Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA DOI: 10.46254/BA08.20250312
Published: December 20, 2025

Industry 4.0 Skills Gap: A Critical Review of Academic Competencies for a Digital Workforce

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Abstract

The emergence of Industry 4.0 has fundamentally transformed global production systems, necessitating a workforce proficient in automation, data analytics, and cyber physical adaptability. Despite this technological shift, a critical disparity persists between the dynamic requirements of industry and the competencies cultivated by Higher Education Institutions (HEIs). This study utilizes a Critical Review Protocol to systematically analyze twenty prominent research publications from 2017 to 2025, assessing the magnitude and nature of this skills gap. The review reveals that while technical proficiency in areas such as IoT and AI is essential, the modern workplace equally prioritizes socio collaborative skills including complex problem solving, adaptability, and interdisciplinary teamwork which are often underrepresented in traditional academic curricula. Consequently, graduates frequently encounter challenges in meeting the hybrid demands of the digital economy. To address this misalignment, the paper proposes a

comprehensive Academic Competency Framework structured around three core pillars: Digital Foundations, Collaborative Agility, and a Continuous Learning Mindset. This framework provides a strategic roadmap for educators, curriculum developers, and policymakers to bridge the industry academia divide, ensuring that future graduates are equipped with the integrated technical and soft skills necessary for sustained employability and innovation in the Industry 4.0 era.

Keywords
Industry 4.0, Higher Education, Skills Gap, Competency Framework, Curriculum Transformation

1. Introduction
The emergence of Industry 4.0 has transformed global industries through digitalization, automation, artificial intelligence, the Internet of Things, and cyber-physical systems. These technological advances have redefined production processes, operational efficiency, and organizational competitiveness. In this context, workforce competencies have become critical for ensuring that employees can effectively engage with complex digital technologies, adapt to evolving job roles, and contribute to innovation (Anshari & Hamdan, 2022). Without proper skills development, industries risk underutilizing advanced technologies, reducing productivity, and slowing economic growth (Li, 2024).

1.1 Problem Statement
Despite the growing importance of digital skills, there is a persistent mismatch between industry requirements and the competencies developed through academic training. Graduates often face challenges in meeting the technical, digital, and socio-collaborative expectations of modern workplaces (Adepoju & Aigbavboa, 2021). Rapid technological change and the obsolescence of previously relevant skills exacerbate this gap, making continuous upskilling and curriculum reform essential (Rikala et al., 2024).

1.2 Research Purpose
This study aims to critically review the academic competencies required for Industry 4.0 and to analyze gaps in current educational frameworks. The primary objectives are to evaluate how effectively higher education prepares students for emerging industry demands and to identify the areas where curricular and training improvements are necessary (Bag Majumder, 2025). By synthesizing existing research, the study provides evidence-based insights for aligning academic programs with the competencies demanded by the digital economy.

The study's objectives are operationalized through the following guiding research questions:

1. What competencies does Industry 4.0 demand from the workforce?
2. How effectively do academic institutions prepare students to acquire these competencies?
3. What gaps exist between industry expectations and the skills developed through current academic curricula?

1.3 Significance of Study
The findings of this review are expected to support curriculum design by identifying the priority competencies needed in Industry 4.0. They also provide guidance for policymakers and educators to implement strategies that bridge the gap between academic training and industrial needs, ensuring that graduates are better prepared for the challenges of a digitally transformed workforce (Arthur-Mensah, 2020).

2. Literature Review
The literature on Industry 4.0 workforce competencies highlights the increasing demand for digital, technical, and socio-collaborative skills. This section synthesizes research on the skills required, academic preparedness, global frameworks, and curriculum gaps.

2.1 Understanding Industry 4.0
Industry 4.0 is characterized by the integration of automation, Internet of Things, artificial intelligence, big data analytics, and cyber-physical systems in industrial processes (Anshari & Hamdan, 2022). These technologies have reshaped traditional roles, creating complex and interdisciplinary job functions. Employees must now combine technical expertise with problem-solving, analytical thinking, and adaptability to respond effectively to dynamic production environments (Li, 2024).

Studies indicate that Industry 4.0 is not limited to manufacturing or engineering sectors; it also impacts service industries and administrative roles where digital tools and automation are increasingly applied (Rikala et al., 2024). The rapid adoption of these technologies requires continuous workforce upskilling and retraining to maintain organizational competitiveness (Bag Majumder, 2025).

