LEARNING BY DOING

Mapping Jobs, Experience, and Ecosystems for Working Learners

ACE® American Council on Education®

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This brief is part of a series that explores work-based learning and seeks to broaden the ecosystem of quality postsecondary education for today's learners. ACE is grateful to the Joyce Foundation for its generous investment in this work.

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Learning is the process whereby knowledge is created through the transformation of experience.

—David Kolb, *Experiential Learning: Experience as the Source of Learning and Development*

But one empirical generalization is so clear that all schools of thought must accept it, although they interpret it in different fashions: Learning is the product of experience. Learning can only take place throughout the attempt to solve a problem and therefore only takes place during activity.

—Kenneth J. Arrow, *The Economic Implications of Learning by Doing*

The practical skills of ordinary people have been a wellspring of widely shared wealth for 200 years, and the economic power of mighty nations rests on the technical knowledge of the humble. Provide the means for ordinary workers to acquire the skills and knowledge to implement new technology today and the economic bounty will not only grow, it will be widely shared.

—James Bessen, *Learning by Doing: The Real Connection Between Innovation, Wages, and Wealth*

Executive Summary

There is a paradox within the modern learning economy—a society in which the capability to learn is critical to the economic success of individuals, firms, regions, and national economies. Are working learners—or those in the active labor force without a four-college degree—the nation's greatest opportunity, or are they its greatest challenge? *Opportunity* is an apt descriptor, in the sense that working learners' knowledge, skills, and abilities, when used in collaboration with technology, can drive productivity, economic growth, and social mobility in an increasingly competitive global economy. *Challenge* also is a telling descriptor; increasing the knowledge, skills, and abilities of working learners in a time of great technological change is actually a very difficult social challenge. Failing to do so leaves behind too many workers who are striving to engage in today's economy, dividing society into haves and have-nots as well as decreasing social cohesion and common purpose.

Attempts to resolve this opportunity-challenge paradox over the past quarter century featured significant experimentation by stakeholders from colleges and universities; businesses; community organizations; and policymakers at federal, state, and local levels.

The higher education and business sectors and their community organization partners have been experimenting with and expanding programs such as internships, apprenticeships, competency-based education, learn and earn programs, cooperative education, boot camps, project-based learning, and credit for prior learning. These three sets of stakeholders are also seeking ways to measure ever smaller, grain-sized measures of learning and competence and then make those skills portable across sectors through skills-based hiring, learning and employment records, stackable credentials, employer certificates, digital badges, and distributed ledgers. Alas, scaling these efforts for direct impact and positive outcomes for millions of working learners remains elusive. In both scenarios, public policymakers are alternatively supporting experimentation—especially in regional or cluster-based approaches—or seeking effective ways to ensure protections for consumers and taxpayers are in place.

While all of the experimentation examples noted previously are efforts toward the deep integration of education and work (Soares 2015), stakeholders are missing a practical theory of learning by doing (LBD), which aligns the role of working learners with knowledge creation and innovation; workplaces as learning environments; and formal, nonformal, and informal learning ecosystems (Pellegrino and Hilton 2012; Dede and Richards 2020; Jackson, Hitt, and DeNisi 2003). Such a theory would create a shared understanding of knowledge creation at the individual, firm, and ecosystem levels, providing a solid foundation for scaled solutions. As noted experiential learning pioneer Kurt Lewin stated, "There is nothing so practical as good theory."

Drawing on a diverse body of literature, this report seeks to build a foundation for such a practical theory by providing tools to map LBD in order to optimize knowledge contribution and economic gains for working learners, relying upon regional innovation systems analyses, experiential learning theory (ELT), job quality, asset-based community development, and performance and competence ecosystems. The mapping tools include:

- Understanding how knowledge is created in a learning economy, particularly via LBD
- Proposing a workplace-centered definition of working learners
- Focusing on job quality as an enabler of workplace learning
- Developing a guide for how individuals and organizations learn from experience and create knowledge
- Describing characteristics of learning ecosystems to optimize knowledge creation, innovation, and growth via LBD

The Learning Economy and Learning by Doing

"A learning economy is one in which the success of individuals, firms, regions, and countries will reflect, more than anything, their ability to learn," observed Bengt-Åke Lundvall (2016), emeritus professor in economics at Aalborg University. Learning in this context refers to the combination of knowledge stocks and flows in ways that yield new knowledge with economic value. In other words, *innovation*—which in turn yields productivity improvements, economic growth, and prosperity. This type of learning for knowledge creation has two basic components: science, technology, and innovation, or STI; and learning by doing, using, and interacting, more commonly referred to as learning by doing, or LBD.[1]

STI is the very familiar learning associated with universities and research labs that are developing new formulas, theories, and technologies, the "know-what" and "know-why" of knowledge. In contrast, LBD is defined as a by-product of other activities. It often results in tacit knowledge with a focus on the "know how" and "know who" of knowledge, which tends to have local reach in terms of connections, customers, supplier, and competitors.

LBD constitutes processes of learning through *doing*—or working experience, increasing skills in production and exchanging knowledge with the firm. LBD processes also involve *using*, meaning feedback from users and their involvement in co-creating products and services. Finally, LBD includes *interacting* with other firms or external actors such as suppliers, competitors, nonprofit organizations, and public institutions (Alhusen et al. 2015). LBD processes are optimized by workplaces that bridge formal and nonformal learning, encourage worker autonomy, enable access to knowledge flows within and from outside the organization, and balance machine and human learning.

Together, these three broad learning processes of doing, using, and interacting result in innovations that are usually incremental, such as cost reductions and quality improvements. But they can also generate new products and services, which are often highly customer-specific. Importantly, in times of great technological change, LBD rises in importance because new knowledge and technology often don't have time to stabilize into curricula for delivery in formal educational settings.

Working Learners

In times of technological change, a nation's ability to help large numbers of workers learn the knowledge, skills, and abilities to implement, deploy, use, and maintain technical knowledge across many technologies is a key to its success. Pivotally, due to the evolving nature of new technologies and how they deploy and change as they move through organizations, businesses, regions, and the broader economy over decades, knowledge about them remains difficult to codify and standardize for transmission and formal teaching.

Consequently, much of workers' learning about technologies—and the commercially viable innovations they produce as a result—occurs in workplace settings. Enabling LBD for millions of workers thus becomes not only a pathway for social mobility but also a key factor in national economic competitiveness that is difficult to replicate.

The rising importance of LBD necessitates a need to develop a workplace-centric definition based on both the reality and potential to participate in knowledge creation for millions of working learners. Working learner is a dynamic, asset-oriented, and challenge-based identity; this term describes a community and subcommunities of workplace-based knowledge creators. Working learners create knowledge that adds value to products, processes, and service innovations at all levels and sectors of the economy by doing the work in production processes. In short, these workers learn by doing the work.

1 In innovation systems research, the acronym DUI is used to describe this type of learning. We have adapted the term "learning by doing" to link this work to earlier efforts by Kenneth Arrow and Robert Lucas as well as to align it with learning in workplaces and experiential learning themes.

The identity of working learners is dynamic because it manifests at the intersection of job quality; LBD; experiential learning theory; and formal, nonformal, and informal ecosystems. The identity of working learners also is asset-based because it accepts their work lives, life roles, and knowledge mastery as assets for knowledge creation and social mobility. And, importantly, this identity is both opportunity- and challenge-based because learning from work is a complex activity and not all workplaces are designed to optimize LBD.

There are more than 100 million working learners in the United States (U.S. Census Bureau 2022), which is 62 percent of its workforce. Working learners, on average, have an associate degree or below, are paid hourly, are more likely to work night shifts, work more than one job, spend more time unemployed, and work in jobs with less access to both formal and informal learning opportunities.

Experiential Learning Theory

Optimization of LBD can enhance competence, yield new knowledge, and produce innovation. Working learners, employers, and higher education institutions all must be intentional in how knowledge is created through experience in workplaces and other settings. This intentionality must manifest nearly in real time because a learning economy needs a theory of learning that can operate at the pace of lived experience—for a tool to map this process, we turn to experiential learning theory (ELT).

When educators, employers, and workforce development practitioners consider experiential learning, they often think of terms such as internships, apprenticeships, co-ops, on-the-job training, learn and earn programs, and service-learning. While these are manifestations of experiential learning, they barely scratch the surface of how David Kolb, the modern founder of ELT, believed his work might be used. The ELT approach to learning views knowledge creation as emerging from the integration of experiences from many settings, especially formal education and work. It stresses the interconnected nature of education, work, and personal development in adults.

This emphasis on growth and change, in turn, allows for creating a continuum of knowledge creation—from performance to learning to development—that is well suited to mapping the experience of LBD.

Moreover, Kolb viewed this experience as a rooted way of understanding learning and knowledge creation as a catalyst that could encompass individual-, institutional-, and societal-level adaptation as the world changes at ever-increasing rates with applications for education, employment, and social development policy and practice. In all these applications, it is important to recognize that experiential learning is not a series of techniques to be applied in current practice but rather a program for profoundly recreating our personal lives and social systems (Kolb 2015, 18).

In the 40 years since its introduction, ELT has evolved into a multifaceted approach for assessing how individuals transform experience into knowledge—with deep implications for LBD. This report discusses a number of key ELT concepts that can help navigate LBD across ecosystems, such as learning cycles or spirals, learning styles and flexibility, learning spaces, learning identities, the zone of proximal development, and social and personal knowledge.

Ecosystems

The aforementioned ELT concepts consider learning as emerging out of experiences across many life contexts—e.g., work, school, family, and community settings. This brief adapts these concepts into a model of interconnected ecosystems that foster LBD and knowledge flows in order to point to a reality for working learners: knowledge creation occurs across different ecosystems of learning, ranging from formal education or training to informal work activity-based and relationship-based exchanges of experience and expertise. Ecosystems thinking is helpful because the act of learning—what is considered knowing—and how one demonstrates competence vary by whether one is in a college classroom, a machine shop, a retail storefront, or a professional community of practice or interest. These very different environments have different boundary

characteristics within which learning is assessed. Together, they form an interconnected set of learning ecosystems. Understanding each ecosystem on its own terms and aligning them can optimize LBD for working learners and create a competitive advantage for them as well as for the economy. This report creates a taxonomy of formal, nonformal, and informal learning ecosystems to optimize LBD across different venues.

Mapping Learning by Doing

Combining the working learner definition, LBD, ELT, and ecosystem tools, this brief provides two visualizations to help facilitate the interconnected use of these concepts as a de facto, practical theory of LBD. One visualization is an individual centered mapping and the other a regional economic hierarchy to illustrate how LBD contributes to innovation and prosperity.

These working learner and regional economic perspectives can help practitioners to align individual- and system-level practices, policies, and interventions with the goal of optimizing the knowledge creation and benefits of LBD.

What to Expect in This Report

New knowledge, innovation, and technology create aggregate wealth for a nation because new ideas can be replicated at low cost. But technology creates wealth for the people (working learners) of a nation by requiring new technical knowledge that cannot be easily replicated (Bessen 2015). This advent of new technical knowledge can take decades to develop in working learners, even as the market, social institutions, and educational offerings that enable them to contribute to knowledge creation—and subsequently benefit from that contribution—are forming at the same time. This leads to employment dislocation and economic inequality for working learners that needs to be addressed via social policies to ensure our nation remains a just and stable democracy.

It is also the case that the more than 100 million working learners in the nation need to be engaged in LBD and knowledge flows that enable them to create knowledge from their work experiences and center their identity in the key assets of today's economy—learning and innovation. While this is a conceptual report meant to lay a foundation for a practical theory of LBD, the following are considerations raised in the report for stakeholders to contemplate as they move deeper into the learning economy.

