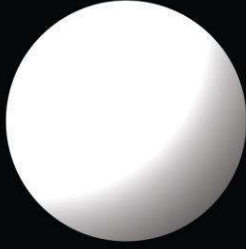




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Towards A Future-Ready Workforce: The Rise of Bionic Skills

INSIGHT PAPER

February 2024

هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission



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INSIGHT PAPER

Introduction

The progression of industrial revolutions has played a crucial role in shaping the modern world. The First Industrial Revolution, starting in the late 18th century, was marked by the invention of the steam engine, followed by the rise of electricity, railroads, and the telegraph (the Second Industrial Revolution). Machines started to perform physical tasks better and faster than humans. Production processes in agriculture and manufacturing became more efficient, requiring fewer workers and eliminating many low-skill, manual jobs. The Third Industrial Revolution, commencing in the mid-20th century, introduced the digital era, characterized by computers, the internet, and mobile phones¹. In recent decades, this cycle of technological innovation has accelerated, with the Fourth Industrial Revolution now unfolding. Artificial intelligence, the Internet of Things (IoT), advanced robotics, and other cutting-edge technologies are now on the verge of disrupting many white-collar, highly skilled jobs that were previously immune.

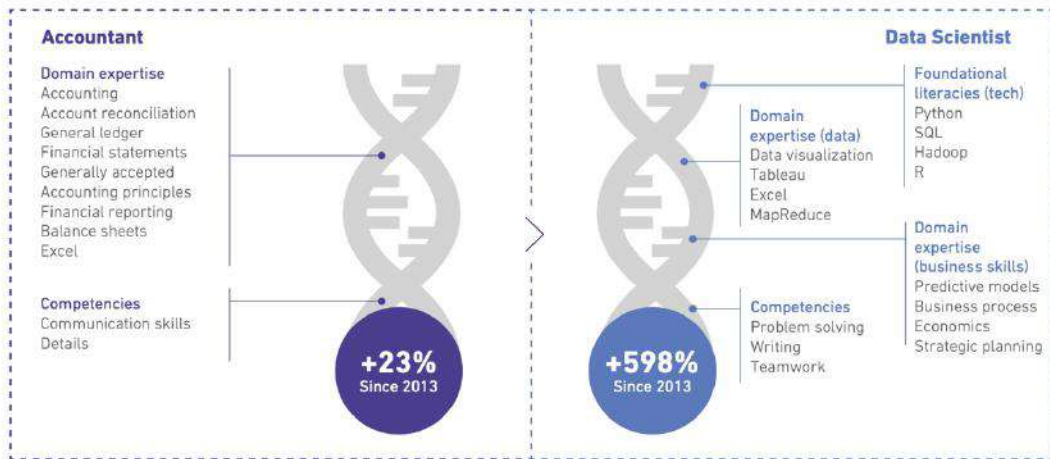
Such rapid technological advancements are profoundly changing the jobs and skills of the future. Sixty percent of jobs globally will be disrupted in 10-15 years², as automation affects an ever-increasing share of jobs in physical and cognitive roles. AI-based technologies can now write code, check student essays, and even draw characters for computer games — thus threatening software coders, teachers, and artists. Fortunately, technological and social shifts are constantly creating new jobs. Sixty-five percent of today's first graders will work in jobs that do not exist yet³. Ten years ago, neither drone pilots, 3D-printing engineers, nor neurointerface programmers existed. The same is true for the growing number of specialists who advise on environmental, social, and governance (ESG) topics. A new cohort of jobs will emerge in the coming years, including AI prompt engineers, metaverse architects, and autonomous car fleet operators. While job titles are changing, so are the tasks within each job, and the skills genome becomes more complex and multidisciplinary. Marketing professionals have shifted from producing print adverts to managing social media accounts; petroleum engineers fly drones to inspect oil wells; and teachers use digital blackboards to engage students.