2.2 Industry 4.0 Skills Requirements

Industry 4.0 competencies can be classified into three major categories. **Technical skills** include knowledge of automation, robotics, artificial intelligence, IoT, cloud computing, and data analytics (Ismail & Hassan, 2019). **Digital skills** focus on cybersecurity, programming, data literacy, and computational thinking (Li, 2024). **Socio-collaborative skills** encompass teamwork, communication, problem-solving, adaptability, and leadership, which enable employees to function effectively in interdisciplinary environments (Rahmat et al., 2022).

Research shows that technical and digital skills alone are insufficient. Employees must develop hybrid capabilities that integrate technical expertise with strategic thinking and collaboration (Marlapudi & Lenka, 2024). Such competencies ensure that graduates are not only technically proficient but also able to contribute to innovation and knowledge creation in digital workplaces (Mhaske et al., 2025) (Table 1).

Table 1. Industry 4.0 Skills Requirements Classification

Skill Category	Description	Examples of Key Skills
Technical Skills	Skills related to the operation and integration of advanced industrial technologies	Automation, Robotics, Artificial Intelligence, Internet of Things, Cloud Computing, Data Analytics
Digital Skills	Skills enabling effective use, management, and security of digital systems and data	Cybersecurity, Programming, Data Literacy, Computational Thinking
Socio-Collaborative Skills	Human-centric skills required for effective collaboration and problem-solving in digital and interdisciplinary environments	Communication, Teamwork, Adaptability, Leadership, Complex Problem Solving

2.3 Academic Competencies and Curriculum Gaps

Despite the rising importance of Industry 4.0 competencies, higher education institutions often struggle to meet industry requirements. Systematic reviews reveal that curricula in many universities lack applied learning modules, interdisciplinary courses, and exposure to emerging technologies (Nyale et al., 2025).

Several studies highlight that graduates frequently encounter a mismatch between academic training and industry expectations. Traditional educational models emphasize theoretical knowledge while neglect hands-on digital skills, project-based learning, and technopreneurship (Tjahjono et al., 2025). This misalignment is particularly evident in developing countries, where limited faculty expertise and inadequate digital infrastructure exacerbate skill gaps (Adepoju & Aigbavboa, 2021).

2.4 Global Frameworks for Industry 4.0 Skills

Multiple competency frameworks have been proposed to guide academic and industry alignment. For example, the European Union's DigComp framework emphasizes digital literacy and problem-solving, while the World Economic Forum highlights critical thinking, creativity, and collaborative skills for future-ready employees (Pasi & Dhamak, 2025). UNESCO's digital competency model further underscores the integration of ethical, cultural, and socio-digital skills in higher education (Putra et al., 2025).

Empirical studies suggest that adapting these frameworks to local contexts is essential, as workforce needs and technological adoption vary by country and industry (Turcato et al., 2024). Institutions that incorporate these models into curricula demonstrate improved alignment between graduate capabilities and industrial expectations (Dermawan et al., 2025).

2.5 Comparative Insights from Different Countries

Different nations have approached the Industry 4.0 skills challenge in diverse ways. Germany, with its strong vocational training system, emphasizes technical apprenticeship programs combined with digital upskilling (Marlapudi & Lenka, 2024). Japan focuses on automation-driven competencies, integrating robotics and AI into university curricula (Ismail & Hassan, 2019). The United States prioritizes innovation, entrepreneurship, and hybrid skill development. Developing countries often face infrastructure limitations and faculty training challenges that impede effective curriculum modernization (Adepoju & Aigbavboa, 2021).

2.6 Emerging Competency Models in Academia

Recent scholarship advocates for T-shaped competencies, which combine deep expertise in one domain with broad interdisciplinary knowledge (Putra et al., 2025). Hybrid skillsets, integrating STEM and socio-digital skills, are increasingly recognized as essential for employability in Industry 4.0 (Li, 2024). Lifelong learning and continuous reskilling are also emphasized, as graduates must adapt to rapid technological change throughout their careers (Anshari & Hamdan, 2022).