Working Learners

- How can experiences be transformed into new knowledge? What are the preferences and strengths?
- How can a job's quality be assessed by its ability to meet both basic and learning needs?
- When mapping the LBD pathways at a current or new job, how are know-what, know-why, know-how, and know-who aligned? What learning flows are needed to access and create knowledge?
- How are machine and human learning balanced?

Employers

- How does the firm experientially create new knowledge? Are working learners included?
- Are the basic and advancement needs for working learners being met such that they can learn by doing?
- Are jobs designed to promote autonomy and problem-solving? How are job training, on-the-job learning, and tuition assistance aligned to optimize knowledge creation?
- Do working learners have access to knowledge flows? Can artificial intelligence help?
- How are formal, nonformal, and informal learning accessed to promote LBD?

Higher Education Institutions

- How does experiential learning inform education practice?
- How does LBD manifest in curriculums and in regional workplaces?
- Have these institutions mapped the formal, nonformal, and informal learning ecosystems in their regional economies? Are they interacting and aligning?
- How can the institution partner more deeply with employers to promote job quality and LBD?

Workforce Development Professionals

- How can workforce developers embrace their role as ambassadors of a learning economy that connects benefits for working learners to knowledge creation?
- How can workforce developers integrate experiential learning, LBD, ecosystems, and job-quality thinking into workforce and economic development practice?
- What tools do professionals have to map the LBD activities region across employers and education institutions?
- What are ways to build the competence of collaborations between employers and higher education practitioners to support continuous LBD for working learners?
- How can stakeholders advocate for policies that enhance LBD?

This report will prepare educators, employers, workforce development practitioners, and policymakers with ways to answer these questions so that the millions of working learners in this nation can contribute much more to economic growth and innovation and, in turn, reap the economic rewards for doing so.

Learning Economies, Learning by Doing, and Regional Competitiveness

> Knowledge is created by individuals, typically working within organizations, and transmitted to others within the organization. It is then transmitted from one organization and individual to another. But the extent, ease, and rapidity of transmission of knowledge is itself one of the central features of a learning economy: for the new knowledge spurs new thinking; it is the catalyst as well as the input out of which new ideas and creativity emerge.
>
> —Joseph Stiglitz and Bruce Greenwald, *Creating a Learning Society: A New Approach to Growth, Development and Social Progress*

An important reality in today's economy is that knowledge is socially constructed and transmitted from universities to manufacturing plants to storefronts in a feedback loop that drives productivity and innovation. The ease with which knowledge flows and who has access to it will be key to national competitiveness and social mobility in the coming decades.

In fact, a learning economy emerges out of a knowledge economy as flows of knowledge grow in importance relative to the stock of knowledge. The relative importance of knowledge flows rises when many innovations interact in what economists call synchronous technological change. The U.S. economy is at such a moment now, and it is experiencing a resultant rise in learning by doing (LBD)—or learning by experience—during the implementation and production phases of a technology's rollout.

LBD by millions of working learners can drive product and process innovation if intentionally pursued by workers, employers, and education stakeholders. In order to be intentional, these actors all need to understand how knowledge is created and, in particular, the importance of LBD—how it flows for economic purposes, who has access to it, and how to align human and machine learning.

The Rise of the Learning Economy

"A learning economy is one in which the success of individuals, firms, regions and countries will reflect, more than anything, their ability to learn," argued Bengt-Åke Lundvall (2016), emeritus professor of economics at Aalborg University. The learning economy is a dynamic concept; it involves the capacity to learn and to expand the knowledge base. Such an economy has two foundational and interrelated pillars—science, technology, and innovation (STI); and learning by doing, using, and interacting, more commonly referred to as learning by doing (LBD).

STI and LBD combine to create new knowledge with economic value—in other words, innovation. Innovation, in turn, yields productivity improvements, economic growth, and prosperity. STI is the very familiar learning we associate with universities and research labs, which work in collaboration with private firms to develop new formulas, theories, and codified knowledge that yield new technologies. LBD emerges from the interactive process of producing a good or service within an organization and solving the problems that arise in doing so.

LBD is an experience-based, community-oriented, contextual, and agentic knowledge creation process. It increases competence—in particular, the economic know-how and know-who on the part of millions of working learners that is necessary to convert ever more complex knowledge into innovative goods and services to be competitive in the global marketplace (Lundvall 2016).

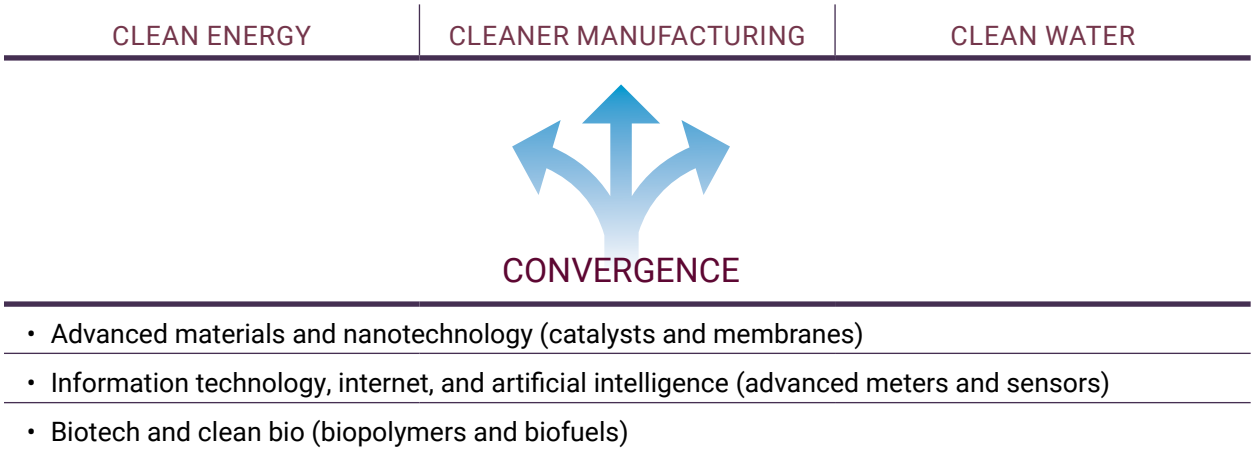
A learning economy evolves from a knowledge economy as general purpose technologies deploy across economies and change the way in which production happens. Economists adopted the term "general purpose technology" to describe technologies that serve as a foundation for a wide range of applications in the economy. Two examples of general purpose technologies are electrification, which transformed manufacturing and household production in the early twentieth century, and mechanization, which transformed manufacturing and agriculture in the nineteenth century.

These forms of technology are disruptive to economies because they yield inventions that profoundly alter commerce over a long period of time—often over two to three decades or more. These changes occur as knowledge related to the technology emerges and stabilizes, causing workers to adapt and learn new skills while employers try to understand how to best leverage new knowledge and skills to optimize and organize production.

Economic life over the past 40 years has been shaped by an especially potent general purpose technology—information technology—that continues to transform multiple economic sectors, among them health care, manufacturing, and logistics. Artificial intelligence will likely be the next general purpose technology to fundamentally change economic sectors, possibly followed by biotechnology and nanotechnology integration.

The following is a simple visualization of how synchronous technical change across material science, information technology, and bioscience can converge to create change across three sectors—energy, manufacturing, and water production—in overlapping technology waves (Cooke 2012, 109) (see figure 1).

FIGURE 1. SYNCHRONOUS TECHNICAL CHANGE INCREASES KNOWLEDGE FLOWS ACROSS SECTORS



Source: Adapted from Cooke 2012.

These overlapping technological waves of synchronous change shift the economic balance of protecting knowledge stocks versus participating in knowledge flows. For much of the twentieth century, economies were accustomed to a knowledge creation model that involved investing in STI to create new knowledge stocks and then legally protecting those assets to yield returns over decades. Today, technological, economic, and social changes are occurring so quickly in both parallel and serial ways that any given stock of knowledge depreciates faster. Thus—for individuals, firms, and economies alike—the focus of value creation is effective participation in knowledge flows, which are being constantly renewed (Hagel, Brown, and Davison 2010).

An important implication of the organic nature of this synchronous, multisectoral economic change and the value of knowledge flows is a sharp increase in LBD, by which productivity is achieved through practice and incremental innovation. LBD rises in importance because early knowledge associated with a technology is too fragmentary, uncertain, and constantly changing to be standardized. Prior to standardization, classroom education is difficult and may not reliably reward workers who invest in their training (Bessen 2015).

What Are Knowledge Flows?

Knowledge flows refer to knowledge movements across people, organizations, place, and time. Knowledge can flow through education, workplace and life experiences, and products and services—such as hybrid wheat seeds, penicillin, robusta coffee, naval weaponry, seed banks, satellites and high-performance computers, and the more conceptual apparatuses of plant phenotype data and statistics (Chauvel 2016). Knowledge flows are complex, with different types of knowledge having different rates of growth. Nanotechnology knowledge, for example, doubles every two years, whereas clinical knowledge does so every 18 months (Schilling 2013).

Research by the McKinsey Global Institute suggests that the knowledge flows driving innovation and productivity gains have fostered growth and supported poverty alleviation for hundreds of millions of people (Hogan 2011; Seong et al. 2022). In the period between 2010 and 2019, McKinsey research also demonstrates the growing importance of knowledge and know-how in the form of data and intangibles relative to other flows. The knowledge flows in the form of human expertise, codified knowledge, and dense social networks are driving economic value (Seong et al. 2022).

How Knowledge Flows

As noted previously, knowledge flows at different rates and in different ways in the process of creating, adapting, and applying it to products, processes, and services innovations. It is thus useful to have a typology of knowledge and how it flows. For this, we turn to learning economists Bengt-Ake Lundvall and Bjorn Johnson, who popularized a four-component model for types of knowledge that are helpful for further contextualizing learning intensity and LBD. With an eye toward enhancing economic performance and LBD, they organized the acquisition and use of knowledge into four categories: know-what, know-why, know-how, and know-who (Lundvall 2016).

- **Know-what** refers to knowledge about facts; this is the closest to simple information, such as how many people live in Ohio. This type of knowledge can be easily codified in a book or database and then shared.
- **Know-why** refers to knowledge about principles and laws of motion in nature, the human mind, and society. This type of knowledge is important in technological development in the sciences. Once known, it can be easily codified in a book or database.
- **Know-how** refers to skills or the ability to do something. It is inclusive of the expert skills of a carpenter to square an edge, a businessperson to develop a marketing plan, and a scientist to design and conduct experiments. Typically, it is embedded in specific contexts and developed alongside more expert guides. It tends to be tacit in nature.
- **Know-who** refers to different stocks of networked knowledge critical to creating a new innovative product or service. Today, most innovations that lead to growth occur through combinations of varied stocks of knowledge. Cooperation through personal and formal networks is key.

Know-why and know-what can be developed in formal schooling environments and by reading books, attending lectures, and accessing databases. Know-how and know-who are rooted in practical experiences, places, and social interaction with knowledge communities as individuals develop competence, expertise, and mastery in a domain.

These four categories of knowledge can be categorized as to whether they are tacit or explicit in nature, and this determines how they are used and shared. Explicit knowledge can be codified, recorded, and easily distributed. Tacit knowledge is intuitive and therefore rooted in context, experience, practice, and values. Because tacit knowledge is not written down and it is often hard to do so, it is not easily shared. Tacit knowledge (i.e., know-how, know-who) blends with explicit knowledge (i.e., know-why, know-what) in knowledge production that yields innovation. Tacit knowledge rises in primacy relative to explicit knowledge because it is rooted in place and involves complexity, novelty, and quality variations that are core to innovation.

Explicit and tacit knowledge drive other forces that shape the knowledge economy. In particular, the creative tension within the globalization of the economy—which was made possible by sharing explicit, codified knowledge among knowledge-based firms and knowledge workers, usually in metropolitan areas—is driven by tacit knowledge that is not easily shareable.

