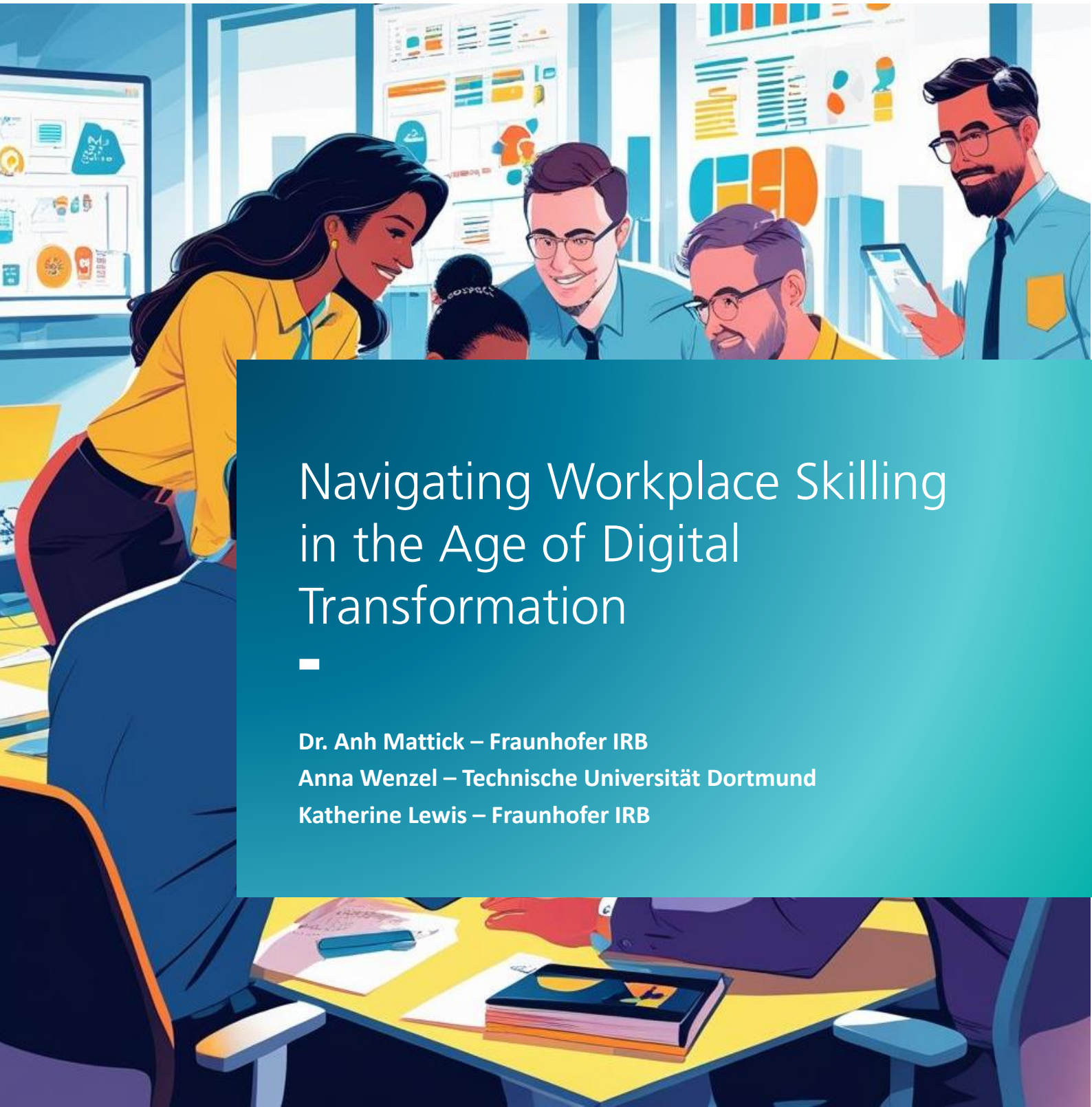
Fraunhofer IRB

technische universität dortmund



Navigating Workplace Skilling in the Age of Digital Transformation

Dr. Anh Mattick – Fraunhofer IRB
Anna Wenzel – Technische Universität Dortmund
Katherine Lewis – Fraunhofer IRB

Abstract

This paper examines the changing landscape of professional learning in the face of rapid technological advancements and evolving workforce demands. It emphasizes the urgency for continuous reskilling and upskilling, driven by a plethora of learning formats and immersive technologies like virtual and augmented reality. Central to the discussion is the necessity of adapting the workforce for business resilience and social inclusion as job roles transform and skill relevance diminishes. Organizations are urged to transcend traditional training models and embrace lifelong learning integrated into daily work. The influence of digitalization and artificial intelligence is highlighted for their role in creating personalized, data-driven, and scalable learning solutions, while also introducing complexities that necessitate structured frameworks for informed decision-making regarding learning investments. Emerging technologies, particularly 3D virtual worlds, VR, and AR, promise to enhance learning engagement through immersive environments. Collectively, these factors advocate for a strategic reimagining of learning ecosystems to ensure that technological progress leads to meaningful and inclusive human development.

Table of Contents

I. Workplace Transformation: Why Skilling is the Key to Business Resilience

A. Skilling in the Age of Industry 4.0 and 5.0

Although Industry 4.0 is still underway, the momentum around Industry 5.0 has already begun to build [1]. At the same time, industries are increasingly voicing concerns about a widening skills gap and the urgent need for qualified talent [2,3]. This gap is being fueled by rapid environmental, economic, social, and technological shifts, particularly in sectors undergoing digital transformation [4,5]. As Industry 4.0 continues to redefine operational processes and job roles, employees are expected to acquire more advanced and diverse skill sets across the entire value chain. These evolving demands underscore the global urgency for continuous upskilling and the promotion of lifelong learning [1].

According to Li [6, p.1697], »workforce, capital, and technology are the three major components that significantly contributed to the evolution of the past three industrial revolutions.« Today, all three components are undergoing profound transformations. Technology is advancing rapidly through innovations such as the Industrial Internet of Things, artificial intelligence, machine learning, hyper-converged infrastructure, deep learning, and virtualization, which together enable increasingly intelligent production systems [6-9]. Other studies named interconnectivity, automation, and the abundance of data - characterizing for Industry 4.0 [1]. At the same time, corporations are facing rising costs - not only for energy, materials, and logistics, but also for technology-driven tools like virtual (VR), augmented (AR), and mixed reality, which require intensive and costly programming.

Among these components, the workforce plays a crucial role. The successful adoption and integration of new technologies rely heavily on the skills of workers who must operate and adapt to these systems. As a result, the importance of reskilling and upskilling has surged.

According to the World Economic Forum's *Future of Jobs Report 2020*, half of the global workforce would need to be reskilled by 2025 [10].

