenon
Diagnostic practice displacement	Does delegation of diagnostically meaningful activities reduce independent practice?	Field experiments and mediation analysis	P1–P2
Feedback detachment	Does weakened corrective feedback amplify developmental losses?	Randomized feedback interventions	P3, P6
Cognitive scaffolding	Which forms of assistance preserve independent expertise?	Comparative experiments with delayed retention tests	P4
Learning-oriented work design	Can protected practice mitigate delegation-induced displacement?	Multisite field studies and quasi-experiments	P5
Human capital overestimation	Do assisted-output indicators misrepresent individual competence?	Multilevel performance assessment studies	P7
Independent intervention vulnerability	Does sustained decoupling weaken unaided performance during exceptional situations?	Simulation and longitudinal field studies	P8

Source: Authors' research agenda derived from the mechanisms, propositions, and boundary conditions of Expertise Paradox Theory.

Table 4 translates EPT into an empirically testable research program. The agenda prioritizes longitudinal differentiation of assisted performance and retained expertise, direct tests of displacement and feedback mechanisms, evaluation of protective organizational arrangements, and assessment of downstream consequences. These designs would clarify whether the proposed relationships generalize across professional contexts and whether EPT requires refinement under different technological and organizational conditions.

The proposed research program is intended to evaluate the explanatory value of EPT relative to existing accounts of automation, skill erosion, and organizational learning. Its cumulative contribution would depend on demonstrating that diagnostic practice displacement, feedback detachment, and cognitive scaffolding explain variation in independent expertise beyond what can be attributed to technological use or immediate assisted performance alone.

6. Conclusion

The integration of intelligent systems into professional work creates a problem for human capital development: improvements in technologically assisted performance may no longer provide evidence that professionals are developing or retaining expertise required for independent judgment. Existing research explains automation, augmentation, delegation, skill erosion, and organizational learning, yet leaves insufficiently specified how cognitively meaningful delegation changes the relationship between performance and expertise. This study addresses that gap by developing Expertise Paradox Theory (EPT), a conditional explanation of when AI-assisted productivity undermines, preserves, or strengthens independent professional expertise.

EPT advances literature by separating assisted performance from independent expertise and treating their divergence as a longitudinal phenomenon rather than technological dependence or absolute skill deterioration. The theory identifies diagnostic practice displacement and feedback detachment as mechanisms through which performance-oriented AI delegation can constrain expertise formation, while cognitive scaffolding and

learning-oriented work design provide countervailing pathways. This distinction extends automation–augmentation research from task allocation to capability development, broadens skill-erosion accounts to include stagnation and unequal developmental trajectories, and specifies how technologically mediated work can separate productive accomplishment from individual learning.

The framework develops this contribution through eight propositions linking delegation, learning-relevant practice, feedback, verification complexity, scaffolding, work design, performance–expertise decoupling, human capital overestimation, and vulnerability during independent intervention. Its central implication is that the developmental quality of intelligent work cannot be inferred from AI intensity or productivity gains alone. What matters is whether meaningful activities, corrective information, and opportunities for independent reasoning remain embedded in repeated work episodes. EPT therefore explains why similar technologies may generate productive erosion, stagnant dependence, learning augmentation, or failed integration.

These arguments carry organizational and governance implications. Organizations should distinguish proficiency in using intelligent systems from independently exercisable judgment, identify which delegated activities are developmentally consequential, and preserve opportunities for diagnosis, verification, reflection, and periodic unaided practice where independent intervention remains necessary. Performance systems relying predominantly on assisted output risk overstating individual human capital. Professional governance should assess whether technological integration preserves capabilities required for accountability, exceptional intervention, and meaningful oversight rather than assuming successful human–AI output demonstrates retained competence.

EPT remains a conceptual theory requiring empirical evaluation. Independent expertise is difficult to assess, developmental effects may unfold slowly, compensatory learning may occur outside routine work, and the theory is less relevant where delegated capabilities no longer matter. Future research should use longitudinal assisted–unaided assessments, field experiments, feedback interventions, delayed retention tests, multisite and cross-domain studies to test mechanisms and boundary conditions. By shifting attention from what systems enable professionals to accomplish today to what professionals remain capable of accomplishing tomorrow, EPT reframes technological productivity as a developmental question and establishes a foundation for workplaces that enhance performance without silently eroding human expertise on which judgment still depends.

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