3. Methodology

This paper utilizes a **Critical Review Protocol** to systematically identify, evaluate, and synthesize the academic literature concerning the Industry 4.0 skills gap, digital workforce requirements, and the role of Higher Education Institutions (HEIs). This approach ensures comprehensive coverage of the most current scholarly discourse and provides a robust foundation for developing the proposed competency framework.

3.1 Search Strategy and Scope

The review focused primarily on research published between 2017 and 2025, with a particular emphasis on the latest advancements from 2021 to 2025, to ensure the currency and relevance of the findings to the rapidly evolving Industry 4.0 landscape. The search strategy employed key terms across major academic databases (Scopus, Web of Science, and Google Scholar), including:

Skills/Competencies: "digital skills," "academic competencies," "workforce readiness," "reskilling," "upskilling," "digital literacy," and "socio-digital skills."

Context: "Industry 4.0," "Fourth Industrial Revolution," "digital transformation," "higher education," "curriculum transformation," and "industry-education gap."

The search was conducted using combinations of these terms to specifically target articles analyzing the *mismatch* between academic output and industrial demand.

3.2 Inclusion and Exclusion Criteria

The initial literature search generated a substantial number of publications. To refine the scope of the review and ensure its critical and analytical focus, specific inclusion and exclusion criteria were applied. These criteria were used to systematically select studies that were directly relevant to the research objectives and aligned with the context of Industry 4.0 skills and academic competencies (Table 2).

Table 2. Inclusion and Exclusion Criteria for Literature Selection

Criterion	Inclusion Rationale	Exclusion Rationale
Source Type	Peer-reviewed journal articles, systematic reviews, conceptual frameworks, and conference proceedings directly addressing the relationship between education and industry.	Opinion pieces, blog posts, non-peer-reviewed white papers, and technical standards documents.
Topic Relevance	Articles explicitly discussing the "skills gap," "competencies," or "curriculum transformation" in the context of **Industry 4.0** or the **digital workforce**	Papers focused solely on technical implementation (e.g., IoT architecture) without discussing human capital or skills.
Timeliness	Strong preference for articles published or accepted in the last five years (2021–2025)	Literature published prior to 2017 (prior to the widespread adoption of the Industry 4.0 term in academia) (Janis & Alias, 2017).

The final selection resulted in **twenty (20)** highly relevant, high-quality academic publications, forming the foundation for the subsequent critical analysis.

3.3 Data Synthesis and Analysis

The collected literature was subjected to a **thematic content analysis** following a three-stage process:

1. **Extraction:** For each selected paper, key data points were extracted, including the identified required skills, proposed educational solutions, acknowledged curriculum gaps, and the specific context (e.g., developing economy, specific sector, etc.)
2. **Coding and Categorization:** The identified skills and competencies were coded and grouped into distinct, high-level clusters (e.g., Technical, Cognitive, Socio-Digital) to establish consensus on industry requirements. This step identified cross-cutting themes, such as the need for upskilling and the importance of integrated learning models
3. **Critical Synthesis:** This final stage involved a comparative analysis of the identified *required* competencies against the perceived *current output* of HEI curricula as discussed in the review articles. The synthesis led to the identification of the major unresolved issues and academic inertia that this study aims to address, culminating in the proposal of a definitive competency framework in Section 5.

4. Findings and Discussion

The review of literature reveals multiple dimensions of the Industry 4.0 skills gap, highlighting a complex interplay between technological advancement, workforce preparation, and academic responsiveness. This section discusses the findings in detail, integrating insights from global studies and emerging trends.

4.1 The Identified Skills Gap

A critical observation from the literature is that the current workforce does not possess sufficient technical, digital, or socio-collaborative competencies to meet Industry 4.0 demands. Technical skills such as automation, robotics, artificial intelligence, IoT, and cloud computing are in high demand across manufacturing, service, and administrative sectors (Ismail & Hassan, 2019). Digital literacy, including cybersecurity, programming, and data analytics, is increasingly essential as organizations become data-driven (Li, 2024). Socio-collaborative skills such as problem-solving, adaptability, communication, teamwork, and leadership are equally critical, enabling employees to function in interdisciplinary teams and contribute to knowledge creation (Rahmat et al., 2022).