Forecasting future jobs and skill sets has thus become increasingly vital, leading to a growing body of research examining labor market trends through the analysis of online job postings [11-18]. These studies provide valuable insights for various stakeholders: graduates can make informed decisions about in-demand skills [19]; universities and colleges can align curricula with labor market needs to offer more future-ready education [20]; and employers can benchmark jobs descriptions and training programs to better match emerging skill demands.

B. Reskilling, Upskilling, and Beyond

In the modern workforce, employers select the candidate with the demanded combination of skills to the company. According to Rikala et al. [1], industries are struggling with finding the »right-skilled« workers. But what makes a right-skilled worker? Employee turnover has become more common in the digital age, prompting companies to prioritize retention and invest in upskilling to build resilience and remain competitive. As new learning formats rapidly emerge, organizations face growing complexity in selecting and evaluating effective methods for developing future-ready skills. Additionally, skills have changed over the period of time. This is shown by Tushar and Sooraksa [21], which investigated the change of skills over the period of 1990s, 2000s and 2010s by analyzing studies. During the 1990s, several influential studies and reports-particularly from the U.S., Canada, the U.K., and Japan-identified key employability skills needed in the evolving workplace [22,23]. Across reports such as ASTD [22] and SCANS [24], a consensus emerged around a core set of top ten employability skills, including problem-solving, self-esteem, teamwork, communication, creativity and initiative, adaptability, responsibility, goal-setting, interpersonal skills, and learning.

Workplace Learning

»Workplace learning is a dynamic and continuous process in which individuals and teams engage in social interactions and personally internalize workplace experiences - both individually and collectively. These interactions foster the development of professional identity, encompassing knowledge, skills, values, and emotional understanding, ultimately leading to meaningful changes in behavior and perspective. As such, the way learning unfolds in the workplace is profoundly shaped by the specific organizational context [25]«.

During the 2000s, various international studies deepened the understanding of employability skills needed for fresh graduates, identifying a broader and more nuanced set of competencies [26,27]. Across all studies from 2000 - 2009, 123 skills were identified, with 59 unique ones after removing duplicates. The top ten most commonly reported skills include communication, teamwork, ICT skills, problem-solving, self-esteem/confidence, creativity and initiative, self-management, planning and organizing, adaptability, and time management. Other frequently mentioned skills included integrity, responsibility, motivation, networking, and commercial awareness.

Between 2010 and 2019, research on employability skills expanded significantly across global contexts, with growing focus in developing countries. Fourteen key studies were reviewed to identify the essential skills expected from graduates. Rosenberg et al. [29] outlined eight dimensions with 47 specific skills, including communication, teamwork, leadership, adaptability, and critical thinking. The World Economic Forum (2018) added a future-oriented perspective, listing top skills for 2018 - 2024, including analytical thinking, complex problem-solving, active learning, emotional intelligence, and digital literacy. Overall, 237 skills were identified in the decade, with 69 unique skills after removing duplicates. The most frequently cited top ten skills were: problem-solving, communication, adaptability, teamwork, critical and analytical thinking, willingness to learn, ethics and integrity, interpersonal skills, leadership, and ICT skills. Additional common skills included creativity, time management, professionalism, emotional intelligence, and responsibility.

Although companies prioritizing ready-to-go skilled workers over long-term training, investing in reskilling, outskilling and upskilling as business resilience strategies are highly important for adaptability and innovation [4]. A skill, which refers to cognitive and noncognitive abilities for a particular job, is a measurable and observable ability that enables an individual to effectively apply knowledge, experience, and technique to perform tasks or solve problems [30]. It can be developed and refined through training and practice and is typically categorized as either a hard skill, involving technical or occupational competencies, or a soft skill, encompassing interpersonal and cognitive capabilities such as communication, adaptability, and emotional intelligence [31]. Ultimately, skills reflect the capacity to act responsibly and purposefully toward achieving specific goals in a given context [32].

Reskilling:

»Reskilling involves training employees to acquire new skills that enable them to transition into different roles within an organization, especially when their current roles become obsolete due to technological advancements or organizational changes«.

Upskilling:

»Upskilling refers to the process of enhancing existing skills or acquiring new competencies to improve performance in one's current role«.

Outskilling:

»Outskilling is the practice of providing departing employees with training and support to help them secure employment in alternative fields. This approach equips individuals with the necessary skills to remain competitive in the job market after leaving their current organization«.

Crossskilling:

»Crossskilling, also known as cross-training, involves training employees to perform multiple roles or tasks beyond their primary job functions. This strategy enhances workforce flexibility and ensures operational continuity by preparing employees to handle various responsibilities within the organization«.

Continuous employee development and training should be treated as ongoing processes, not one-time efforts. Rather than overhauling entire education systems, organizations can address skill gaps by identifying specific training needs and aligning them with evolving job requirements.

II. Lost in Learning: How to Navigate the Overload of Skilling Options

A. Trends & Trials in Learning

In the rapidly evolving landscape of workplace skills, organizations and employees alike face an unprecedented challenge: navigating the vast and complex ecosystem of online and offline learning opportunities available today [33,34]. This section examines the proliferation of learning formats and platforms that, while offering tremendous potential for skills development, often create greater inefficiency by means of choice overload and option fatigue.

As the duration for which professional skills remain relevant continues to shorten, organizations increasingly recognize the necessity of embedding continuous learning into everyday work processes [35]. This integration requires new approaches to learning design and delivery that accommodate time constraints, workflow interruptions, and varying levels of learner motivation. Learning must now happen in the flow of work - accessible at the point of need and designed to complement, rather than solely rely on, traditional training events that may not always translate into meaningful application.

The digital transformation has catalyzed an explosion of innovative learning formats designed to accommodate flexible learning styles, content delivery preferences, and skill acquisition needs [34]. These diverse emerging formats represent a significant departure from traditional classroom-based, workshop-based, or linear e-learning approaches that dominated organizational training in previous decades.

The contemporary learning ecosystem encompasses an array of technologies and methodologies. In our current decade, VR and AR have gained significant traction. VR and AR technologies provide immersive experiences that enable professionals to simulate real-world scenarios, enhancing learning through interactive and engaging environments. These technologies offer several distinct advantages for professional development, including realistic simulations for practicing skills, remote collaboration opportunities, safe experimentation in risk-free environments, zero material waste, and significantly enhanced learner engagement [36]. As of 2025, the largest buyer in the VR educational market is industrial and corporate training programs [37].

Beyond immersive technologies, other emerging formats include gamification, which incorporates game mechanics such as scores, badges, and challenges to increase user engagement [38]. Additionally, there is microlearning, which breaks content into brief, focused segments [39]. Social learning, which leverages peer interaction and knowledge sharing [40]; and adaptive learning systems, which personalize content based on individual progress and performance [41]. The global e-learning market reflects this expansion, with projections indicating growth to approximately $400 billion by 2026, nearly doubling from $200 billion in 2019 [42].