¹World Economic Forum, The Future of Jobs Report (2023)

²BCG analysis

³World Economic Forum, The Future of Jobs Report (2016)

Figure 1. The skills genome becomes more complex and multidisciplinary



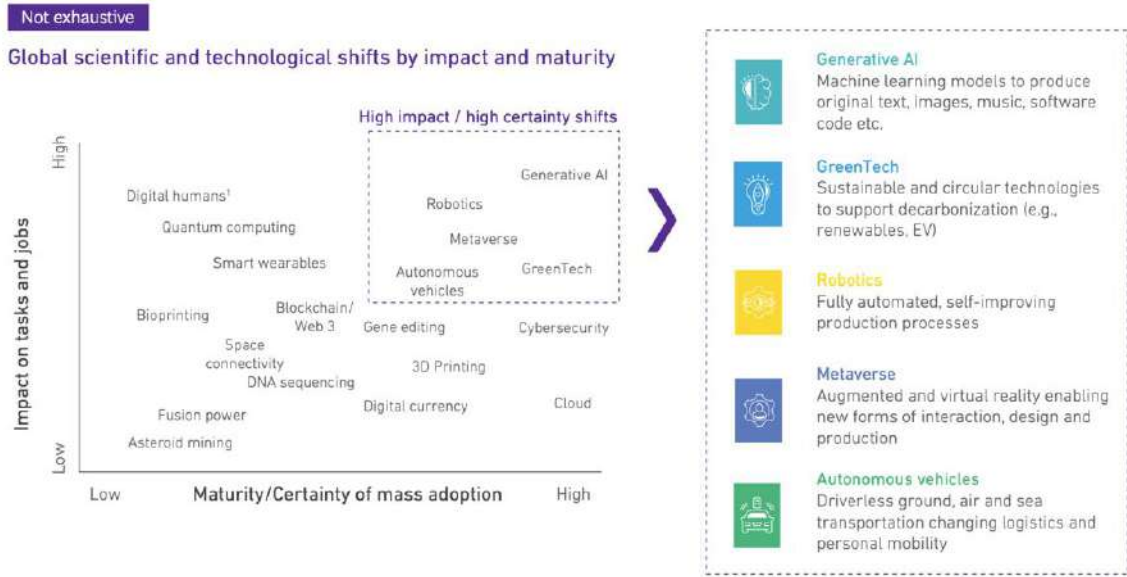
Source: Burning Glass analysis.

It is not only technical skills that are rapidly evolving. Technological, social, and environmental trends are also shaping the 'skills genome', meaning that the composition of skills is changing, as shown in Figure 1. A more complex and multidisciplinary set of skills is required for successful workers: domain expertise and technical skills need to be complemented by a range of generalist skills, like digital literacy, critical thinking, empathy, communication, and green skills⁴. As technology becomes deeply embedded into most jobs, the ability to leverage the latest tools effectively and collaborate closely with other humans is becoming critical for workers to meet future workplace requirements. Therefore, a new model of lifelong learning is becoming paramount for workers to keep their skills up to date throughout their professional careers. Several globally emerging technologies have been identified and ranked according to their disruption potential for job skills and their maturity.

In Figure 2, many technologies will shape future skills, but five major shifts have been identified according to global scientific and technological shifts and maturity: Generative AI, GreenTech, Robotics, Metaverse, and Autonomous vehicles. These technologies are highly disruptive and on the verge of mass adoption in the next 10-15 years.

⁴Green skills refer to individuals' knowledge, abilities, and competencies to address environmental challenges and promote sustainability in various industries and occupations. These skills specifically focus on the needs and demands of a green or sustainable economy, which aims to minimize environmental impacts, conserve resources, and support ecological balance.