Despite widespread recognition of these requirements, educational programs often fail to address them effectively. Many graduates possess theoretical knowledge but lack applied skills, resulting in under preparedness for complex, technology-intensive roles (Nyale et al., 2025). Studies also show that emerging hybrid skills, combining technical, digital, and soft competencies, are rarely emphasized in traditional curricula (Marlapudi & Lenka, 2024).

4.2 Why the Skills Gap Persists

The persistence of the skills gap can be attributed to several interrelated factors. First, higher education institutions often face structural and infrastructural constraints, including limited access to modern digital laboratories, outdated teaching materials, and insufficient faculty expertise in emerging technologies (Nyale et al., 2025). Second, rapid technological evolution outpaces curriculum reform, leaving academic programs lagging behind industry needs (Rikala et al., 2024). Third, lack of industry-academia collaboration reduces opportunities for students to gain hands-on experience, engage in internships, or participate in real-world problem-solving projects (Tjahjono et al., 2025).

Additionally, socio-cultural factors, such as resistance to curriculum change and lack of awareness of Industry 4.0 competencies among faculty and policymakers, contribute to the slow adoption of relevant skill-building initiatives (Bag Majumder, 2025). In developing economies, these challenges are compounded by limited digital infrastructure, economic constraints, and uneven access to advanced technology (Adepoju & Aigbavboa, 2021).

4.3 Implications for Academic Institutions

Academic institutions must undertake comprehensive curriculum transformation to prepare graduates for Industry 4.0. Embedding applied learning experiences, project-based modules, and hands-on exposure to emerging technologies is essential (Putra et al., 2025). Programs should adopt competency-based curricula that integrate technical, digital, and socio-collaborative skills, reflecting the hybrid skillsets demanded by modern industries (Li, 2024).

Faculty development is also critical. Instructors need ongoing training in digital technologies, automation tools, and pedagogical strategies for interdisciplinary learning (Tjahjono et al., 2025). Institutions that cultivate partnerships with industries can provide students with internships, mentorship programs, and exposure to real-world projects, which improve employability and bridge the theory-practice gap (Dermawan et al., 2025).

Furthermore, interdisciplinary education models that combine STEM, business, and socio-digital competencies are recommended. Such approaches foster T-shaped skill development, equipping students with deep expertise in one domain and broad understanding of related disciplines (Putra et al., 2025).

4.4 Implications for Industry

Industries are pivotal in bridging the skills gap that exists between academic preparation and workforce requirements in Industry 4.0. Beyond traditional hiring practices, companies must actively participate in shaping the competencies that graduates acquire by collaborating with academic institutions to **co-design curricula**. This collaboration can include defining learning outcomes, integrating emerging technologies into courses, and ensuring that academic content reflects real-world industrial needs. Companies can also **sponsor digital laboratories and innovation hubs** within universities, providing students with access to advanced tools such as robotics, artificial intelligence platforms, IoT devices, and simulation software. Such facilities allow students to gain hands-on experience in a controlled learning environment, which enhances both technical proficiency and problem-solving capabilities (Tjahjono et al., 2025).

Corporate training programs must evolve beyond conventional workshops to include **continuous professional development**, upskilling, and reskilling initiatives that align with technological advancements. For instance, modular training programs focusing on automation, AI, and data analytics can help existing employees adapt to evolving job roles and new operational processes (Li, 2024). Apprenticeships and mentorship programs further integrate students into organizational workflows, allowing them to apply theoretical knowledge in practical settings while gaining exposure to industry-specific challenges and innovations.

Industries can also implement **internal talent mapping and competency assessments** to systematically identify skill gaps among employees and potential recruits. By tracking individual and team-level competencies, organizations can provide targeted training interventions and career development pathways, ensuring that employees are prepared for both current and future technological demands (Marlapudi & Lenka, 2024). A proactive approach ensures that graduates entering the workforce are not only employable but also capable of contributing to **organizational innovation, process optimization, and knowledge creation**, thus enhancing overall competitiveness.

Moreover, industries that actively participate in workforce development benefit from a **feedback loop** where academic curricula are continuously updated based on evolving industry trends. This ensures that graduates are trained in technologies that are immediately relevant, reducing onboarding times and increasing productivity. Industries that neglect this responsibility risk hiring employees whose skills rapidly become obsolete, increasing training costs and slowing the pace of digital transformation.