Learning professionals face many challenges in this complex environment. A primary difficulty lies in evaluating the efficacy and appropriateness of numerous teaching and learning formats available today. The accelerating rate of innovation in learning technologies creates a perpetual state of adaptation, requiring continuous assessment of new tools and approaches. For example, a single Canadian university study evaluating the effectiveness of laboratory simulation found that the majority of students struggled with motivation and engagement until the program was redesigned to be more immersive (i.e., better match the familiar environment and structure of their traditional laboratory) [43]. These challenges are equally relevant in professional learning contexts, where similar hurdles (trial and error, fine-tuning, reactionary decision-making) often impede effective skill acquisition.

B. Overabundance of Learning Platforms and Programs

The proliferation of online learning platforms represents both an opportunity and a challenge for organizations committed to employee development. The diversity of available options-from enterprise-grade learning management systems to specialized skill development platforms-creates a paradox of choice that may actually overwhelm both learning professionals and learners themselves.

The current learning ecosystem includes numerous platform categories and sub-categories of mostly Massive Open Online Courses (MOOCs), each targeting specific segments of the learning market. For independent course creators, platforms like LearnWorlds, Thinkific, Teachable, and Kajabi offer tools to create, brand, and monetize content. For enterprises, solutions like Docebo, Litmos, and Coursera for Business provide capabilities for employee training, tracking, and compliance. Academic institutions might leverage Moodle, edX, or Coursera for Campus to deliver structured learning with appropriate assessment mechanisms.

Despite the availability of numerous learning platforms and content providers, most organizations still rely on patchwork solutions to manage workforce development. Common approaches include maintaining multiple learning platforms, supplementary third-party content libraries, and delegating the responsibility for course selection to individual departments or employees [44]. While these strategies offer flexibility, they often result in duplicated effort, inconsistent learning experiences, difficulties in tracking learning progress, and overly complex administrative stewardship.

Furthermore, without a unified framework for evaluating the quality and relevance of learning options, organizations struggle to ensure that investments in upskilling actually translate to measurable improvements in workforce capability [45-47]. These limitations highlight the pressing need for a more systematic and evidence-driven approach to navigating the learning landscape.

Beyond platform proliferation, organizations and individuals struggle to match learning needs with appropriate content and delivery. This challenge manifests in several ways:

- Content quality assessment becomes increasingly difficult, as the volume of available materials is too vast or pay-walled without sufficient preview. [48]
- Alignment between learning methods and specific skill requirements often remains unclear [49]
- Determining the appropriate depth and breadth of learning for particular roles creates uncertainty [48]
- Balancing more accessible standardized learning paths with personalized development needs [49]

This challenge frequently results in suboptimal learning investments, with organizations either over-investing in comprehensive solutions that exceed actual needs or under-investing in approaches that fail to deliver sufficient skill development. For individual learners, this complexity can lead to abandonment of learning initiatives altogether, with 78% of learning professionals acknowledging that information overload represents a significant barrier to effective learning.

III. Theory in Action: The Learning Toolbox – A Project of the Global Upskill Initiative

The growing complexity of workplace learning-driven by rapid technological change, evolving skill demands, and an overload of learning options-calls for innovative strategies in curating, organizing, and delivering training content. Global Upskill, a forward-looking initiative supported by the Dieter Schwarz Foundation, addresses these challenges by bridging the gap between emerging trends and practical workforce needs.

The project »Learning Toolbox« aims to design a platform that helps organizations stay future-ready by identifying key technologies, forecasting skill requirements, and recommending tailored learning solutions. Developed in collaboration with industry experts and educational researchers, the Learning Toolbox provides a structured, user-centric solution to support modern workforce development. Its core mission is to empower companies to make informed decisions about learning formats and strategies by offering criteria-based, personalized recommendations aligned with organizational goals and learner needs.

Functioning as a decision-support system, the platform enables users to evaluate, select, and implement the most appropriate training approaches for their specific contexts - whether the goal is onboarding, upskilling, outskilling, reskilling, or leadership development. By integrating expert knowledge with practical insights, the Toolbox serves as a one-stop resource to navigate the ever-expanding ecosystem of corporate learning, ultimately fostering resilience and adaptability in a fast-paced business environment (Figure 1).

The ideal implementation of the Learning Toolbox features web-based accessibility that serves user accounts. For learning professionals, it provides evidence-based

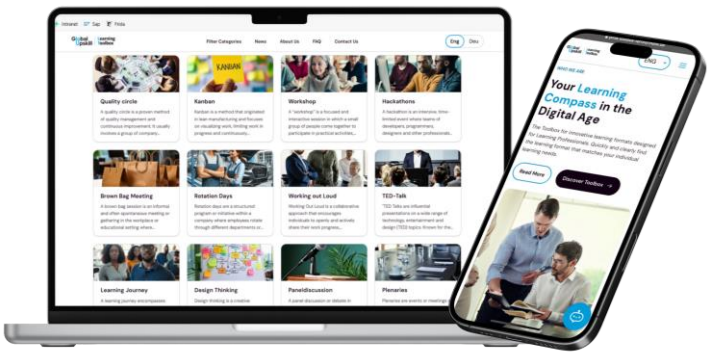


Figure 1: Toolbox Landing Page © Fraunhofer IRB

frameworks for selecting appropriate learning methodologies based on content type, learner characteristics, and organizational constraints. For individual learners, it offers learning pathway recommendations based on objective, skill level, and preferred learning styles. By accessing database content via relevant criteria search, the Learning Toolbox helps organizations prioritize learning investments strategically rather than reactively.

The system's architecture includes:

- A comprehensive content database of learning options, categorized by format, content area, skill level, and time commitment
- Available option for AI Large Language Model (LLM) guidance and automatic direction through database to pinpoint relevant content by means of conversation over search bars
- Recommendations directing users to providers of the relevant learning formats and platforms