Figure 2. Technological shifts disrupting the future of work



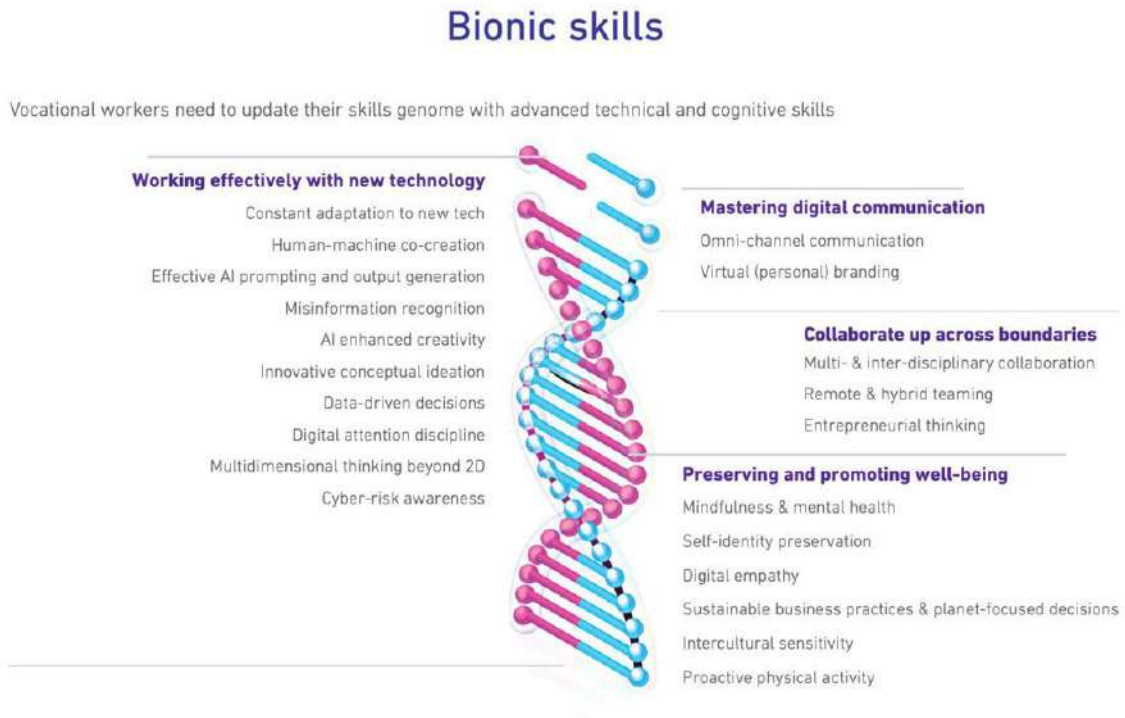
Sources: Global Education Futures, Gartner, BCG analysis.

1. New human-computer interfaces (e.g., brain/touch).

Bionic skillset: the key to future competitiveness

The core feature of the future workplace will be the dramatic ascent of ‘bionic workers’. The term ‘bionic worker’ means a professional extensively using modern technology to boost their productivity, efficiency, and output quality. Working seamlessly alongside new technologies, ‘bionic workers’ will increasingly perform more complex tasks. Thus, significant upskilling is required for such workers to acquire a bionic skillset and remain competitive. To prepare today’s workers for increased responsibilities and for dealing with new technologies, a large investment in their upskilling is needed. Realizing sustained productivity gains requires a bionic skillset with four key categories: working effectively with new technologies, mastering digital communication, collaborating across boundaries, and preserving and promoting well-being in a tech-intense world, as shown in in Figure 3.

Figure 3. Bionic Skillset



1- Working effectively with new technologies necessitates advanced cognitive skills to maximize the benefits of AI, robotics, and the metaverse⁵. For instance, specific skills are needed to pose well-structured, logical questions to AI tools and discern between genuine and fabricated AI-generated outputs. A novel form of AI-enhanced creativity will also be required to guide AI tools in generating unconventional, creative content by providing prompts that transcend existing patterns. The metaverse will challenge workers to improve their geospatial thinking abilities beyond two dimensions to fully exploit the immersive opportunities offered by the metaverse.

Constant adaptation to new tech refers to the ongoing process of staying up-to-date and proficient in the use of emerging technologies. It involves acquiring new skills, knowledge, and practices to remain relevant and effective in a rapidly changing technological landscape.

Human-machine co-creation is the skill of collaborating with computers and other technologies, merging human creativity and expertise with machine capabilities, often driven by AI. This collaboration enhances efficiency, decision-making, and problem-solving across various fields, emphasizing the synergy between human and machine strengths.

⁵OECD Future of Education and Skills 2030 Concept Note, 2019

Effective AI prompting and output generation skills are essential for harnessing the capabilities of generative AI.

AI-enhanced creativity refers to the integration of artificial intelligence (AI) technologies into the creative process to augment and inspire human creativity. It involves using AI algorithms, machine learning models, and computational tools to assist, collaborate with, or provide new insights to creative professionals across various domains. It can assist artists, writers, designers, musicians, and other creative individuals by generating creative ideas and concepts, automating repetitive tasks to free up time for creative work, offering suggestions and improvements based on data-driven insights, and enhancing the quality and efficiency of creative projects.