Tacit knowledge plays an important role for working learners and optimizes human capital because of two factors: social networks and place-based clustering. Social networks play an important role in the diffusion of information and knowledge, especially for sectors in which knowledge is being adapted and recombined, since social networks provide the formal connections and informal linkages through which information and ideas flow among individuals. Place-based economies are a powerful force that helps to explain the advantages of the clustering effect of many activities, such as transport terminals or retail. Place-based clustering can be driven by the size of markets; growing populations; and available infrastructure, including universities (Hogan 2011).

With this description of the learning economy, we can then begin to focus on particular aspects that are relevant to working learners. The realities that knowledge is socially constructed in communities, that there is a balance between STI and LBD learning, and that the place-based clustering drives knowledge creation all suggest ways to optimize human capital by creating a unified platform with a unified theory of learning and assessment.

Learning by Doing

In education, learning by doing (LBD) is the process whereby people make sense of experiences, especially those experiences in which they actively engage in making things and exploring the world. LBD is both a conceptual designation applied to a wide variety of learning situations and a pedagogical approach in which teachers seek to engage learners in more hands-on, creative modes of learning (Bruce and Bloch 2012).

In the economics literature, LBD originated in the work of economist Nobel laureate Kenneth Arrow in 1962 as a centerpiece of his theory of endogenous economic growth and firm learning.[2] In the mid-1980s, fellow Nobel laureate Robert Lucas enhanced the literature on LBD with a focus on continuous improvement; it increased worker productivity and firm performance. In the late 1990s, Belgian economist Bengt-Åke Lundvall expanded the conceptualization of LBD, adding using and interacting activities as a tool for understanding knowledge economies, innovation systems, and regional cluster-based growth.

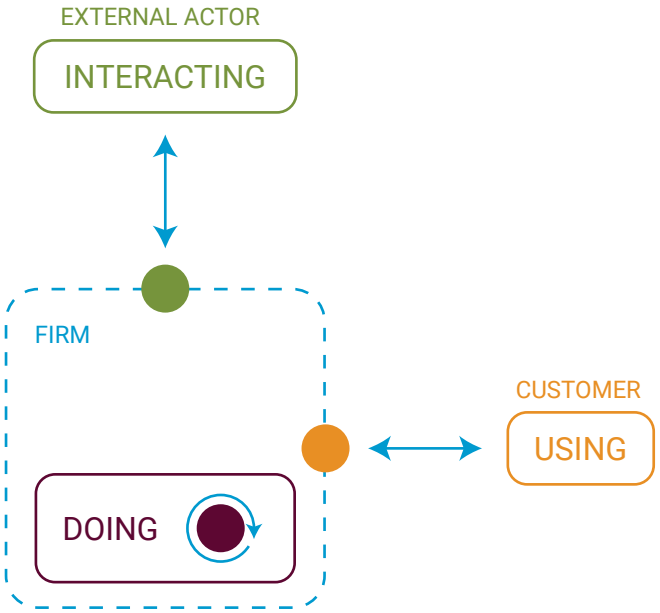
Today, LBD is defined as a by-product of other activities. It often results in tacit knowledge with a focus on know-how and know-who, which tend to have a local reach in terms of connections, customers, suppliers, and competitors. LBD constitutes processes of learning through *doing*—or learning through working experience—increasing the skill in production and exchanging knowledge with the firm. LBD processes also involve *using*, meaning feedback from users and their involvement in co-creating products and services. Finally, LBD includes *interacting*, or learning through interactions with other firms or external actors, such as suppliers, competitors, nonprofit organizations, and public institutions (Alhusen et al. 2015).

Together, these three broad learning processes of doing, using, and interacting result in innovations that are usually incremental, such as cost reductions and quality improvements. But they can also generate new products and services, which are often highly customer-specific. Crucially, to engaging in LBD is to understand how to use knowledge flows and knowledge facilitators within firms. Knowledge flows emerge within firms via doing and from outside firms via using and interacting. These flows contain new knowledge for the receiving firms, which serves as an input to knowledge creation and innovation activities (Alhusen et al. 2015).

These flows of knowledge can be measured with respect to their intensity and quality. Facilitators are essential actors, organizational practices, or technical means—such as artificial intelligence in today's world—within firms that capture, augment, and promote flows of new knowledge and help to translate them into economic application (see figure 2).

2 Robert Lucas, Paul Romer, and other noted economists also added to the LBD body of knowledge.

FIGURE 2. LEARNING BY DOING (USING AND INTERACTING) ACTIVITIES



Source: Alhusen et al. 2015. Used with permission from the authors.

Figure 2 provides a visual aid to understand LBD, knowledge flows, and facilitators. The dashed rectangle represents the firm and—importantly for the thesis of this brief—working learners carrying on daily production, sales, marketing, customer service and other activities. Within the firm, working learners were involved with production, sales, marketing, customer service, and other activities, engaging in LBD processes represented by circular arrows. Customers and external actors are depicted outside of the firm. Arrows represent bidirectional knowledge, illustrating learning by using and learning by interacting. Dots represent facilitators (Alhusen et al. 2015).

Each LBD category is aligned with a list of key activities that are necessary to effectively engage in knowledge creation and promote innovation (see table 1).

Cross-national comparisons show a positive correlation between the national share of employees engaged in advanced forms of LBD at the workplace and the percentage of private-sector enterprises doing more radical forms of innovation (Arundel et al. 2007). Further, "in nations where work is organized to support higher levels of discretion in solving complex problems, firms tend to be more active in terms of innovation developed through their own in-house creative efforts," argued Anthony Arundel, Edward Lorenz, Bengt-Åke Lundvall, and Antoine Valeyre (2007). The innovation that promotes LBD environments described is this research journal article are aligned with the business culture, job design, and on-the-job training elements of job quality (Jensen et al. 2007, Lundvall 2005).

TABLE 1. LEARNING BY DOING ACTIVITIES

KF = Knowledge Flow, F = Facilitator

DOING	USING	INTERACTING
Employed Technology • New tech introduction (KF) • Existing tech improvement (KF)	**Cooperation with Customers** • Firm functions cooperation with customers (KF) • Intensity of customer cooperation and interaction (KF) • Customer innovativeness (KF) • Customer tech know-how (KF) • Duration of customer contact (KF)	**Interaction with Suppliers** • Innovation cooperation with suppliers (KF) • Supplier's competencies (F) • Supplier relationships (F)
Training • General skills (KF) • Firm-specific skills (KF)	**Customer Contact** • Active request for feedback (F) • Use of customer support (F) • Use of social media (F)	**Interaction with Competitors** • Competitor relationship (KF) • Competitive pressure (F)
Trial and Error Learning • Scope of trial and error learning (F) • Use of experience (KF) • Creativity in the workplace (F)	**Product Specifications** • Customized products (F) • Additional products and services (F) • Complementary products and services (F) • Customer involvement (KF)	**Interaction with Intrasectoral Firms** • Innovation cooperation within the sector (KF) • Intrasectoral relationships (F)
Informal Contacts and Firm Internal Relations • Mutual support among employees (KF) • Maintaining good relations within the firm (F) • Learning by observing (KF)		**Interaction with Extra-sectoral firms** • Innovation cooperation across sectors (KF) • Extra-industry relationships (F)
Mechanisms of Knowledge Exchange • Regular team meetings (F) • Knowledge exchange among employees with different tasks (KF) • Open communication culture (F)		**Interactions with Consultancies and Public Institutions** • Supporting innovation cooperation (KF) • Relationship with consultants (F) • Collaboration financing (F) • Regional cluster participation (F) • Support innovation awards (F)
Human Resource Management Tools • Delegation and degree of autonomy (F) • Integration of functions (F) • Monetary incentives for idea disclosure (F) • Knowledge management (F) • Idea management (F)		**Trade Associations and Networks** • Participation in network events (KF) • Importance of network relations (F)

Source: Adapted from Alhusen et al. 2015.

Division of Learning and Learning Collectives

In daily life, knowledge flows are also curated by data-driven firms, such as Alphabet Inc., the parent company of Google; Microsoft Inc.; and Meta Inc., the parent company of Facebook. These and other information technology firms—by blending technology, cognitive science, and business—have created a knowledge-and-data-flow universe that at once controls the information we have access to with which to do our work and live our lives—all the while ingesting the outcomes to inform further control (Zuboff 2019, 339).

In workplaces, this dynamic manifests in whether and how working learners have access to knowledge flows in ways that facilitate knowledge creation, productivity enhancement, and innovation. Drawing on the work of Harvard Business School professor Shoshana Zuboff, this brief highlights two important guideposts for optimizing LBD—division of learning and learning collectives (Zuboff 2019, 339).

Division of Learning

Building on previous work on the technology mediated workplace, Zuboff describes a world of work in which accessing and curating data from knowledge flows is increasingly key for working learners to be competitive at work. What in the industrial economy of the nineteenth and twentieth centuries was a division of labor is fast becoming in the twenty-first century knowledge economy a division of learning, with only those workers who have access to knowledge flows being able to participate in knowledge creation and competence-building. Zuboff's division of learning raises key questions about:

- How knowledge is distributed and who is included or excluded from the opportunity to learn through knowledge flows
- Which people, institutions, or processes have the authority to determine who is included in learning, what they are able to learn, and how they are able to act on their knowledge
- What source of power undergirds the authority to share or withhold knowledge (Zuboff 2019, 339)

If LBD is to be optimized, then working learners need to have access to knowledge flows. Using these three concerns as a guide stakeholders can ensure working learners are not left out.

Learning Collectives

LBD in today's economy is impossible without an ability to interact with knowledge flows mediated by technology and, in particular, artificial intelligence. Yet the current dialogue defaults to an understanding of learning in which machine learning is the model for human learning, so it becomes a machine-first approach. According to the World Economic Forum (2023, 6), a 65 percent/35 percent human/machine split exists in many work tasks in the global economy. With this level of interaction, how humans and machines learn deeply influences how LBD may happen in the workplace.

Zuboff's thinking is useful here because it emphasizes that most current thinking on how these collectives might work defaults to a machine-first view of learning. Citing public speeches of technology executives with regard to how knowledge flows are enabled by the cloud and the internet of things for advance manufacturing, she explained that "human and machine behaviors are tuned to pre-established parameters determined by superiors and referred to as 'policies'" (Zuboff 2019, 409) These policies are algorithmic rules that substitute for social functions, such as supervision, negotiation, communication, and problem-solving. In this model, human learning is circumscribed by the way machines learn.

While human learning metaphors for how machines learn are a useful heuristic, it isn't clear that machine learning is the best way for humans to use LBD in their work. ELT is a better tool for understanding how working learners create new knowledge *through* LBD (see Experiential Learning Theory as a Tool to Help Optimize Learning by Doing). But before detailing that approach, we need to further explore how workers in the industrial economy work in the learning economy.

From Workers as Learners to Working Learners

At more than 100 million (U.S. Census Bureau 2022), working learners—or those already in the workforce with an associate degree or less—compose 62 percent of the national workforce. This section of the report develops a dynamic definition of working learners centered on enabling learning by doing (LBD) in the workplace as part of a knowledge creation, innovation, and economic growth cycle. This requires taking a holistic look at work stability, schedules, access to learning, and job quality overall with regard for whether a workplace enables learning and to what degree.

This section of the report centers learning in work in times of technological change, defines working learners based on four tensions in the education and work debate, and then closes with a snapshot on the work lives and relative job quality of working learners.

Workers as Learners

When technological change rolls through an economy and changes products, services, businesses, and work itself, workers are impacted by job displacement, wage instability, loss of workplace voice, and, of course, the need to learn. This need to learn manifests most obviously in newspaper headlines and public discussions of skills gaps and slowing productivity, as well as in the loss of economic competitiveness—leading to calls for more postsecondary education and training opportunities. While this is appropriate, it is only half the story.