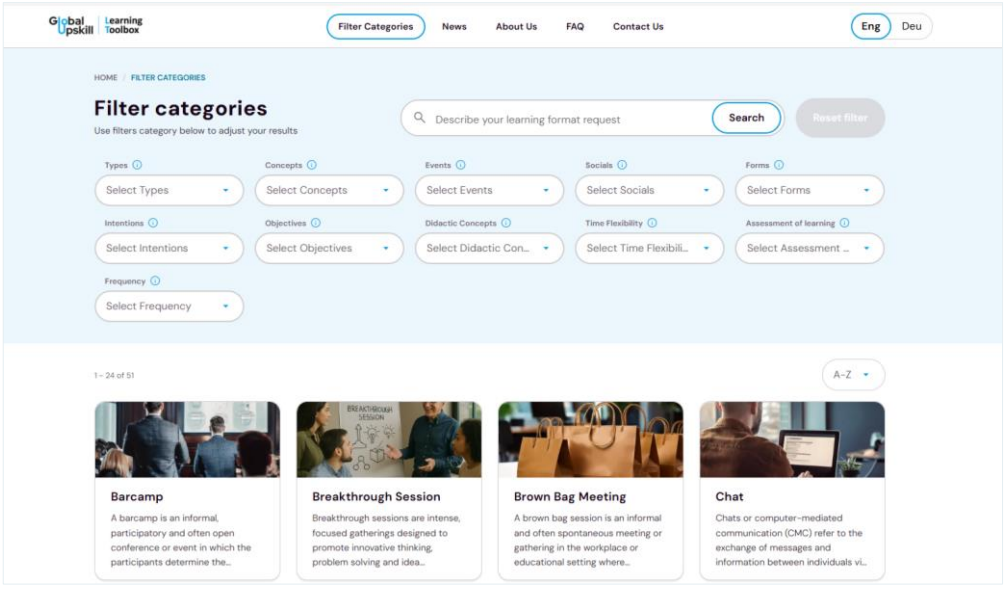


Figure 2: Toolbox Filter categories
© Fraunhofer IRB

The Learning Toolbox user journey is simple but effective. Consider a personnel manager tasked with developing an upskilling agenda for their workforce. By logging into the Learning Toolbox, the manager can filter available learning formats based on skill area, time commitment, and preferred delivery method. Each recommendation is accompanied by evidence-based description and links to providers.

The Learning Toolbox offers a structured approach to navigating the overwhelming array of learning options, providing personalized recommendations and evidence-based guidance. However, the rapid evolution of technology, especially in the realm of Artificial Intelligence, is poised to fundamentally alter the landscape of workplace learning itself. As we transition from simply curating existing learning resources to leveraging AI-driven tools for personalized instruction and immersive experiences, a new set of opportunities and challenges emerge. The future of professional upskilling will explore the transformative role of AI and related technologies in shaping the future, and how organizations can leverage these innovations to drive enhanced learning outcomes.

IV. Skilling in the Digital Era: The Role of AI and Technology in Learning

A. 3D Virtual Worlds as a Gateway to the Metaverse

At the latest since Mark Zuckerberg's announcement in 2021 of renaming the Facebook group to Meta, there has been a heightened focus on realizing the concept of the metaverse, which draws inspiration from the ideas presented in Neil Stephenson's novel »Snow Crash« [50] and can be conceptualized as »a massively scaled and interoperable meta-ecosystem of other digital ecosystems of real-time rendered 3D virtual worlds which can be experienced synchronously and persistently by an unlimited number of complementors and consumers with an increased user experience caused by a creativity-guided co-creation of goods managed by orchestrators and supported by platform owners« [51, p. 7]. By enabling users to interact simultaneously as avatars within a 3D virtual environment, that »capitalizes upon natural aspects of human perception by extending visual information in three spatial dimensions« [52, p. 833] alongside software applications, the metaverse merges conventional modeling and simulation techniques with emerging user dynamics, fostering emergent knowledge processes [53,54]. By now, it was envisioned that 3D virtual environments »may become primary tools (with video and text secondary) for learning many aspects of history, for acquiring new skills, for job assessment, and for many of our most cost-effective and productive forms of collaboration.« [55, p. 7]. Although these assumptions have not yet been fulfilled, 3D virtual environments of popular gaming platforms such as Roblox and Fortnite as well as their extensions VR and AR are increasingly gaining popularity and considered enabling technologies of the metaverse [56,57]. Particularly in education, discussions about the metaverse have gained momentum, demonstrated by an increase in scientific publications since 2021 [58], although the potential of 3D virtual worlds as key elements of the metaverse for educational purposes has been explored for more than a decade:

In education, 3D virtual worlds are believed to offer advantages over 2D learning platforms, such as learning management systems [59]. These advantages include enhanced spatial knowledge representation, greater opportunities for experiential learning, increased motivation and engagement, better contextualization of learning, and improved collaborative possibilities. This potential can be attributed to their unique design features, particularly in terms of 1) representational fidelity and 2) learner interaction, allowing for increased realism in Human-Computer Interactions [59]. Furthermore, 3D virtual worlds are suggested for fulfilling needs for autonomy, relatedness, and competence [60] and moreover, for encouraging gameful experiences [61] that can even outperform traditional learning methods [62].

Although it is suggested that 3D virtual worlds can exist, and have already existed independently in the past, the metaverse needs to draw on some type of virtual environment, whether being in the field of AR or VR that build on the concept of virtual worlds [56].

B. Augmented and Virtual Reality in Professional Development

Following Girvan [63], virtual reality systems are designed to deepen users' immersion in virtual environments, primarily through the use of VR hardware such as head-mounted displays. These systems provide novel ways to engage in virtual worlds by increasingly enveloping the user's senses, thereby minimizing awareness of the physical environment, finally enhancing the user's presence within the virtual world. Contrary to VR, Augmented Reality (AR) is defined as the enhancement of the real physical environment through the addition of computer-generated virtual information. It integrates virtual elements into real-world data to create

interactive, three-dimensional experiences, blending virtual and real objects, supporting real-time interaction and incorporating 3D virtual components [64,65].

To date, VR applications are most prominent in healthcare, followed by engineering, language learning, business, among others and have the potential to increase learning effectiveness, going beyond mere knowledge transfer and facilitating the development of critical competencies [66,67]. Regarding professional development, VR is suggested to offer powerful tools for accelerating employee onboarding, enhancing leadership skills, and supporting decision-making. By simulating realistic work environments, it can provide employees with hands-on experience, helping them adapt quickly to company procedures and minimize costly errors. Additionally, VR has strong potential in leadership development, enabling immersive training in soft skills such as communication, team management, and conflict resolution. Furthermore, simulated high-pressure scenarios offer a safe space for leaders to practice decision-making without real-world consequences [68]. Thus, VR is particularly suitable for learning environments that prioritize active learner engagement and practical application, such as active manipulation and constructive creation [67].

Like VR, AR applications serve a wide range of educational purposes, including visualizing abstract concepts, using gamification to develop skills such as problem-solving, critical thinking, and collaboration, enabling virtual field trips to explore diverse environments, and providing simulations that allow learners to practice real-world scenarios [69]. Beyond higher education, AR presents valuable opportunities for professional development, particularly in industry and vocational training. It is increasingly applied in fields such as industrial manufacturing and building safety, alongside the medical field [70]. These implementations have been shown to enhance learning outcomes, including the development of relevant vocational skills, improved task performance and decision-making, increased professional expertise and experience, greater engagement and motivation, enhanced self-regulated learning, reduced cognitive load, shorter training durations, and a lower rate of operational errors (ibid.).

Thus, both AR and VR allow to recreate real-life scenarios, employ immersive learning environments and provide hands-on experiences that bridge theory and practice that are expected to transform education, including professional development [68,70,71]. However, despite promising characteristics, both VR and AR face hurdles which make implementation difficult at scale. For example, many current VR solutions are designed for broad audiences, without tailoring content to specific fields of study, education levels, or professional roles. This lack of personalization limits their effectiveness in addressing the needs of different user groups and employers [68].