Innovative conceptual ideation is the ability to generate creative and original ideas, concepts, and solutions to problems. This skill involves thinking outside the box, connecting seemingly unrelated concepts, and envisioning novel approaches to challenges.

Multidimensional thinking beyond 2D means the capacity to explore and understand intricate issues by considering various factors, angles, and layers, going beyond a simplistic or two-dimensional perspective. It enables individuals to approach problem-solving and decision-making with greater depth and complexity.

Data-driven decision-making skill refers to the ability to make informed and effective choices based on data analysis and interpretation. It involves gathering, analyzing, and drawing meaningful insights from data to guide decision-making processes.

Misinformation recognition is the skill of identifying and distinguishing false or misleading information from accurate and reliable content, particularly in the context of information dissemination, communication, or media consumption. Misinformation recognition involves the use of critical thinking, fact-checking, and often technology-driven methods to assess the accuracy and trustworthiness of information sources. This is crucial in today's digital age, where misinformation and fake news can spread rapidly, helping individuals make informed decisions and combat the harmful effects of false information.

Digital attention discipline refers to the deliberate and conscious approach to managing one's focus and cognitive resources in the context of the digital age. It encompasses a set of strategies and habits that individuals develop to navigate the constant influx of digital information, devices, and distractions in a manner that aligns with their goals and values.

Cyber-risk awareness refers to understanding and recognizing potential cybersecurity threats, knowing how to prevent them, and responding effectively if they occur. It is essential for protecting digital assets and privacy in the online world.

2- Mastering digital communication is crucial in the bionic age. Effectively engaging with remote teams from various disciplines through multiple channels is needed to remain relevant in the future workplace.

Omni-channel communication skills enable effective and seamless communication across various channels and platforms in a cohesive and integrated manner. This skill ensures consistency, responsiveness, and a positive user experience across different communication channels, such as email, social media, chat, phone, and in-person interactions.

Virtual personal branding is the skill of shaping and promoting online identity to create a consistent and compelling image of self in the digital realm.

3- Collaborating across boundaries includes teaming with diverse colleagues and partners in an omnichannel environment.

Multi- and inter-disciplinary collaboration skills involve the ability to work effectively with individuals from diverse fields and backgrounds to collectively address complex challenges or projects.

Remote and hybrid teaming skills involve the ability to effectively collaborate and work as part of a team when team members are distributed across different locations or when some team members work remotely while others are on-site. These skills are essential in the modern workplace, where remote work and hybrid work models have become increasingly common.

Entrepreneurial thinking, often referred to as an entrepreneurial mindset, is a way of approaching problems, opportunities, and challenges with an entrepreneurial perspective. It involves thinking creatively, embracing innovation, and proactively identifying and pursuing new ideas, ventures, or solutions.

4- Preserving and promoting well-being is crucial in a tech-intensive age⁶. Interacting with humans purely in virtual environments can foster isolation and loneliness. To stay grounded, mindful workers regularly reconnect with the physical world and nature. Adapting human empathy to the digital realm is a challenge, yet it is vital to foster deep, trusted relationships, which are increasingly significant in many jobs. To drive positive societal impact, workers also need to be skilled in sustainable business practices and intercultural awareness.

Mindfulness and mental health skills pertain to the capacity to employ mindfulness methods and approaches to improve mental and emotional health. This skill encompasses the cultivation of mindfulness routines that foster self-awareness, alleviate stress, manage emotions, and contribute to overall mental well-being.

⁶OECD Future of Education and Skills 2030 Concept Note, 2019

The self-identity preservation skill refers to the ability to protect and maintain one's sense of self, personal values, beliefs, and individuality actively and effectively. It involves the capacity to navigate external influences, societal pressures, and challenges while staying true to one's core identity.

Digital empathy skill is the capacity to understand and share the feelings, perspectives, and experiences of others in online or digital environments. It involves demonstrating compassion, consideration, and sensitivity when interacting with people through digital communication channels, such as social media, email, or messaging apps. Digital empathy is essential for fostering positive and respectful online interactions, promoting understanding, and avoiding misunderstandings or conflicts that can arise in the digital world.

Intercultural sensitivity involves acknowledging, comprehending, and appreciating cultural distinctions and diversity when interacting with individuals from various cultural backgrounds. It requires maintaining an open-minded, respectful, and empathetic attitude toward people of different cultures and recognizing how cultural factors can impact communication, behavior, and perspectives.