New technologies require much more than invention in order to be designed, built, installed, operated, and maintained. Initially much of this new technical knowledge develops slowly because it is learned through experience, not in the classroom. Throughout history workers have acquired their technical knowledge through a combination of formal training and experience. They gained much of their important technical knowledge on the job through LBD. Formal and nonformal experimentation aided by informal communication with others allowed workers to acquire new skills and knowledge of technology and how to use it to create value in workplace settings (Bessen 2015). LBD, in turn, enhances competence and adds new knowledge and innovation to the production cycles.

Yet it can take decades for technical knowledge to be developed, longer for it to spread, and even longer for institutions to emerge, such as labor markets that allow ordinary workers to benefit from their new knowledge. Such learning on a mass scale both was and still is a difficult problem for society (Bessen 2015). Today, with multiple waves of technological change moving through the economy, we need a definition of working learners centered in LBD in order to craft workplaces that optimize knowledge creation.

Working Learners

For this report, working learners are defined as a dynamic, asset-oriented and challenge-based identity describing a community and subcommunities of workplace-based knowledge creators. Working learners create knowledge that adds value to products, processes, and services innovations through LBD in the production process. In short, they learn by doing the work.

This identity is dynamic because it manifests at the intersection of job quality; LBD; ELT; and formal, nonformal, and informal ecosystems. This identity is asset-based because it accepts the working learners' work lives, life roles, learner roles, and knowledge mastery as assets for LBD in knowledge creation (Kasworm 2007).[1] It is challenge-based because learning from

work is a complex activity. Additionally, many workplaces are not designed in ways that optimize LBD, nor do they enable working learners to represent both realized and unrealized contributions to knowledge creation and innovation or to benefit from those contributions.

In attempt to both center the dynamic working learner concept in current policy and practices debates and place a number on the group, this brief draws on four tensions in the public debate about education and work as well as available data on their work lives to provide access points for working learners, employers, higher education institutions, and other stakeholders.

The four tensions encompass learning across contexts, the experience of work, and the relative friendliness of workplaces to learning. These tensions are:

- Class versus access to opportunity
- Education versus labor market policy
- Liberal arts education versus career preparation
- Job quality versus skills development

The working learner definition aligns with the recent trends in sociological analysis to align class identity (working class, middle class, upper middle class, wealthy) with education attainment. With the bachelor's degree remaining both the cultural and economic touchstone for access to good jobs and social mobility, the associate-level cutoff demarcates different work and life experiences that provide a reference point for whether workers are enabled with LBD in the workplace. Education attainment, especially the four-year-and-above split, is highly correlated to job quality in the economy; those individuals with an associate degree or lower experience poorer job quality, including less access to formal and informal learning in the workplace (Draut 2018). Overall, a worker with a bachelor's degree has a 75 percent chance of holding a good job. An associate degree holder has a 40 percent chance. Associate degree holders face more restrictive choices, as most of the "good jobs" are in the growing skilled-services fields (Scholarship America 2023).[3]

The working learner definition also conceptually bridges the divide between education and labor market policy. As others have written, the United States continues to attempt to solve its talent development challenges through siloed education and labor market policies (Merisotis 2020; Aoun 2018). For a learning economy in which integrating STI and LBD is increasingly important to national competitiveness, policymakers need to embrace an integrated approach to education and labor markets.

For higher education institutions, the definition of the working learner drives deep into the heart of the ongoing debate about the purposes of the sector to help individuals live a good life (liberal arts education) versus earning a living (career preparation) (O'Bannion 2016). The reality is that the learning economy has encompassed the knowledge, skills, and abilities needed to be successful across work and life contexts (Dede and Richards 2020). This summons higher education institutions to view themselves as one among many ways that individuals learn and to act as a collaborative platform for learning across domains, in addition to being a provider of an education.

Finally, job quality and skills development have been positioned as opposing solutions to how to align economic opportunity with knowledge-driven growth. The job-quality movement appropriately posits that public policy should focus on ensuring that jobs pay good wages and offer benefits and safety, while skills development solutions push for building knowledge, skills, and abilities of working learners such that they can keep up with changing job requirements. For working learners seeking LBD, job quality, and skills development are a both/and necessity. In order to foster LBD by engaging and curating knowledge flows, workplaces need to be redesigned in keeping with the key attributes of job quality.

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3 The term "good jobs" was used in the study and report from Georgetown University's Center for Education and the Workforce upon which Scholarship America's blog post was based. As Scholarship America (2023) stated in a note to their analysis, "The study defines 'good jobs' as 'those paying an annual wage of least $35,000 for workers under the age of 45 and $45,000 for workers over 45.' The overall median income for jobs that meet those standards is $55,000."

Working Learners by the Numbers

With these themes framing our definition, working learners make up 62 percent of the nation's workforce, or more than 100 million people. Even with growing numbers of college-educated individuals entering the labor market, working learners continue to represent the largest portion of the workforce (Glass 2023). Of those, 34 million have some education or credential beyond high school, while 71 million have a high school diploma or less (Glass 2023).

For working learners, education attainment also correlates with access to training, digital preparedness, and knowledge flows—all of which impact LBD. Within the working learner framing, the further a working learner moves down the ladder of education attainment, the less likely they are to benefit from formal training, on-the-job training, and tuition assistance benefits than those with a four-year degree (Carnevale, Strohl, and Gulish 2015). Also, working learners are far less likely to have access to technology and knowledge flows that allow them to benefit from LBD, problem-solve, and add value in technology-mediated workplaces (OECD 2023).

Working learners are concentrated in service, retail, health care, food service, accommodation, and construction sectors with lower wages and less job quality (Glass 2023) as measured by unstable schedules, lack of benefits, and low access to formal and informal learning. With regard to race and ethnicity, working learners are a diverse group. Black, Hispanic, and other workers of color make up 45 percent of the working learner population, while non-Hispanic, White workers compose the remaining 55 percent. In addition, at 44 percent, women make up nearly half of all working learners (Parker 2021). Working learners are more likely to:

- Be hourly wage earners; nearly six out of 10 workers are paid hourly wages versus annual salaries, and eight out of every 10 hourly workers do not hold a bachelor's degree (U.S. Bureau of Labor Statistics 2014)
- Start work early, often commuting before dawn; 23 million working learners start work in the dark (beginning their shifts between 7:00 p.m. and 7:00 a.m.) (Glass 2023), and 2 million working learners work the night shift (Price 2011; Lei 2023)

Across many industries for working learners, lower wage jobs with few benefits prevail and legal protections and little worker voice are scant. The industries in which they work are predominantly in the services sector (Glass, Madland, and Walter 2022), including food service (Madland 2021), health care (Duffy 2022), retail (Corser 2017), and home care (SEIU 775 and Center for American Progress 2021). Whether in terms of economic instability, health risk, or lack of time, the data enumerated previously frame workplaces that are both indirectly and indirectly inhospitable to learning in the workplace as part of the production process. Thus, working learners miss out on the opportunity to participate in the LBD that is so crucial to national competitiveness and individual success in the learning economy.

This is why educators, employers, workforce practitioners, and policymakers need a language to describe the structures that could create this opportunity. For that, we turn to the job quality literature.

Job Quality

Job quality is at once a cultural, social, political, and economic term. From the intersection of these societal trends, key themes of work and economic life emerge, including:

- How a nation and its citizens value work
- How the benefits of economic growth are shared
- How workers, businesses, and government shape markets

As technology, knowledge, and global trade continue to cause dramatic shifts in the economy causing dislocation, economic inequality, and poverty for working learners, the debate on job quality justly shifts to the ethical and moral imperatives for a democratic nation to create generative work environments that can sustain families and help them invest in a positive future. Yet, as LBD becomes a central part of productivity and innovation activity, key characteristics of a quality job also create conditions for workers to participate in LBD with knowledge flows (see table 2).

TABLE 2. ELEMENTS OF JOB QUALITY

	ELEMENTS THAT PROVIDE BENEFITS IN CURRENT JOB	ELEMENTS THAT SUPPORT ADVANCEMENT
Pay	• Level of pay • Predictability of pay	
Benefits	• Health insurance • Retirement plans • Leave • Other benefits (e.g., disability, insurance)	• Educational benefits (e.g., tuition assistance)
Working conditions	• Stable, predictable hours • Control over hours or location • Job security • Safety • Nondiscrimination	
Business culture and job design	• Culture of belonging • Culture of diversity, equity, and inclusion • Strong organizational mission • Meaningfulness of tasks	• Focus on personal growth (e.g., mentoring) • Autonomy/power to change things • Diversity of tasks • Clearly defined career paths
On-the-job skill development	• Training for specific tasks	• Cross-training • Advancement training and education

Source: Adapted from Congdon et al. 2020 with permission from the Urban Institute.

Table 3, along with the research on LBD, demonstrates how we can create workplaces that sustain knowledge creation that leads to innovation. Pay, benefits, and working conditions are shaded in blue and are most often characterized as aspects of a good job that meet a workers basic needs. Business culture and job design, on-the-job skills development, and education benefits are blue- and purple-shaded and are focused on meeting workers' higher needs for meaning, growth, belonging, and achievement.

If working learners' basic needs aren't met, then clearly focusing on how to create knowledge and LBD is nearly impossible, thus the good jobs movement strives to ensure these areas first. Still, the opportunity for workplaces that meet these higher needs, if enabled, creates opportunities for working learners to fully engage in the knowledge creation so critical being relevant in today's economy.

Work has long been a central part of the identity of millions of Americans. Building on this identity by ensuring that workplaces are centers of learning simply leans into a strength that could very well be a key to national competitiveness. With the rising importance of LBD and as pointed out previously, the challenge of upgrading the skills of millions of workers occurs in real time throughout workplaces across an economy. The nation that develops strategies for this organic, production-driven human capital development will lead in both technology adoption and eventually equitable growth. The more than 100 million Americans who are empowered through LBD can lead the way.

Experiential Learning Theory as a Tool to Help Optimize Learning by Doing

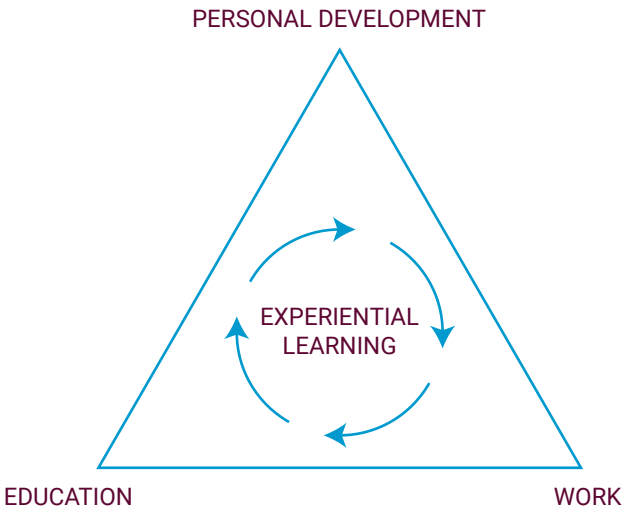
In order for learning by doing (LBD) to enhance competence, yield new knowledge, and produce innovation, working learners must be intentional in how they process experience in workplaces, on teams, and when engaging with knowledge flows. This intentionality must manifest nearly in real time, which means educators, workforce development practitioners, employers, and policymakers need a theory of learning for a learning economy so that it can operate at the pace of lived experience. For this, we turn to experiential learning theory (ELT).

Experiential learning often conjures thoughts of terms such as internships, apprenticeships, cooperatives, on-the-job training, learn and earn programs, and service-learning. While these are manifestations of experiential learning, they barely scratch the surface of how David Kolb, the modern founder of ELT, believed his work might be used. As he observed, "Learning is the process whereby knowledge is created through the transformation of experience" (Kolb 2015).