Moreover, the sustainable implementation of AR and VR is oftentimes limited due to limited proficiency in these tools both by educators and scholars as well as shortage of educational software, challenges with maintenance and technological updates, and high implementation costs [66,72]. As a common practice employers often develop technology platforms that suit their own educational needs and combine these platforms with off-the-shelf digital products to maximize user experience [70].

This highlights the growing importance of metaverse and online gaming platforms for educational purposes, such as Roblox, Fortnite, and Minecraft, which are projected to reach a market value of $31.6 billion by 2025 [73]. Their success is partly driven by their strong appeal to users and subcultures [57], as well as the platforms' ability to customize visually captivating 3D virtual worlds [59]. These platforms increasingly support VR (as seen with Roblox and Minecraft) and explore early-stage and experimental AR, such as Roblox's *Replica* and the *Minecraft Earth* project. Given the ongoing technological advancements, educational VR and AR applications are expected to become increasingly prevalent, opening up new opportunities for the design of immersive learning environments that promote professional development in the future.

C. AI-Age: Impact of AI on Learning & Skilling

As we transition into the era of Industry 5.0, artificial intelligence is emerging as a transformative force in education, moving beyond the outdated »one-size-fits-all« approach to support highly personalized learning experiences. Companies and educational institutions are now positioned to leverage AI to tailor educational pathways to individual learner needs - taking into account preferences, learning pace, cognitive styles, and favored formats [74]. This personalized learning environment not only enhances engagement but also promotes deeper understanding and long-term retention of knowledge.

AI applications in education span a wide spectrum, from adaptive learning systems and intelligent tutoring to automated assessments and performance analytics. These tools facilitate real-time feedback, support learning diagnostics, and enable data-driven decision-making to improve both teaching and learning processes [75]. Chatbots and virtual assistants also play a growing role, providing on-demand support to learners and freeing up educators' time for more complex instructional tasks.

However, with these technological advancements come a host of complex challenges - ethical, legal, social, and educational. The integration of AI into learning environments raises important ethical questions about data privacy, algorithmic

transparency, and bias. For instance, concerns over how AI systems collect, store, and process student data demand rigorous safeguards to ensure security, consent, and fairness. Legally, educational institutions must navigate an evolving landscape of regulations related to AI usage, intellectual property, and accountability for automated decisions, which often lack clear precedent.

Socially, AI risks deepening the digital divide by disproportionately affecting learners and educators with limited access to reliable technology or digital literacy skills. There is also the potential for AI to reshape traditional educational roles, particularly the teacher-student relationship, challenging established pedagogical norms and interpersonal dynamics.

From an educational standpoint, AI integration calls for significant shifts in curriculum design, assessment methods, and instructional strategies. Educators must embrace a more flexible and interdisciplinary mindset, aligning teaching practices with the evolving capabilities of intelligent systems. This transformation requires not only technological adaptation but also a rethinking of educational goals in light of what AI can and cannot do.

A further pressing issue is the need for comprehensive educator training to equip teachers with the skills necessary to effectively utilize AI tools. Many educators currently lack sufficient knowledge of AI and its practical applications, posing a major barrier to meaningful implementation [76]. Professional development programs must therefore prioritize not only technical skills but also competencies such as critical thinking, ethical reasoning, creativity, and value creation. Additionally, educators should be trained to understand the broader implications of AI, machine learning, and automation - particularly in terms of optimizing learning outcomes while ensuring equity and inclusivity [77,78]. Lastly, a fundamental understanding of artificial intelligence is essential for its effective use. Reviews of existing studies indicate that there is a widespread lack of knowledge regarding AI applications, particularly within the healthcare and medical fields. This knowledge gap is evident across both low- and middle-income countries (LMICs) and high-income countries (HICs), highlighting a global issue. Many participants reported having neither attended formal AI-related courses nor engaged with academic literature on the topic, pointing to insufficient exposure to structured AI education [79].

To navigate these challenges, collaboration is key. Policymakers, educators, developers, and researchers must work together to establish clear ethical frameworks, inclusive digital policies, and best practices for the responsible use of AI in education. Only through such a holistic and collaborative approach can we ensure that AI serves as a tool for empowerment - enhancing rather than replacing the human dimension of teaching and learning.

V. Theory in Action: Virtual Worlds for Sustainable Innovation in the Textile Industry

As the world of work continues to evolve at an unprecedented pace, immersive technologies such as the metaverse are opening up new frontiers for professional learning and skills development. In our current project, a spinoff of the Learning Toolbox Project, Fraunhofer IRB is harnessing the potential of virtual worlds to transform how learning professionals engage with complex industrial processes. Our focus lies in the textile industry, with a specific spotlight on the production of running shoes - a globally relevant sector at the intersection of fashion, performance, innovation, and sustainability.

We are developing a metaverse-based training environment on the Roblox platform that enables learners to explore the entire lifecycle of running shoe production. Designed for roles such as junior product designer or junior brand manager, the virtual world offers immersive learning scenarios to onboard new employees, build cross-functional understanding, and foster a culture of collaboration and sustainable innovation.

Our virtual world is modeled after a realistic shoe manufacturing supply chain, with different zones dedicated to design, material sourcing, prototyping, tooling, assembly, marketing, and retail. Learners take on role-based challenges, interact with NPCs (non-player characters), but also collaborate with other peers to solve real-world problems. For instance, a junior product designer can explore what a *Specification Sheet* is, understand its key components, and gain insight into the various elements that make up a running shoe. They also learn to identify which parts offer the greatest potential for sustainable innovation.

These tasks go beyond theoretical learning - they are grounded in real-world developments in eco-design, advanced materials, and digital manufacturing practices. This metaverse approach supports experiential learning, a method proven to increase engagement, retention, and critical thinking. Learners navigate the shoe production process in a non-linear, exploratory way, which reflects the real-life dynamics of the industry. They can experiment with design decisions, see their outcomes in real-time, and receive instant feedback. By simulating the consequences of sustainable versus unsustainable choices, learners gain a deeper understanding of the trade-offs and opportunities in product development.

The textile and footwear industry, particularly in fast fashion and sportswear, faces growing scrutiny for its environmental and social impact - from CO_2 emissions and water consumption to labor practices and material waste [80,81]. Yet, it also holds immense potential for circular innovation, digital transformation, and localized, on-demand production. Our project aims to equip the next generation of professionals with the skills, mindset, and tools to navigate this transformation. By making the invisible visible - whether it's the carbon footprint of a material or the lifecycle of a design - we hope to build awareness, responsibility, and innovation literacy among learners.

Figure 3: First Impressions of the Metaverse Environment Within Roblox © Copyrights

Learning in virtual worlds like Roblox blurs the line between simulation and reality, creating authentic learning experiences that are dynamic, social, and impact-driven. As we move towards a future where sustainability is no longer optional, but imperative, immersive learning environments like ours become powerful vehicles for systemic change. They provide a safe space for experimentation, collaboration, and discovery, fostering the kind of interdisciplinary knowledge that the textile industry urgently needs.