Sustainable business practices and planet-focused decisions refer to the adoption of environmentally responsible and ethical approaches in business operations and decision-making. This involves incorporating practices that minimize negative environmental impacts, promote resource conservation, and prioritize the well-being of the planet and its ecosystems.

Proactive physical activity entails actively participating in regular physical exercises and movements to enhance one's overall health and well-being. It involves taking intentional steps to include physical activity in daily routines to prevent health issues and foster a healthy lifestyle.

Table 1. Bionic Skillset with Four Key Categories

Skill category	Skill	Skill description
1-Working effectively with new technology	Constant adaptation to new tech	Enhancing productivity by constantly searching & upskilling to new tools
	Human-machine co-creation	Collaborating effectively with AI and robotics tools to produce output
	Effective AI prompting	Asking the right questions to generate meaningful outputs from AI
	Misinformation recognition	Challenging AI-generated output through “triangulation” or fact-checking
	AI-enhanced creativity	Unlocking the creative potential of AI content generation tools
	Innovative conceptual ideation	Leveraging the accessibility of information to distill new concepts and ideas
	Data-driven decisions	Utilizing AI-generated insights and recommendations effectively
	Digital attention discipline	Maintaining focus and concentration on a single task
	Multidimensional thinking	Adapting 3-dimensional thinking to realize the full potential of the metaverse
	Cyber-risk awareness	Identify and remediate cyber threats as more applications become vulnerable
2-Mastering digital communication	Omni-channel communication	Navigating multiple realities in parallel, from physical to metaverse
	Virtual (personal) branding	Building a professional digital identity in virtual channels
3-Collaborating across boundaries	Multi- & inter-disciplinary teams	Teaming up across disciplines to build cutting-edge solutions
	Remote & hybrid teaming	Collaborating effectively with others through digital channels
	Entrepreneurial thinking	Proactively taking action, developing innovative solutions
4-Preserving and promoting well-being	Mindfulness & mental health	Maintaining focus on the present, regularly reconnecting with real world
	Self-identity preservation	Keeping a sense of community and humanity amid purely digital interaction
	Digital empathy	Caring for others in virtual communication channels
	Sustainable business practices	Integrating environmental considerations and know-how into activities
	Intercultural sensitivity	Respecting cultural customs, even if tech eliminates many boundaries
	Proactive physical activity	Engaging in physical activity despite work and social life being virtual

The ‘new’ bionic skillset does not replace the ‘old’ general skills, but rather it complements them. In the Future of Jobs Report 2023 by WEF⁷, several key skills are highlighted as vital for the future workforce. These include Analytical thinking, Creative thinking, Technological literacy, and a range of soft skills such as Resilience, Flexibility & Agility, Motivation & Self-awareness, Curiosity & Lifelong Learning LLL, Dependability & Attention to Detail, Empathy & Active Listening, and Leadership & Social Influence.

These skills are projected to be highly in demand in the coming years. Combined with the bionic skillset, they lay the foundation for preparing a competitive and future-ready workforce.

Principles for creating a future-proof lifelong learning ecosystem

Developing bionic skills necessitates a comprehensive lifelong learning ecosystem. Rapid technological advancements have shortened the lifespan of skills, making it essential to acquire new skills regularly and at various stages of life.

Moreover, bionic skills can be effectively taught and evaluated within innovative educational environments. Instead, they often require practical experiences. To address this need, all stakeholders in lifelong learning — employers, employees, and academic institutions — need to collaborate to devise innovative teaching and assessment methods tailored to bionic skills.

Employees should also take on greater responsibility for proactively learning new skills, many of which cannot be acquired solely through classroom instruction. Learning becomes not only ‘lifelong’ but also ‘life-wide,’ encompassing education within institutions, families, communities, and workplaces. Additionally, learning is ‘life-deep,’ involving the continuous and active absorption and application of knowledge.

⁷Future of Jobs Report 2023, World Economic Forum

A review of best practices from countries around the world has unearthed 12 principles for an effective lifelong learning ecosystem as shown in Figure 4:

1. Learner-centered systems: The focus of curriculum design, learning processes, models, and credentialing should be on the needs and purposes of learners rather than institutions. The education system needs to adapt to the evolving needs of learners throughout their lives. For instance, in Finland, technical and vocational education and training (TVET) colleges create personalized learning plans for each student, developed with the help of a mentor.