ELT is an approach to learning that views knowledge creation emerging from the integration of experiences from many settings, especially formal education and work. Kolb (2015) used the term experience to describe a theoretical perspective on individual learning that could be applied in all situations and arenas of life—education, family, work, and community.

The aim of ELT is firmly rooted in social psychology, philosophy, and cognitive psychology.[4] ELT explains how experience is transformed into learning and reliable knowledge. It stresses the interconnected nature of education, work, and personal development—all lifelong adaptive processes that help individuals to reach their full potential as citizens, family members, and human beings (see figure 3).

FIGURE 3. EXPERIENTIAL LEARNING AS THE PROCESS THAT LINKS EDUCATION, WORK, AND PERSONAL DEVELOPMENT



Source: Kolb 2015. Used with permission from Experience Based Learning Systems, LLC.

This whole life perspective on learning extends the time horizon of how we consider learning and its impact. This gives rise to three terms that are critical to LBD: performance, learning, and development. Immediate reactions to a situation or problem

4 ELT is dependent upon the work of scholars John Dewey, Kurt Lewin, Mary Parker Follett, Jean Piaget, William James, Lev Vygotsky, Paulo Freire, Carl Rogers, and Carl Jung.

are thought to be more performance than learning, while—at the other extreme—long-term adaptations to work and life change are seen more as adult development than learning (Kolb 2015).

Importantly, Kolb viewed this experience as a rooted way of understanding learning and knowledge creation and as catalyst that could encompass individual-, institutional-, and societal-level adaptation as the world changes at ever-increasing rates, with applications for education, employment, and social development policy and practice. In all of these applications, it is important to recognize that experiential learning is not a series of techniques to be applied in current practice but a program for profoundly, recreating our personal lives and social systems (Passarelli and Kolb 2011; Kolb 2015, 19).

In the 40 years since its introduction, ELT has evolved into a multifaceted approach for assessing how individuals transform experience into knowledge, which has deep implications for LBD. This section of the report introduces the key concepts of ELT that can help navigate LBD across ecosystems:

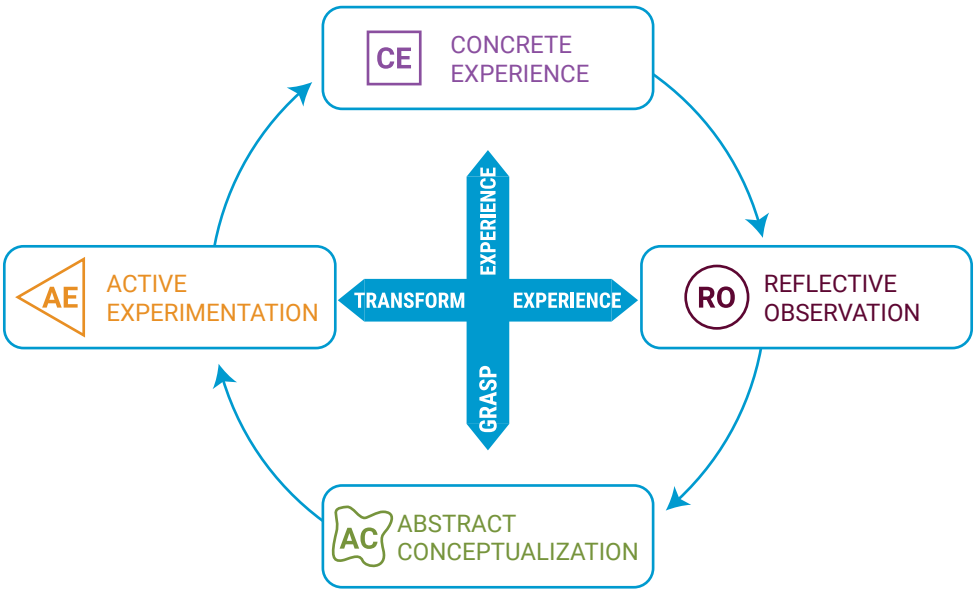
- Learning cycle or spiral
- Learning style and flexibility
- Learning spaces
- Learning identity
- Zone of proximal development
- Social and personal knowledge

Let's consider each of these concepts briefly in turn.

Learning Cycle or Spiral

In ELT, learning is "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience" (Kolb 2015, 49). The experiential learning cycle, pictured in figure 4, is the central concept in this process, portrayed as an idealized learning cycle or spiral in which the learner "touches all the bases" (Passarelli and Kolb 2011)—experiencing, reflecting, thinking, and acting in a recursive process that is sensitive to the learning situation and to what is being learned.

FIGURE 4. THE EXPERIENTIAL LEARNING CYCLE



Source: Kolb 2015. Used with permission from Experience Based Learning Systems, LLC.

Beginning at the top center of the circle, immediate or concrete experiences are the basis for observations and reflections. These reflections are assimilated and distilled into abstract concepts from which new implications for action can be drawn. These implications can be actively tested and serve as guides in creating new experiences (Passarelli and Kolb 2011; Kolb 2015).

In the cycle of learning, learners receive information through experiences, transform it by reflecting and thinking, and then transform it further by acting to change the world. In this way, new knowledge leads to new action (Passarelli and Kolb 2011; Kolb 2015)—which is LBD.

The learning cycle is driven by two dialectically opposed dimensions. The vertical grasping dimension presents two opposing ways of knowing the world: experiencing (concrete experience) and thinking (abstract conceptualization). The horizontal transforming dimension presents two opposing modes of transforming experience: reflecting (reflective observation) and acting (active experimentation).

Looping back to the performance, learning, and development distinction, the visually simple learning cycle is most often described as a spiral, with each movement around the circle creating a richer, deeper knowledge base with which to meet the next set of opportunities and challenges. This upward spiral of adult development continues throughout life and is described by Kolb (2015) with the following typology:

- Acquisition—self as undifferentiated—immersed in the world
- Specialization—self as content—interacting with the world
- Integration—self as process—transacting with the world

Individuals grow in behavioral, symbolic, affective, and conceptual complexity as they move through the cycles of learning and up the spiral (Kolb 2015).

Learning Style and Flexibility

Learning style and flexibility describes the unique ways that individuals spiral through the learning cycle based on their preference for the four different learning modes. These modes are experiencing, reflecting, thinking, and acting. Research has shown that learning style and flexibility is influenced by culture, personality type, educational specialization, career choice, and current job role and tasks (Passarelli and Kolb 2011; Kolb 2015).

In human resource management practice and workplaces, the most visible manifestation of ELT is the Kolb Experiential Learning Profile (KELP), which helps individuals identify their learning style. The KELP is a survey-based assessment that places individuals on a continuum of how they use the learning cycle to learn and develop (Institute for Experiential Learning 2023). Understanding one's learning style can enhance the intentionality with which one learns from experiences and creates new knowledge.

Learning Spaces

Learning takes place in learning spaces. They exist in the perception of the individual and are formed by objective factors, such as the physical setting where the learning happens and time available for learning. They are also formed by subjective factors such as learning preferences and expectations (Passarelli and Kolb 2011).

Learning Identity

People with a learning identity see themselves as learners who seek and engage in life experiences with a learning attitude and a belief in their learning ability. A learning identity develops over time, tentatively adopting a learning stance toward life experience, moving to a more confident learning orientation, engaging a learning self that is specific to certain contexts—and ultimately developing a learning identity that permeates deeply into all aspects of the way one lives and works. The primary focus is not on immediate performance or goal achievement but rather on the ongoing process of learning from these experiences (Passarelli and Kolb 2011).

Learning Relationships

Learning relationships are connections between one or more individuals that promote growth and movement through the learning spiral, ultimately inspiring future learning and relationship-building.

Zone of Proximal Development

The zone of proximal development is defined as the distance between the actual development level (as determined by independent problem-solving) and the level of potential development (as determined by problem-solving under adult guidance or in collaboration with more capable peers) (Kolb and Kolb 2017).

Social and Personal Knowledge

ELT of development focuses on the transaction between internal characteristics and external circumstances, *or* between personal knowledge and social knowledge. One can intuit from the learning cycle that ELT has a dual theory of how knowledge is created and structured—grasping reality through the direct apprehension of experience *and* via the mediated experience of abstract conceptualization.

Apprehension is a personal, subjective process that cannot be known by others unless the comprehensions that we use to describe immediate experience are communicated. Comprehension is thus a social activity when in the context of groups of individuals communicating about experience. There are two kinds of knowledge:

- **Personal knowledge**—the combination of individuals' direct apprehensions of experience and the socially acquired comprehensions they use to explain this experience and guide their actions
- **Social knowledge**—the independent, socially and culturally transmitted network of words, symbols, and images that is based is based solely on comprehension (Kolb 2015).

In a learning economy, LBD is a path for working learners to add value in knowledge creation, innovation, and production and to glean the benefits of doing so. These experiential learning concepts point the way to how individuals need to consciously engage with experience as the raw material of new knowledge, how workplaces need to be designed using the ELT concepts describes above in order to optimize learning, and how even more broadly used tools are needed to engage in system-level learning and change.

Concepts such as these can help educators, workforce development practitioners, employers, and policymakers take action to promote LBD comprehensively through the ecosystems and cluster-based regional growth strategies.

Learning Ecosystems, Learning by Doing, and Knowledge Creation

Learning by doing (LBD) and knowledge flows point to a reality about knowledge creation for working learners, who must operate across different ecosystems of learning. These ecosystems range from formal education and training to informal activity-based work and relationship-based exchanges of experience and expertise. Yet the act of learning, what is considered knowing, and how one demonstrates competence all vary whether one is in a college classroom, a machine shop, or a professional community of practice or interest. These environments have different boundary characteristics within which learning is assessed as happening.

Together, they form a sort of interconnected set of learning ecosystems. If educators, workforce development practitioners, employers, and policymakers can understand each ecosystem on its own terms and find ways to align them, they can then optimize LBD for working learners—creating a key competitive advantage in the U.S. economy. To understand how learning ecosystems, LBD, and knowledge creation come together to create this competitive advantage, this section of the report adapts applied research from the Deloitte Center for the Edge on performance ecosystems; the National Research Council on learning science in informal environments; and the European Commission and the Organisation for Economic Co-operation and Development on formal versus informal learning environments—or ecosystems—to create a map of sorts that can help optimize learning for working learners.

From Living to Learning Ecosystems

Living ecosystems have much to teach us about how distinct learning ecosystems come to be and why understanding them is important. Two attributes of living ecosystems have particular relevance: they arise to solve certain problems in a given settings, and the ways in which they solve these problems exhibit adaptive, resilient, and emergent qualities.

Ecosystems have boundaries defined by the interplay of their organisms and environment. "Each ecosystem, and each organism, is an answer to a set of problems, presented by the environment," said Thomas Lovejoy, university professor of environmental science at George Mason University (Friedman 2016, 303). This emergent purposefulness to solve problems within an environment shapes what successful competence looks like for interconnected actors. In biologic and nonbiologic cases, ecosystems exhibit emergent, resilient, and adaptive qualities that create affordances for novel self-organization of solutions when confronted with changing conditions and disturbances. More specifically:

- **Resilience** is the capacity of an ecosystem to respond to a perturbation or disturbance by resisting damage or recovering quickly. Resilience is supported by attributes of diversity and modularity—a balance between self-reliance and interdependence—and tight feedback loops that allow for quick warnings of condition changes.
- **Adaptation** is a change or the process of change by an ecosystem entity that becomes better suited to its environment. Adaptation has attributes of communication, cooperation, specialization, spatial and temporal organization, and reproduction.
- **Emergence** is the phenomenon of novel creation whereby larger entities arise through interactions among smaller or simpler entities, such that the larger entities exhibit properties not shown by the smaller or simpler entities.