In sum, our metaverse-based learning world not only addresses the urgent skills gap in sustainable product development but also reimagines how professional training can be delivered - engaging, relevant, and transformative.

VI. Conclusion and Outlook

As the pace of digital transformation accelerates, organizations face mounting pressure to keep their workforce equipped with the skills needed to stay competitive and resilient. Systematic upskilling and reskilling are no longer optional - they are strategic imperatives for long-term sustainability and societal progress. This publication has explored the evolving landscape of professional learning, examining the challenges and opportunities presented by digital platforms, emerging technologies, and the shifting demands of the modern workplace.

One key issue identified is the fragmentation of learning ecosystems. While a broader array of formats and platforms has democratized access to knowledge, it has also introduced complexity, inefficiencies, and decision fatigue. Organizations increasingly recognize the need to embed learning into the day-to-day flow of work - making it timely, contextual, and aligned with actual job tasks. This shift requires more than new tools; it calls for a fundamental cultural change in how we view professional development - not as a one-time event, but as a continuous, integral part of performance.

Simultaneously, the explosion of digital content and credentials presents both opportunity and challenge. Learning professionals must now navigate a vast array of offerings while ensuring relevance, quality, and alignment with organizational goals. Structured, data-informed solutions - such as the Learning Toolbox developed within the Global Upskill initiative - help address this challenge by guiding users to the right learning format based on role, context, and learning goals. These tools play a crucial role in reducing decision paralysis and improving the effectiveness of learning strategies. Looking ahead, immersive technologies such as VR and AR are set to redefine how we learn. Virtual learning environments, including those developed in platforms like Roblox, offer hands-on, experiential training that mirrors real-world complexity. By simulating industry-specific scenarios - like running shoe production in the textile sector - learners can explore sustainable practices, collaborate globally, and develop skills in a realistic, engaging setting. However, for these innovations to reach their full potential, they must be thoughtfully integrated into broader learning ecosystems and supported by educators, employers, and policymakers alike.

The road forward requires coordinated efforts across sectors. Businesses must invest in adaptable and inclusive learning infrastructures. Educators need resources and training to harness new tools effectively. Policymakers must create enabling frameworks that support lifelong learning while ensuring equity and accessibility. Ultimately, the future of work will be shaped not only by technological innovation but by our collective ability to foster a culture of continuous learning. Those who can build and sustain that culture will lead the way in productivity, innovation, and human-centered growth.

References

[1] Rikala *et al.*, »Understanding and measuring skill gaps in Industry 4.0 - A review,« Technological Forecasting and Social Change, vol. 201, 2024.

[2] G. Braun, M. Järvinen, J. Stahre, and R. Hämäläinen, »Motivational challenges of engineers participating in an online upskilling program,« in Proc. 21st Eur. Conf. e-Learning (ECEL), P. Fotaris and A. Blake, Eds., Academic Conferences International, 2022, pp. 25–31.

[3] T. Enders et al., »Future Skills: Six Approaches to Close the Skill Gap,« *World Government Summit*, 2019

[4] A. Felsberger, F. H. Qaiser, A. Choudhary, and G. Reiner, »The impact of Industry 4.0 on the reconciliation of dynamic capabilities: Evidence from the European manufacturing industries,« Prod. Plan. Control, vol. 33, no. 2–3, pp. 277–300, 2022.

[5] Y. Guo, C. Langer, F. Mercorio, and F. Trentini, »Skills mismatch, automation, and training: Evidence from 17 European countries using survey data and online job ads,« *EconPol Forum*, vol. 23, no. 5, 2022.

[6] L. Li, »Reskilling and Upskilling the Future-ready Workforce for Industry 4.0 and Beyond,« *Inf Syst Front*, vol. 26, 1697–1712 (2024).

[7] L. Li, »China's manufacturing locus in 2025: With a comparison of 'Made-in-China 2025' and 'Industry 4.0',« *Technol. Forecast. Soc. Change*, vol. 135, pp. 66–74, 2018.

[8] L. Li, »Education supply chain in the era of Industry 4.0,« *Syst. Res. Behav. Sci.*, vol. 37, no. 4, pp. 579–592, 2020.

[9] L. Xu, E. Xu, and L. Li, »Industry 4.0: State of the art and future trends,« *Int. J. Prod. Res.*, vol. 56, no. 8, pp. 2941–2962, 2018.

[10] K. Schwab and S. Zahidi, »*The Future of Jobs Report 2020*, World Economic Forum, Oct. 2020. [Online]. Available: https://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf

[11] K. Schwab and R. Samans, »*The Future of Jobs: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution*«, World Economic Forum, 2016.

[12] A. Verma, K. M. Yurov, P. L. Lane, and Y. V. Yurova, »An investigation of skill requirements for business and data analytics positions: A content analysis of job advertisements,« *J. Educ. Bus.*, vol. 94, no. 4, pp. 243–250, 2019.

[13] P. G. Lovaglio, M. Cesarini, F. Mercorio, and M. Mezzanzanica, »Skills in demand for ICT and statistical occupations: Evidence from web-based job vacancies,« *Stat. Anal. Data Min.*, vol. 11, no. 2, pp. 78–91, 2018.

[14] A. Ternikov and E. Aleksandrova, »Demand for skills on the labor market in the IT sector,« *Business Informatics.*, vol. 14, no. 2, pp. 64–83, 2020.

[15] N. G. Leigh, H. Lee, and B. Kraft, »Robots, skill demand and manufacturing in US regional labour markets,« *Camb. J. Reg. Econ. Soc.*, vol. 13, no. 1, pp. 77–97, 2020.

[16] J. Grüger and G. Schneider, »Automated analysis of job requirements for computer scientists in online job advertisements,« in *Proc. 15th Int. Conf. Web Inf. Syst. Technol.*, 2019.

[17] J. Prüfer and P. Prüfer, »Data science for entrepreneurship research: Studying demand dynamics for entrepreneurial skills in the Netherlands,« *Small Bus. Econ.*, vol. 55, no. 3, pp. 651–672, 2019.

[18] T. Van Huynh, K. Van Nguyen, N. L. Nguyen, and A. G. Nguyen, »Job prediction: From deep neural network models to applications,« in *RIVF Int. Conf. Comput. Commun. Technol. (RIVF)*, 2020.

[19] J. Napierala and V. Kvetan, »Changing Job Skills in a Changing World,« in: *Bertoni, E., Fontana, M., Gabrielli, L., Signorelli, S., Vespe, M. (eds) Handbook of Computational Social Science for Policy,* Springer, 2023.

[20] H. Ketamo, M. Moisio, A. Passi-Rauste, and A. Alamäki, »Mapping the future curriculum: Adopting artificial intelligence and analytics in forecasting competence needs,« in *Proc. 10th Eur. Conf. Intangibles Intellect. Capital (ECIIC)*, 2019.