2. Holistic learning: Every learning experience should integrate disciplinary and interdisciplinary knowledge, cognitive, socioemotional, and practical skills, and attitudes and values. In India, the Dream a Dream program helps underprivileged teenagers develop life skills through extracurricular activities such as sports and arts while incorporating these skills into the school curriculum.

3. Future-focused: Curriculum design and learning formats should address current knowledge and opportunities and anticipate future skills, working environments, and realities. The global initiative Teach the Future provides resources to teach future-thinking skills to students and educators worldwide, spanning primary school to university levels and various disciplines.

4. Tech-intensive/bionic: To prepare learners for tech-intensive environments, they should gain familiarity with technologies like AI, augmented reality, robotics, and neurointerfaces as an integral part of their learning journey. For example, KinderLab Robotics in the US provides KIBO robots to kindergartens and elementary schools, enabling students to learn science, technology, engineering, math, programming, and robotics through play.

5. Regular learning: To sustain their learning capacity, individuals should partake in ongoing learning experiences throughout their lifetimes. This requires establishing a LLL culture in the country, and both the proactive role of individuals (LLL mindset and willingness to learn) and the active role of LLL ecosystem players (creating learning opportunities).

6. Inclusive learning: All citizens should have equal access to lifelong learning opportunities, regardless of age, gender, education level, health, or other factors. This contributes to extending the skilled workforce and avoiding inequality and the digital divide.

7. Integrated learning journeys: A diverse range of providers, including employers, training companies, museums, and nongovernmental organizations (NGOs), should contribute to learning journeys, offering various contexts and perspectives. LRNG, a US-based platform, provides underprivileged youth with personalized learning playlists to develop tangible skills applicable to academic and career settings. LRNG uses open badges to recognize skill acquisition and unlock opportunities such as micro-scholarships and internships.

8. Experience-based learning models: Education should not solely focus on knowledge acquisition but also incorporate various learning experiences, including project work, research, and employer interaction. These experiences contribute to both individual and collective learning journeys. In Saudi Arabia, the digital e-learning platform FutureX organizes BootCampX, aimed to provide intensive synchronous training and mentoring in partnerships with international institutions.

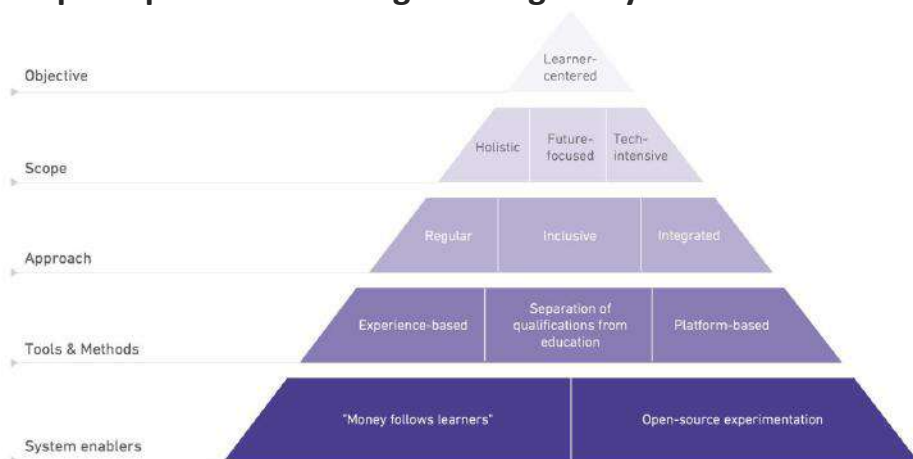
9. Separation of qualifications from education: Independent testing and certification centers, rather than training providers, should be responsible for assessing the knowledge and skills of professionals. This model, currently employed in driver licensing and software engineer certification, allows for a more flexible and competitive system. Integrating microcredentials into the LLL ecosystem enhances flexibility to a greater extent.

10. Platform-based learning: Digital platforms that map learning opportunities and track learner progress, alongside ecosystem-oriented educational institutions, play a vital role in providing integrated learning journeys. Dutch platform SkillLab empowers learners to turn their skills into careers. It provides an AI-backed tool for skills assessment and profiling, designing and comparing new education and career trajectories, finding the best-matching jobs, and providing personalized career support.