The highly emergent, resilient, and adaptive qualities of these ecosystems are specifically relevant to LBD. First, the multi-actor interactivity of knowledge creation and innovation is emergent, resilient, and adaptive. Second, the concept of communities with distinct identities and boundaries that, in turn, foster a particular approach to learning are key actors in knowledge creation.

Learning Ecosystems

The concepts of ecosystem boundaries, resilience, adaptation, and emergence provide a foundation for understanding how ecosystems are different from each other and how they grow and change. To this we need to add a learning problem that the ecosystem—including its people, organization, and technologies—is meant to solve. For this we turn to the study of performance ecosystems by the Deloitte Center for the Edge (Hagel, Brown, and Kulasooriya 2011). Here we adapt Deloitte's definition of a performance ecosystem to define a learning ecosystem as consisting of a community of individuals and organizations interacting with one another and their environment to pursue some form of competence and performance enhancement—in other words, learning.

To solve the ecosystemic problem of learning, we turn to the work of the European Commission and the Organisation for Economic Co-operation and Development on formal versus informal learning environments, or ecosystems, and the National Research Council's learning science in informal environments to identify boundary characteristics of ecosystems that form a continuum from formal to nonformal to informal learning (Misko 2008). More specifically:

- **Formal learning** occurs in an organized and structured environment in terms of learning objectives, time or resources, such as an education or training institution. From the learners' standpoint it is always intentional, meaning that the learners' explicit intention is to gain credentialled knowledge and skills. Typical examples include K–12 primary and secondary education and higher education systems, as well as workplace training programs arranged by employers.
- **Nonformal learning** is a midway point between formal and informal learning. It occurs in the framework of planned activities (in terms of learning objectives, time, or resources) when learning support may be present in some form, such as student-teacher or trainer relationships, but the primary purpose of the activity is not learning.
- **Informal learning** occurs in the framework of daily activities, such as work, family, or leisure, none of which are explicitly designated as learning activities in terms of objectives, time, or learning support (Cedefop, European Commission, and ICF 2019; OECD, n.d.).

In assessing science learning in formal and informal environments, the National Research Council (2009) identified three continua by which to distinguish the former from the latter:

- Assessment, from evaluative/high consequence to contextual feedback/low consequence
- Choice, from mandatory participation and curricula to voluntary
- Design, from structured by another to structured by the learner

This section of the report combines and adapts the NRC learning science with the OECD learning environments, or ecosystems (Werquin 2010), and then adds two new ones—community and economy—with an eye on the importance of these in LBD. The goal here is to present six boundary characteristics that frame formal, nonformal, and informal ecosystems in an effort to unique purposes and ways for operating in order optimize LBD:

- Intentionality
- Organization
- Assessment
- Control
- Economy
- Community

This labeling represents the dynamism that can exist within the learning ecosystem; it suggests that while one learning scene might be emblematic of all characteristics, others might differ somewhat in their orientation but still lean more toward one ecosystem (see figure 5).

FIGURE 5. LEARNING ECOSYSTEM BOUNDARY CHARACTERISTICS TO SUPPORT LBD

CONTINUUM OF LEARNING ECOSYSTEMS AND BOUNDARY CHARACTERISTICS

Characteristics	Formal Dominant	Nonformal	Informal Dominant
Intentionality	• Mandated, planned		• Voluntary, unplanned
Organization	• Highly structured by other and curricular components		• Structured by learner with no traditional curricular components
Assessment	• Evaluative, objective		• Situated feedback, subjective
Control	• Regulated, barriers to entry		• Unregulated, no barriers to entry
Economy	• Fee for service		• Gift or sharing economy
Community	• Designed, hierarchical		• Organic, flat

Source: Adapted from National Research Council 2009 and OECD, n.d.

Boundary Characteristics

Boundary characteristics serve as indicators of how communities of learning ecosystems interact with their environments to enhance competence and performance. In this sense, these boundary characteristics help frame the unique qualities of learning and implications for knowledge production. As presented in figure 5, the descriptions of these boundary characteristics are framed as formal-dominant and informal-dominant ecosystems, with an eye toward the contextual, interactive, and social aspects of knowledge production.

Intentionality

In formal-dominant ecosystems, learners knowingly engage in a learning process with prescribed structure and outcomes mandated by others. Learners expect some sort of external validation, typically by way of a grade or certificate for their time and effort. Engagement varies and is driven by interest in subject area, applicability to a life domain, and perhaps the cost of attendance.

In informal-dominant ecosystems, learning is largely unplanned and happens by chance as a by-product of an activity. While learners knowingly and willingly participate, learning might not be the goal or ultimate purpose for participation. It is acquired through everyday occurrences in work, family, and leisure, often referred to as experience (Misko 2008; Werquin 2010). As a result, the experience is highly contextual and relevant. Engagement tends to be high, as is the expectation given its voluntary, experiential nature.

Organization

In formal-dominant ecosystems, learning is structured by discipline or field of study, with prescribed curricular components such as objectives or learning outcomes, teacher and student roles, time, and place that characteristically lead to some form of validation. Given its highly structured nature, there is often a requirement of prerequisites or prior experience tied to relevant

know-what and know-why conditions are required (see Learning Economies, Learning by Doing, and Regional Competitiveness for a review of the know-what, know-why, know-how, and know-who conditions for LBD).

Organization in formal-dominant ecosystems can be at odds with the external demands of potential participants, thus limiting access. Roles are clearly defined. Teachers, instructors, or authoritative others are experts who dispense predominately know-what and know-why learning experiences. Learning can be social in that students share a similar experience; the nature of interaction, however, is bound by the content and the delivery and nature of instruction as determined by an expert or authority, thus limiting opportunities for reciprocity and know-how and know-who conditions.

On the other end of the continuum, learning is neither organized by discipline or field of study nor follows curricular conventions or a set of prescribed standards determined by an authoritative other. Learning is self-directed, so learners have more autonomy and control over its organization and content. Roles are fluid and participants learn from one another. The social and local aspects of informal-dominant environments further support this reciprocity. Everyone is welcome, thus opening doors to know-what, know-why, know-how, and know-who to which participants might not otherwise have access.

Assessment

In formal-dominant ecosystems, assessment is summative and objective, determined by an authoritative other who follows an accepted standard of measure. Assessment is typically designed to measure a given skill—or the know-what and know-why knowledge of an individual—in a particular field of study or area. In this sense, assessment is not holistic and does not require students to apply knowledge to other domains.

In informal-dominant ecosystems, assessment is formative and subjective. Assessment occurs in everyday learning, and it is:

> [M]ost often structured as immediate feedback through situated responses. Doing, learning, knowing, and demonstrating knowledge are typically intertwined and not easily distinguished from each other. . . . demonstrating competence often results in a more central role in the learning configuration. (National Research Council 2009)

The participatory nature of this kind of assessment also means that learners can identify areas of feedback that are important to them, typically in response to a performed action that could measure know-what, know-why, and know-how. An important distinction is that participants define their own success; they determine what is of value to them and what is not.

Control

Formal-dominant ecosystems are closed and competitive in that barriers to entry exist. Barriers, often seen as quality control measures, can manifest as regulations, qualifications, and capital. In the case of higher education, states regulate public and private providers. Institutions must be accredited by a nationally recognized accrediting agency to be eligible for Title IV federal financial aid programs. More regulation often translates to bureaucracy, which can stymie creativity, initiative, risk-taking, and innovation—the cornerstones of know-how and know-who.

Informal-dominant ecosystems are open to anyone with a desire to enter the space; there are no barriers to entry or formal quality assurance mechanisms. This gives rise to a flow of information and resources that is not possible with regulated markets, increasing access to know-how and know-who. While participants need to do their own due diligence to ensure that they are in a space conducive to their needs, the organization and intentionality of these types of ecosystems allow participants to come and go at will.

Economy

Formal-dominant ecosystems typically have a fee for service. Postsecondary education and training require tuition. In the workplace, employers pay for training, whether employer-led or organized. In fee-for-service arrangements, individuals typically want to know what they are paying for and that they are paying for a quality service, hence its organization and control. Know-what and know-how can more easily be developed in environments that demand a higher level of certainty.

A fee-for-service structure also aligns with the formal ecosystem's relational aspects in that learning is largely a personal endeavor. If students or families cannot pay out of pocket, mechanisms exist for them to borrow needed capital. If employers do not provide funds for professional development or training, employees must pay for any validated upskilling or training themselves. This contributes to unequal distribution of resources as employers spend more on those with higher qualifications and skill levels (Carnevale et al. 2015).

The informal-dominant ecosystem depends heavily on its relational aspects. It tends to employ practices from what is popularly referred to as the sharing and gift economies. Sharing takes the form of open source educational resources, volunteering time and expertise to present workshops and teach classes. The line between teachers and learners is often fluid, which is an important component. Everyone learns and has skills to offer. Giving happens in online discussion forums or communal gatherings, such as jams, that this ecosystem uses to encourage members to share information, ideas, and suggestions. The open, fluid nature of this mode of exchange—similar to control and organization—increases the probability of attracting individuals with varied knowledge stocks who are interested in sharing their expertise and network, thus opening the door to the development of all four types of knowledge.

Community

Formal-dominant ecosystems tend to have an external authority that determines the community's purpose or reason for being, which dictates its duration. Given the defined leader-follower roles inherent in formal-dominant ecosystems, the community of practice is similarly hierarchical, which has implications for the type of information shared and its flow. While learning is largely independent, the communities that form tend to be subject-specific and organized around prescribed goals or objectives.

Communities of practice in informal-dominant ecosystem form organically, typically around a shared interest, passion, or problem. The community determines its purpose, coming together when necessary. Given its organic configuration, roles and responsibilities are negotiated and emerge from what seems fitting for the task. In this sense, everyone participates, lending their expertise or inquiries with potential to push the knowledge envelope.

These boundary characteristics are meant to help working learners and other stakeholders map the unique knowledge creation pathways available to them as they seek to optimize LBD.[5]

5 See the appendix for three examples of these boundary characteristics mapping formal, informal, and nonformal learning ecosystems to model this way of seeing for all working learners, employers, higher education institutions, and other stakeholders.

Mapping Tools to Envision Learning by Doing

This report has woven together concepts from the academic literature on knowledge creation, learning by doing (LBD), experiential learning theory (ELT), and different types of learning ecosystems to create a new frame for how working learners can engage in the all-important work of knowledge creation, regardless of their role or level in an organization. When put together in this way, however, the level of abstraction can seem daunting.

This section provides visual mapping tools to help stakeholders navigate the work of optimizing LBD. The first visual tool depicts working learners at the center of theories and practices that enable LBD. The second one illustrates how LBD contributes to knowledge creation and innovation leading to prosperity in a regional context.

Working Learners at the Center of Learning by Doing

The first visualization places working learners at the center of a set of concepts and practices that can enable participation in LBD. With working learners at its core, figure 6 maps how job quality contributes to the systems and structures to enable learning at the firm level, how LBD practices create a road map for engaging with knowledge flows, how learning ecosystems pull in and leverage learning from different contexts, and how experiential learning provides a theoretical underpinning for ways to best engage in all of the other elements.