[21] H. Tushar *et al*., »Global employability skills in the 21st century workplace: A semi-systematic literature review,« *Heliyon*, vol. 9, 2023.

[22] M. McLaughlin, »Employability Skills Profile: What Are Employers Looking For?« ERIC Digests, 1995. [Online] Available: https://eric.ed.gov/?id=ED399484

[23] T. Bailey, »*Changes in the Nature and Structure of Work: Implications for Skill Requirements and Skill Formation*, National Center for Research in Vocational Education«, Berkeley, CA, 1990.

[24] SCANS, »*What Work Requires of Schools: A SCANS Report for America 2000*,« U.S. Department of Labor, 1991.

[25] J. Hillberg, »The impact of leadership on the workplace learning of individuals and teams: a literature review and synthesis,« *The Learning Organization*, vol. 31, 2024.

[26] D. Curtis, and P. McKenzie, »Employability Skills for Australian Industry: Literature Review and Framework Development,« 2002. [Online]. Available: https://www.researchgate.net/publication/254581576_Employability_Skills_for_Australian_Industry_Literature_Review_and_Framework_Development

[27] J. Andrews and H. Higson, H, »Graduate Employability, 'Soft Skills' Versus 'Hard' Business Knowledge: A European Study,« *Higher Education in Europe*, 33(4), 411–422, 2008.

[28] R. Bennett, »Employers' demands for personal transferable skills in graduates: A content analysis of 1000 job advertisements and an associated empirical study,« *J. Vocat. Educ. Train.*, vol. 54, pp. 457–476, 2002.

[29] S. Rosenberg, R. Heimler, E. Morote, »Basic Employability Skills: A Triangular Design Approach,« *Education + Training*, vol. 54, no. 1, pp. 7-29, 2012.

[30] M. Hlavac, »Knowledge, skills and abilities (KSAs) as a metric to re-conceptualise aptitude: A multi-stakeholder perspective,« *Interpreter and Translator Trainer*, vol. 17, pp 29-53, 2023.

[31] J. Lamri and T. Lubart, »Reconciling Hard Skills and Soft Skills in a Common Framework: The Generic Skills Component Approach,« *J Intelligence,* 2023.

[32] U. D. Ehlers, »Towards a Future Skills Framework for Higher Education,« in *Creating the University of the Future*, Zukunft der Hochschulbildung – Future Higher Education, Springer, 2024.

[33] C. Ziguras, »The political economy of digital educational content and the transformation of learning and teaching in global higher education,« *Digital Global Condition,* pp 179-194, 2023.

[34] A. Haleem, M. Javaid, M.A Qadri, R. Suman, »Understanding the role of digital technologies in education: A review,« *Sustainable Operations and Computers*, 3, pp. 275 - 285, 2022.

[35] B. Pelster, J. Stempel, »Careers and learning: Real time, all the time,« Deloitte Insights, 2017. [Online]. Available: https://www2.deloitte.com/us/en/insights/focus/human-capital-trends/2017/learning-in-the-digital-age.html

[36] M. A. M. AlGerafi, Y. Zhou, M. Oubibi, and T. T. Wijaya, »Unlocking the potential: A comprehensive evaluation of augmented reality and virtual reality in education,« *Electronics (Switzerland)*, vol. 12, no. 18, art. no. 3953, 2023.

[37] Fortune Business Insights, »Virtual Reality in Education Market Size, Share & Industry Analysis, By Component (Hardware, Software, and Content), By End User (Academic Institutions and Corporate Training), and Regional Forecast 2024-2032«. Accessed: Mar. 31, 2025. [Online]. Available: https://www.fortunebusinessinsights.com/industry-reports/virtual-reality-in-education-market-101696

[38] E. Pacheco, J. Palma, D. Salinas, and I. Arana, »Gamification and self-directed learning,« in *Proc. Eur. Conf. Games-Based Learn.*, Sep. 2020, pp. 417–426.

[39] S.-Y. Yao and Y. Y. Ho, »Evaluating the usefulness of microlearning to adult students in higher education: An empirical study in Singapore,« *Adult Learning*, 2024.

[40] A. Gradassi, S. K. Slagter, A. da Silva Pinho, L. Molleman, and W. van den Bos, »Network distance and centrality shape social learning in the classroom,« *School Psychology*, vol. 38, no. 2, pp. 67–78, 2022.

[41] F. A. Orji and J. Vassileva, »Modelling and quantifying learner motivation for adaptive systems: Current insight and future perspectives,« in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Bioinformatics)*, vol. 12793 LNCS, pp. 79–92, 2021.

[42] R. Bohne, »Size of the global e-learning market in 2019 and 2026, by segment,« Statista, 2022. [Online]. Available: https://www.statista.com/statistics/1130331/e-learning-market-size-segment-worldwide/

[43] N. Ivanov et al., »Discovery: Transition of an inquiry-focused learning program to a virtual platform during the COVID-19 pandemic (evaluation),« ASEE Annu. Conf. Expo., Conf Proc., 2021.

[44] E.J. Altman, D. Kiron, J. Schwartz, R. Jones, »*Workforce Ecosystems: Reaching Strategic Goals with People, Partners, and Technologies,*« MIT Press, 2023.

[45] Deloitte, »Learning in the flow of work,« *Deloitte Insights*, podcast transcript, 2018. [Online]. Available: https://www2.deloitte.com/content/dam/Deloitte/us/Documents/human-capital/us-human-capital-learning-in-the-flow-of-work.pdfM.

[46] C.O. Okuh, E.O. Nwulu, E. Ogu, P.I. Eg, »Creating a Workforce Upskilling Model to Address Emerging Technologies in Energy and Oil and Gas Industries,« *Intl Journ Multi Disc Research and Growth Eval*, vol. 5, pp. 1327-1339, 2024.

[47] H.L. Davidz and J.N. Martin, »Defining a strategy for development of systems capability in the workforce,« *Syst. Engin.*, vol. 14, pp. 141-153, 2011.

[48] M. Tavakoli, A. Faraji, S. T. Mol, and G. Kismihok, »OER recommendations to support career development,« in *Proc. Frontiers in Educ. Conf. (FIE)*, Oct. 2020, art. no. 9274175.

[49] A. Godha, »Opportunity and challenges in offering tourism and skill-based MOOCs in India,« *Springer Int. Handb. Educ.*, Part F3475, pp. 1121–1144, 2024.

[50] N. Stephenson, »*Snow Crash,*« Bantam Books, 1992.

[51] S. M. Schöbel and J. M. Leimeister, »Metaverse platform ecosystems,« *Electron. Markets*, vol. 33, no. 1, p. 12, 2023.

[52] J. Wann and M. Mon-Williams, »What does virtual reality NEED?: human factors issues in the design of three-dimensional computer environments,« *Int. J. Hum.-Comput. Stud.*, vol. 44, no. 6, pp. 829–847, 1996.