11. “Money follows learners”: Economic models should prioritize learner needs, flexibility, and adaptation. For example, France’s Personal Training Account enables workers to access a personal budget for professional training, with the sum calculated based on years worked. Individuals can decide how to spend the money on skills assessments, professional certification courses, or business setup support.

12. Open-source experimentation: Incentives such as grants, tax breaks, infrastructure access, and training contracts should be provided to educational providers willing to experiment with new formats, approaches, and solutions. These incentives should be conditioned upon documenting and sharing the experimental results across the system as open-source or “copyleft” content, thus fostering system-wide evolution. Canada’s Future Skills Centre has invested over \$209 million CAD in 120+ innovation pilot projects since 2020, supporting organizations in testing and adopting breakthrough solutions for the future of work in a low-stakes yet risk-taking environment.

Figure 4. 12 principles for a lifelong learning ecosystem



Conclusion

Education providers are encouraged to ensure the future readiness of their curricula and teaching methods. This includes ensuring experience-based learning through projects, interdisciplinary teaching, and tech-intensive learning models designed around future working environments, incorporating AI, robotics, or metaverse tools. Updating curriculum standards across all education levels is imperative to infuse the bionic skillset.

Kindergartens can adopt innovative teaching techniques, like a game-based approach, and utilize cutting-edge tools to create holistic learning experiences. This approach establishes the foundation for the bionic skillset, fostering familiarity with new technologies, enhancing communication skills, and cultivating a universal well-being mindset.

Schools, universities, and TVETs are encouraged to revamp curricula to emphasize general and technical skills pertinent to the future. Deep integration of future skills into both specialized and traditional disciplines (like mathematics or history) is essential. The introduction of personalized learning plans tailored to individual strengths, interests, learning habits, and behaviors is also pivotal. Employing a tech-intensive environment and modern technologies, including communication tools, AI, and AR/VR equipment, in the learning process is instrumental in acquiring the bionic skillset. Students can be encouraged to use technologies (i.e., generative AI) while fulfilling learning tasks and projects. Partnerships with employers and other learning providers will help education institutions to offer integrated experience-based learning journeys to their students.

Assessment tools across all education levels need to be aligned with these changes. Teacher training requirements and mandatory programs should be customized to encompass future skills, ensuring that educators are equipped with the necessary knowledge and tools to effectively prepare students for the evolving job landscape.

Policymakers play a critical role in orchestrating a vibrant lifelong learning ecosystem by bringing together education providers, businesses, and learners. This entails providing the right incentives and funding framework, including innovative and sustainable funding solutions, to foster partnerships between education providers and employers and to encourage citizens of all ages to invest the time to acquire new skills.

Policymakers also need to encourage education providers to make access to their courses inclusive for workers across ages. By reviewing and attesting to the future readiness of different courses and programs, the public sector can guide learners toward the right institutions and encourage providers to keep their courses in line with future labor market needs. The public sector can also play a key role in the independent certification of bionic skills, working with employers and academic providers to define standards and assessment methods.

Employers are critical to the upskilling of the workforce. Employers are positioned to foster a culture of continuous learning, encouraging LLL mindset development within their companies. Dedicated resources, policies, and internal regulations should be in place to offer employees tailored skill-development opportunities. This can be either through formal training or on-the-job learning. Businesses may partner with digital platforms to provide sector-specific training courses or encourage employees to actively participate in lifelong learning programs. Through partnerships with education providers such as TVETs or universities, employers can enhance the quality of education at those institutions by creating experience-based learning opportunities and gaining access to the best talent.

Training providers, including sectorial training academies, corporate training organizations, independent training institutions, and NGOs, can develop upskilling and reskilling programs that empower the current workforce with bionic skills, enabling them to adapt to new technology and enhance productivity. Training market players can be much more flexible than educational institutions and promptly address the demand for bionic skills.

Citizens can adopt a mindset of continuous, regular learning to prosper in the workplace of the future. This requires taking responsibility for one's learning and seeking out experiences that will help to acquire new skills at work or outside (for example, through digital learning platforms). Proactively engaging with new technologies will be a competitive advantage for workers as they embrace the concept of lifelong, life-wide, and life-deep learning.

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