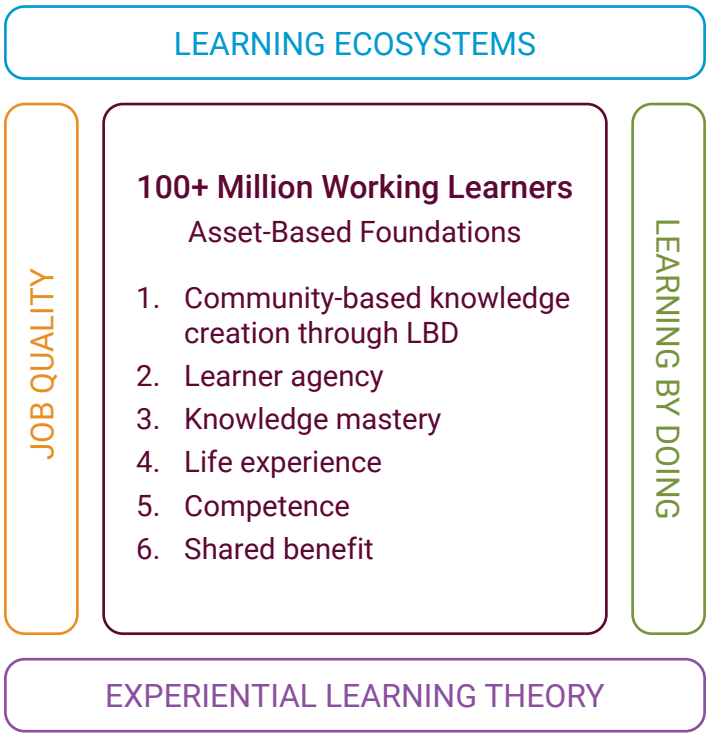
The working learner core of the map reinforces the asset-based identity of working learners as workplace-based knowledge creators that was developed for this report with five foundational propositions:[6]

1. **Community-based knowledge creation**—As we noted in the learning economy section, knowledge creation is a social process. Working learners affirm their identity as knowledge creators who collaborate with their peers in the workplace. They advocate for policies and practices that enable community formation and access to knowledge flows.
2. **Learner agency**—Working learners expect their work and their workplace to be an environment in which they are able to engage in learning and knowledge creation. They empower themselves with tools to learn and advocate for workplaces that enable their participation in community-based learning.
3. **Life experience**—Working learners act in many roles (e.g., worker, family member, citizen, and student) in their lives and across ecosystems. Informed by personality, culture, and world view, when appropriate, working learners seek to align learning across life experiences to optimize knowledge creation.
4. **Competence**—Competence developed through LBD in knowledge creation is most often demonstrated in performance. Working learners seek workplaces that link enterprise knowledge creation with underlying skills documentation.
5. **Shared benefit**—Working learners seek workplaces in which they can share in the economic benefits of LBD-based knowledge creation.

Taken together, this map provides a mental model that employers, higher education leaders, and workforce development leaders can use to create learning environments that enable LBD and optimize knowledge creation.

6 These propositions are a synthesis of ideas developed from Wikipedia 2023, Kasworm 2007, and McKnight 2007.

FIGURE 6. OPTIMIZING KNOWLEDGE CREATION FOR WORKING LEARNERS: CONCEPTS AND PRACTICES



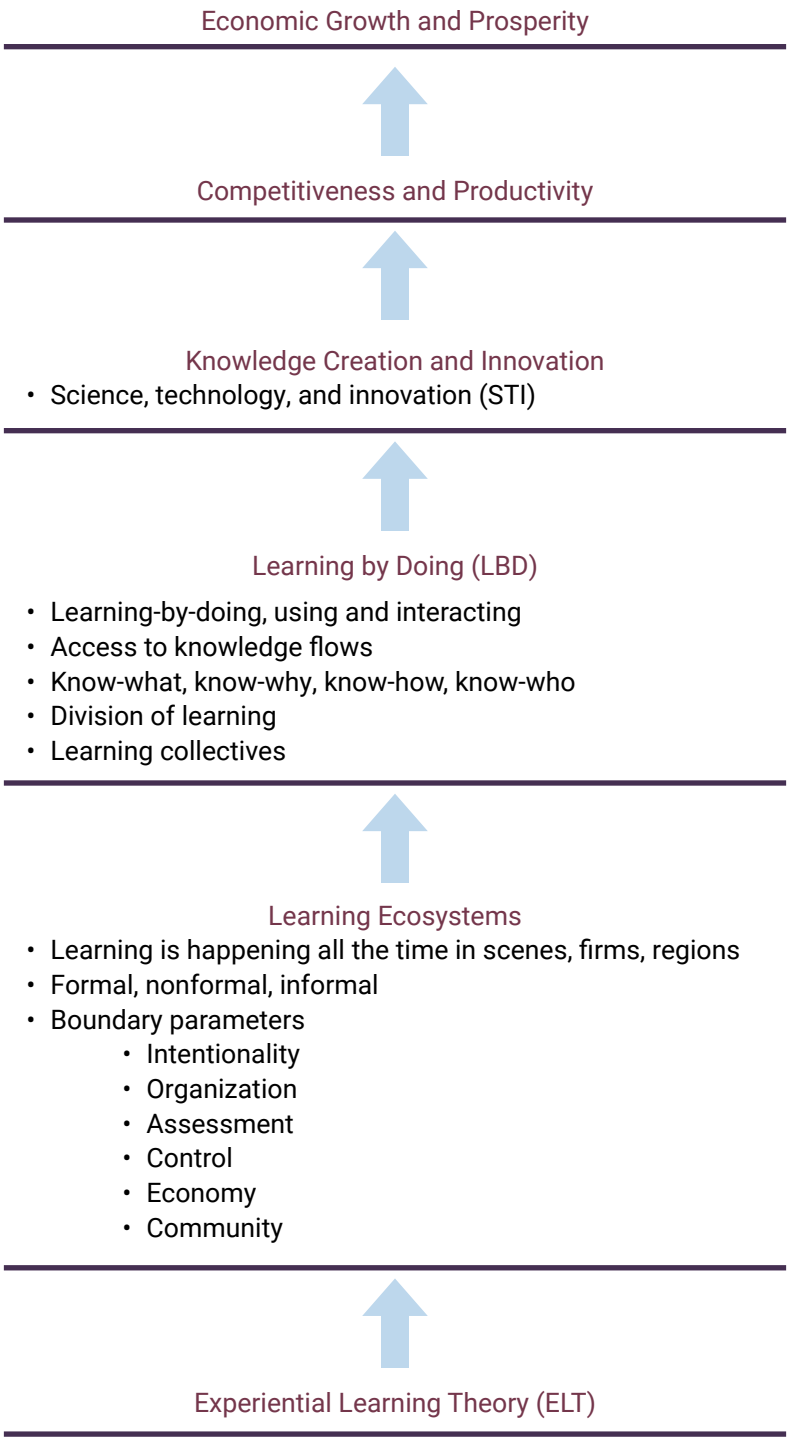
Learning by Doing's Contribution to Knowledge Creation and Innovation

The second visualization adapts the place-based or regional economic cluster thinking of Harvard University's Michael E. Porter. Building on a century of economic literature on why certain geographies tend to specialize in certain economic sectors, Porter mapped evidence that linked clusters of interconnected companies and institutions to the innovation and productivity that yield sustained regional prosperity and resulting national economic growth (Porter 2001) (see figure 7).

Porter created this three-level, bottom-up trajectory in which knowledge creation and innovation drive competitiveness and productivity enhancement that, in turn, drive economic growth and prosperity within a region. Using the new learning economy lens detailed in this report, this trajectory demonstrates that knowledge creation and innovation are underpinned by STI and LBD. The focus of this report is LBD; the key concepts that underpin LBD were detailed previously alongside the characteristics of overlapping ecosystems and ELT, which pull it all together.

These visualizations can help working learners, employers, higher education institutions, and public policymakers to map LBD in their areas of effective action. In turn, this informs individual behaviors policy and practice within firms, and regional approaches to economic development.

FIGURE 7. LEARNING BY DOING: FOUNDATIONS OF THE LEARNING ECONOMY



Source: Adapted from Porter 2001.[7]

7 See also Michael E. Porter, *The Competitive Advantage of Nations* (New York: Free Press, 1990).

Conclusion

New knowledge, innovation, and technology together create aggregate wealth for a nation because new ideas can be replicated at low cost. But technology creates wealth for the working learners of a nation by requiring new technical knowledge that cannot be easily replicated (Bessen 2015). The development of new technical knowledge can take decades to develop in working learners; the necessary market and social institutions, which ensure that working learners are enabled to not only contribute to knowledge creation but also to benefit from that contribution, form concurrently. This time frame leads to employment dislocation and economic inequality for working learners that must be addressed via social policies to ensure that the United States remains a just and stable democracy.

It is also the case that engaging the nation's more than 100 million working learners in learning by doing (LBD) and knowledge flows will enable them to create knowledge from work experience and center their identities in the key assets of today's economy—learning and innovation. This centering is enabled by workplaces designed with job quality, LBD practices, learning ecosystem alignment, and ELT in mind, thus optimizing knowledge-creation contributions and corresponding economic gains for working learners.

While this report provides a practical theory of LBD, the following are considerations for working learners, employers, workforce development practitioners, and higher education institutions to contemplate as they move deeper into the learning economy.

Working Learners

- How can experiences be transformed into new knowledge? What are the preferences and strengths?
- How can a job's quality be assessed by its ability to meet both basic and learning needs?
- When mapping the LBD pathways at a current or new job, how are know-what, know-why, know-how, and know-who aligned? What learning flows are needed to access and create knowledge?
- How are machine and human learning balanced?

Employers

- How does the firm experientially create new knowledge? Are working learners included?
- Are the basic and advancement needs for working learners being met such that they can learn by doing?
- Are jobs designed to promote autonomy and problem-solving? How are job training, on-the-job learning, and tuition assistance aligned to optimize knowledge creation?
- Do working learners have access to knowledge flows? Can artificial intelligence help?
- How are formal, nonformal, and informal learning accessed to promote LBD?

Higher Education Institutions

- How does experiential learning inform education practice?
- How does LBD manifest in curriculums and in regional workplaces?
- Have these institutions mapped the formal, nonformal, and informal learning ecosystems in their regional economies? Are they interacting and aligning?
- How can the institution partner more deeply with employers to promote job quality and LBD?

Workforce Development Professionals

- How can workforce developers embrace their role as ambassadors of a learning economy that connects benefits for working learners to knowledge creation?
- How can workforce developers integrate experiential learning, LBD, ecosystems, and job-quality thinking into workforce and economic development practice?
- What tools do professionals have to map the LBD activities region across employers and education institutions?
- What are ways to build the competence of collaborations between employers and higher education practitioners to support continuous LBD for working learners?
- How can stakeholders advocate for policies that enhance LBD?

Postscript: Relearning to Be Human

> If the economic problem is solved, mankind will be deprived of its traditional purpose . . . . Yet there is no country and no people, I think, who can look forward to the age of leisure and of abundance without a dread.
>
> —John Maynard Keynes, "Economic Possibilities for Our Grandchildren"

The economic problem Keynes referred to is the necessity to work to provide for basic survival needs. Even in 1930, when Keynes published his essay, he imagined a time when technology would take on these production needs and leave more and more of humanity asking an existential question: *When technology tools can perform most any work task, what should I do with my time and life?*

Keynes himself had deep concerns for how billions of human beings might answer this question and the resulting waves of tumult and revolution that would assail humanity. Ultimately, though, he was optimistic about a post-work world. While billions of individuals still live in a world in which work is required for life essential and survival, advances in artificial intelligence (AI)—the latest wave in the information technology revolution—are making a post-work world more plausible.

This report posited that a practical theory of learning by doing (LBD) would help scale efforts to create a learning economy, inclusive of working learners' contributions and shared benefits. In extending the argument, the paper introduced technology mediated processes such as knowledge flows, division of learning, and human and machine learning collectives, as well as a broadened view of legitimate learning beyond formal higher education institutions to integrate experiences across life contexts—work, family, and community—into competence ecosystems.

LBD, combined with the aforementioned process and ecosystem tools, is a strong foundation for answering a broader existential question: *What should I do with my time and life?* At its core, this question suggests a need to relearn the purpose, meaning, and value of being human—not as an academic exercise but as a real-life concern to be lived out in the moment in a complex, connected, and chaotic world; this is LBD to the extreme!