[53] H. Duan et al., »Metaverse for social good: A university campus prototype,« in *Proc. 29th ACM Int. Conf. Multimedia*, 2021.

[54] J. Huggett, »Virtually real or really virtual: Towards a heritage metaverse,« *Stud. Digit. Herit.*, vol. 4, no. 1, pp. 1–15, 2020.

[55] J. Smart et al., »A cross-industry public foresight project,« in *Proc. Metaverse Roadmap Pathways 3DWeb*, pp. 1–28, 2007.

[56] Y. K. Dwivedi et al., »Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy,« *Int. J. Inf. Manage.*, vol. 66, p. 102542, 2022.

[57] E. Park, »Examining metaverse game platform adoption: Insights from innovation, behavior, and coolness,« *Technol. Soc.*, vol. 77, p. 102594, 2024.

[58] X. Chen, D. Zou, H. Xie, and F. L. Wang, »Metaverse in education: contributors, cooperations, and research themes,« *IEEE Trans. Learn. Technol.*, vol. 16, no. 6, pp. 1111–1129, 2023.

[59] B. Dalgarno and M. J. Lee, »What are the learning affordances of 3-D virtual environments?,« *Br. J. Educ. Technol.*, vol. 41, no. 1, pp. 10–32, 2010.

[60] A. Uysal and I. G. Yildirim, »Self-determination theory in digital games,« in *Gamer Psychology and Behavior*, pp. 123–135, 2016.

[61] S. Park and S. Kim, »Identifying world types to deliver gameful experiences for sustainable learning in the metaverse,« *Sustainability*, vol. 14, no. 3, p. 1361, 2022.

[62] N. Pellas and S. Mystakidis, »A systematic review of research about game-based learning in virtual worlds,« *J. Univers. Comput. Sci.*, vol. 26, no. 8, pp. 1017–1042, 2020.

[63] C. Girvan, »What is a virtual world? Definition and classification,« *Educ. Technol. Res. Dev.*, vol. 66, no. 5, pp. 1087–1100, 2018.

[64] R. T. Azuma, »A survey of augmented reality,« *Presence: Teleoperators & Virtual Environments*, vol. 6, no. 4, pp. 355–385, 1997.

[65] J. Carmigniani, B. Furht, M. Anisetti, P. Ceravolo, E. Damiani, and M. Ivkovic, »Augmented reality technologies, systems and applications,« *Multimedia Tools and Applications*, vol. 51, pp. 341–377, 2011.

[66] A. Cabrera-Duffaut, A. M. Pinto-Llorente, and A. Iglesias-Rodríguez, »Immersive learning platforms: analyzing virtual reality contribution to competence development in higher education-a systematic literature review,« *Frontiers in Education*, 2024.

[67] M. Conrad, D. Kablitz, and S. Schumann, »Learning effectiveness of immersive virtual reality in education and training: A systematic review of findings,« *Computers & Education: X Reality*, vol. 4, p. 100053, 2024.

[68] A. Dubiel et al., »Virtual reality for the training of soft skills for professional education: trends and opportunities,« *Interactive Learning Environments*, pp. 1–21, 2025.

[69] Y. Koumpouros, »Revealing the true potential and prospects of augmented reality in education,« *Smart Learning Environments*, vol. 11, no. 1, p. 2, 2024.

[70] F.-K. Chiang, X. Shang, and L. Qiao, »Augmented reality in vocational training: A systematic review of research and applications,« *Computers in Human Behavior*, vol. 129, p. 107125, 2022.

[71] A. M. Al-Ansi, M. Jaboob, A. Garad, and A. Al-Ansi, »Analyzing augmented reality (AR) and virtual reality (VR) recent development in education,« *Social Sciences & Humanities Open*, vol. 8, no. 1, p. 100532, 2023.

[72] B. R. Martins, J. A. Jorge, and E. R. Zorzal, »Towards augmented reality for corporate training,« *Interactive Learning Environments*, vol. 31, no. 4, pp. 2305–2323, 2023.

[73] Statista, »Statista Market Insights. Metaverse Gaming - Worldwide,« 2024. [Online]. Available: https://www.statista.com/outlook/amo/metaverse/metaverse-gaming/worldwide

[74] K. I. Vorobyeva, S. Belous, N. V. Savchenko, L. M. Smirnova, S. A. Nikitina, and S. P. Zhdanov, »Personalized learning through AI: Pedagogical approaches and critical insights,« *Contemp. Educ. Technol.*, vol. 17, no. 2, ep. 574, 2025.

[75] K. C. Li and B. T. M. Wong, »Artificial intelligence in personalised learning: A bibliometric analysis,« *Interact. Technol. Smart Educ.*, vol. 20, no. 3, pp. 422–445, 2023.

[76] Y. Kwak, J. W. Ahn, and Y. H. Seo, »Influence of AI ethics awareness, attitude, anxiety, and self-efficacy on nursing students' behavioral intentions,« *BMC Nurs.*, vol. 21, no. 267, 2022.

[77] S. Shalender, »Skill Development für Society 5.0: A focus on the new-age skilling process,« in E. Namaziandost and A. Rezai (Eds.), Special issue: Artificial intelligence in open and distributed learning: Does it facilitate or hinder teaching and learning?, *Int. Rev. Res. Open Distrib. Learn.*, vol. 25, no. 3, 2024.

[78] E. Namaziandost and A. Rezai, »Special issue: Artificial intelligence in open and distributed learning: Does it facilitate or hinder teaching and learning?,« *Int. Rev. Res. Open Distrib. Learn.*, vol. 25, no. 3, 2024.

[79] S. F. M. Baigi, M. Sarbaz, K. Ghaddaripouri, M. Ghaddaripouri, A. S. Mousavi, and K. Kimiafar, »Attitudes, knowledge, and skills towards artificial intelligence among healthcare students: A systematic review,« *Health Sci. Rep.*, 2023.

[80] M. Boström and M. Micheletti, »Introducing the Sustainability Challenge of Textiles and Clothing,« *Journal of Consumer Policy*, vol. 39, pp. 367–357, 2016.

[81] C. Costa et al., »Textile Industry in a Changing World,« *Journal of Engineering*, vol. 6, no. 2, pp. 86–97, 2020.

Imprint

Corresponding Authors
Dr. Anh Mattick
Team Lead Organizational Empowerment
anh.mattick@irb.fraunhofer.de

Katherine Lewis
Organizational Empowerment
katherine.lewis@irb.fraunhofer.de

Anna Wenzel
Technische Universität Dortmund
anna.wenzel@tu-dortmund.de

Editorial, Layout and Design:
Fraunhofer IRB, Marketing | Sales | PR

Image sources:
© Cover image created using Canva AI
Learning Toolbox webpage designs © Fraunhofer IRB
© Mockup created with Canva

Nobelstraße 12, 70569 Stuttgart
Telefon +49 711 970-2500
Telefax +49 711 970-2508
irb@irb.fraunhofer.de
www.irb.fraunhofer.de