Framed in this holistic way, even in an era in which the algorithms that drive technology are becoming a too easy metaphor for how all life should operate, the LBD perspective enables individuals and society to reclaim agency over human learning and integrate knowledge domains for essential growth and development. Knowledge domains in the form of the United Nations Educational, Scientific, and Cultural Organization's (UNESCO) five pillars of learning can be used as a means to catalyze an LBD movement. UNESCO's five pillars of learning are:

- **Learning to know**—the development of skills and knowledge needed to function in this world, e.g., literacy, numeracy, critical thinking, and general knowledge
- **Learning to do**—the acquisition of applied skills linked to professional skills
- **Learning to live together**—the development of social skills and values such as respect and concern for others and the appreciation of cultural diversity
- **Learning to be**—the learning that contributes to a person's mind, body, and spirit, e.g., creativity and personal discovery
- **Learning to transform oneself and society**—when individuals and groups gain knowledge, develop skills, and acquire new values as a result of learning, they are equipped with tools and mindsets for creating lasting change in organizations, communities, and societies (UNESCO Education Sector 2010)

As the world moves deeper in the AI revolution, LBD can empower millions to engage across all learning ecosystems (formal, nonformal, and informal) to create knowledge in these domains and build a foundation for a resilient, inclusive, and prosperous economy and society.

Appendix

This appendix provides three brief case studies of the effect of specific learning by doing (LBD) ecosystems on the U.S. economy.

Formal-Dominant Ecosystem

The most obvious examples of formal dominant ecosystem are schools, postsecondary education, training institutions, and employers. All comprise a kaleidoscope of bodies and interests. Higher education alone can be broken down into university PhD programs, MA and MS programs, BA and associate degree programs, community college programs, tribal colleges, and special-focus institutions that offer a broad selection of degree and certification programs.

Yet the formal learning ecosystem does not stop there. It also encompasses employer-led or organized workplace training or training in a formal setting that aligns with the formal-dominant boundary characteristics presented in Learning Ecosystems, Learning by Doing, and Knowledge Creation. Apprenticeships, for example, are well-established and accepted models of on-the-job training and instruction as an alternative to a college degree.

Through leveraging shipbuilding and higher education, Huntington Ingalls Industries—the largest shipbuilding company in the United States—has for more than 90 years invested in the workforce development pipeline through long-term rigorous education and training of eligible employees at The Apprentice School (Huntington Ingalls Industries 2016) (see table 3).

TABLE 3. FORMAL DOMINANT ECOSYSTEM: APPRENTICESHIP EXAMPLE

HUNTINGTON INGALLS INDUSTRIES' THE APPRENTICE SCHOOL	
Intentionality Employee undergoes application process; company demands full participation	Similar to other company-based apprenticeship programs, Huntington Ingalls Industries' (HII) The Apprentice School develops a demand-driven talent pipeline through classroom and on-the-job training and education (Huntington Ingalls Industries 2016). An apprenticeship is a formal training program that provides aspiring journeypersons or trades professionals with on-the-job training and instruction in a selected craft that can be coupled with related classroom instruction, as is the case with HII's The Apprentice School at Newport News Shipbuilding. Newport News Shipbuilding is a division of HII, a military contractor that provides shipbuilding and technical services to the U.S. Navy and Coast Guard. The Newport News Apprentice School offers four-, five-, and eight-year apprentice programs for students interested in pursuing or securing shipbuilding careers while supporting the operational needs of the company. Contingent on trade, apprentices spend a set number of hours on course work. For most programs, this is about one to three and a half years in academic classes in discipline theory and related content that complement on-the-job training. As Newport News Shipbuilding employees, they work and are paid for a 40-hour week, which includes academic instruction and training. The Apprentice School, with a highly competitive admission rate (roughly 225 spots per 4,000+ applications), is credited by the Council on Occupational Education and offers opportunities for college credit through partnerships with Old Dominion University, Thomas Nelson Community College, and Tidewater Community College (Huntington Ingalls Industries 2016). Despite residing in the formal ecosystem, assumed to transmit predominantly explicit knowledge, apprenticeships exemplify spaces for explicit and tacit knowledge creation. Participants gain know-why and know-what through formal instruction, which provides a foundation for know-who and know-how knowledge acquired through operating in a community of practice within the program and organization. Know-who is developed as participants engage with and learn from classmates and experts with their own lived experience in shipbuilding and related contexts. Know-how is acquired over time through daily practice. Trust within a community that shares common values—in this case, integrity, engagement, safety, responsibility, honesty, and performance—further facilitates tacit knowledge creation. In these ways, HII taps into LBD to build competence and develop the shipbuilding craftsman pipeline within the company.
Organization Company-designed curriculum/program; apprentice earns certificate of apprenticeship	
Assessment A mix of evaluative, summative, and experience-based	
Control Program is accredited; has entrance requirements; is highly competitive	
Economy Employer assistance	
Community Craft defines cohort; master-apprentice relationship defines explicit knowledge creation; set duration	

Informal-Dominant Ecosystem

Learning in informal-dominant ecosystems is largely unplanned. It is acquired through everyday activities in work, family, and leisure and often referred to as experience (Misko 2008; Werquin 2010). Learning is neither organized by discipline or field of study nor does it follow formal curricular conventions. Assessments in everyday learning are ongoing and based on demonstrated competence. Informal learning is uncontrolled, in that no barriers to entry or formal quality assurance mechanisms exist. It tends to employ practices from the sharing and gift economies.

Informal learning is perhaps best understood in the context of on-the-job learning, not to be confused with formal on-the-job training. Know-how and know-who are predominantly tacit, contextual, and place-based and are gained through listening, observing, experiencing, and internalizing surroundings.

Yet informal learning ecosystems may be better mapped through a case that pushes the edges of the boundary characteristics. This example is from research by John Seely Brown and John Hagel III at the Deloitte Center for the Edge on the informal learning ecosystem in global big wave surfing—an example of people uniting around a common interest and developing the know-how and know-who to advance the sport (Hagel, Brown, and Davison 2010) (see table 4).

TABLE 4. INFORMAL DOMINANT ECOSYSTEM: BIG WAVE SURFING EXAMPLE

	BIG WAVE SURFING
Intentionality Learning is a by-product of passion	Through decades of observation and collaboration, surfers united by a passion for pushing boundaries defined and transformed the sport of big wave surfing, which is characterized by riding waves bigger than 10 or 20 feet. Originating in Hawaii in the 1940s and 50s, big wave surfing pioneers turned their passion into a global sport that evolved alongside advancements in board production and other technologies into a multimillion dollar industry. Surfers tracked waves by following weather patterns and forecasts. They learned by observing and analyzing each other's techniques against tide conditions, and wave shape, for example. This informal learning was and continues to be an iterative, experiential process of surfers syncing their ability to the rhythms of mother nature, refining and pushing their performance envelope with every wave. Big wave surfing entered another growth period in the mid-1990s with tow-in surfing. Aided by jet skis or personal watercrafts, tow-in surfing pulls surfers into waves that were previously impossible to catch by paddling into them. Described as the "unridden realm," it takes surfers over 10 years of strategizing before taking action (Bradshaw 2008). While the advent of personal watercrafts turned ambitions into reality, continued advances in board design aided mastery of big waves. Shorter boards offered speed and the ability to turn, which advanced know-how and further developed the sport. Finally, in 1998, Ken Bradshaw was towed into 85-foot wave in Hawaii, shattering the unimaginable (Bradshaw 2008). This was until Garrett McNamara caught a 90-foot wave in Portugal in 2011 (*SurferToday.com* 2011). LBD has been paramount to the growth and advancement of big wave surfing. To meet the challenge of how to ride big waves, surfers first relied on explicit knowledge to identify places with the right swell and wind conditions, developing over time a map of the big wave spots around the world. Big wave surfers developed know-how and know-who in communities of practice anchored in key big wave locations. Alongside the tacit knowledge being developed at scale, the sport grew into an industry when expert surfers interacted with communities outside of their network, including engineers and material designers, to create new technologies, thus engaging an iterative process of knowledge creation. Trust-based relationships formed around a passion for the sport facilitated this success.
Organization Surfer determines location, wave, and equipment	
Assessment Surfer determines objectives and evaluates performance; reciprocal feedback is based on totality of given ride	
Control Anyone with access to big waves, a surfboard, and know-how can participate	
Economy Surfers share information (weather, wave spots) and expertise (techniques)	
Community Egalitarian; surfers determine purpose and duration; big wave spots determine location	

Nonformal Ecosystem

Nonformal learning ecosystems exist on a continuum between the formal and informal endpoints. Learning is intentional and deliberate for individual learners. To map a nonformal learning ecosystem example, this appendix explores House of Genius, a multicity-based nonprofit organization that assembles entrepreneurs for community problem solving (Hagel, Brown, and Davison 2010). Barriers to entry may be present in the nonformal-dominant ecosystem, as they are with the House of Genius, where entrepreneurship gatherings are by invitation only.

Entrepreneurs have first to apply to a local chapter before they are accepted and matched with cross-industry leaders. This translates into a quality assurance mechanism as chapter organizers strive to identify the appropriate mix of people for helping to solve select business challenges. Similarly, regulations tend to be internally set and are designed to protect participants (see table 5).

TABLE 5. NONFORMAL ECOSYSTEM: ENTREPRENEUR COMMUNITY EXAMPLE

	HOUSE OF GENIUS
Intentionality Volunteer for a specific length of time	House of Genius (2024a) "assembles interesting, diverse groups of people to focus their collective creativity and experience to explore, discuss and solve important problems of entrepreneurship." One evening a month in cities throughout the world, a diverse coupling of 15 to 18 community members gather at a local chapter to give advice to three individuals who are seeking insight into a business challenge. Each presenter takes five minutes each to describe their opportunity or quandary, which is followed by two rounds of feedback from attendees. Gatherings are by invitation only and include business, civic, and government representatives, front-line workers, academic experts, and citizens. Only the meeting organizer knows who participants are. Introductions are made at the end of the event (House of Genius 2024a). The "genius" stems from the convergence of cross-sector discussion and collaboration with constructive feedback and anonymity. Attendees introduce themselves by their first names only; no one references their title or background. Everyone offers comments during the meeting, but no idea will be valued according to title or status. Presenters are rewarded with creative thinking, fresh ideas, and networking opportunities (House of Genius 2024b). House of Genius markets itself as a community service that cultivates innovation and entrepreneurship and is funded by like-minded sponsors. House of Genius is foremost about developing know-who. Entrepreneurs tap into the know-why, know-what, know-how, and know-who of cross-industry community members to help solve their own business challenges. This coming together of varied stocks of knowledge, or learning by interacting, is critical to innovation. House of Genius is a catalyst for cooperation and knowledge creation, understanding the need for supportive, rich spaces that engender trust and goodwill. If local entrepreneurs succeed through a productive exchange of knowledge, so does the community. The social, contextual, and agentic nature of House of Genius serves as building block for community development.
Organization All chapters have a chapter organizer who follows a similar format	
Assessment Peers provide immediate feedback and presenters determine what is of value for them	
Control Participation is by invitation only	
Economy Chapters funded by donations and sponsors interested in promoting local innovation and entrepreneurship	
Community Equalitarian community within a structured event	

The boundary characteristics in these three examples show different motivations, purposes, and incentives for learning that require different levels of relationship, trust, and transparency. Tapping into the intrinsic motivation of working learners as they engage in an ecosystem may be among the most important catalysts for driving LBD at scale; agency will drive the resilience, adaptivity, and emergence that are key to producing not easily replicable, tacit know-how and know-who in the process of knowledge creation.

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