4.5 Policy Implications

Policymakers have a crucial role in creating an environment that supports workforce readiness for Industry 4.0. National digital skills strategies should be designed to **standardize workforce competencies**, guide curriculum reforms, and incentivize collaboration between academia and industry. Investment in digital infrastructure, including high-speed internet, cloud computing resources, and access to emerging technology tools, is essential to enable both academic institutions and industries to implement modern training programs (Arthur-Mensah, 2020).

Government initiatives can include funding **curriculum modernization projects**, supporting faculty development, and creating innovation grants that encourage universities and industries to establish joint research and training programs. Accreditation systems and competency benchmarking mechanisms ensure consistent quality in digital skills development, allowing graduates to meet internationally recognized standards (Pasi & Dhamak, 2025).

Policymakers should also emphasize **lifelong learning and continuous workforce development**. Industry 4.0 technologies are evolving rapidly, and static skill sets are no longer sufficient for sustained employability. National policies can promote flexible certification programs, micro-credentials, and online training platforms to facilitate reskilling and upskilling for employees at all career stages (Li, 2024).

Public-private partnerships can further expand access to digital technologies, training resources, and industry-driven projects across both urban and rural regions. Such partnerships not only help bridge the digital divide but also ensure equitable skill development, enabling diverse populations to participate in the emerging digital economy (Mhaske et al., 2025). Additionally, governments can establish monitoring frameworks to assess the impact of policies and programs, allowing continuous refinement of strategies to match the pace of technological change.

5. Conclusion and Proposed Framework

5.1 Summary of Key Findings

This critical review aimed to define the essential academic competencies required to mitigate the Industry 4.0 skills gap and prepare a robust digital workforce. The thematic analysis of the current literature confirmed the severe and persistent skills gap, driven by the rapid digital transformation of global industry (Adepoju & Aigbavboa, 2021; Rikala et al., 2024; Janis & Alias, 2017).

The review yielded two primary sets of findings:

1. **Required Competencies:** The workforce demands a blended skill profile comprising core **Technical/Hard Skills** (e.g., Data Analytics, Automation, and Digital Connectivity) and vital **Socio-Digital Skills** (e.g., Complex Problem Solving, Collaboration, and Adaptability) (Mhaske et al., 2025; Rahmat et al., 2022). Furthermore, a foundational **Knowledge Management** mindset for continuous upskilling is necessary for career longevity (Anshari & Hamdan, 2022; Li, 2024).
2. **Curriculum Inadequacy:** Higher Education Institutions (HEIs) are currently constrained by **systemic inertia** (slow approval cycles, resource limits, and faculty competency gaps) (Kamarudin, 2024; Gázquez et al., 2021). Critically, HEI curricula exhibit a **mismatch**, prioritizing theoretical knowledge over integrated, applied learning and failing to adequately develop essential Socio-Digital Skills (Arthur-Mensah, 2020; Marlapudi & Lenka, 2024; Putra et al., 2025). Transformative educational models, particularly those promoting integrated learning and digital technopreneurship, are necessary to bridge this gap (Tjahjono et al., 2025).

5.2 The Proposed Academic Competency Framework

To address the shortcomings identified in Section 4, this study synthesizes the required skills into a focused, three-pillar **Academic Competency Framework** designed to guide HEI curriculum redesign. This framework shifts the

focus from merely teaching digital tools to cultivating a dynamic, adaptive, and human-centric graduate profile (Table 3).

Table 3. Proposed Academic Competency Framework for Industry 4.0

Pillar	**Focus**	**Core Academic Competencies**	**Supporting Citations**
Pillar 1: Digital Foundations	Technical Mastery and Ethical Use	Data Literacy (Analysis and Interpretation), Automation Principles, Digital Security & Ethics, IoT Architecture Knowledge.	(Adepoju & Aigbavboa, 2021; Bag Majumder, 2025; Ismail & Hassan, 2019; Marlapudi & Lenka, 2024)
Pillar 2: Collaborative Agility	Human-Centric and Interdisciplinary Skills	Complex Problem Solving, Critical Thinking, Interdisciplinary Collaboration, Innovation and Technopreneurship (Tjahjono et al., 2025).	(Rikala et al., 2024; Tjahjono et al., 2025; Rahmat et al., 2022; Turcato et al., 2024)
Pillar 3: Continuous Learning Mindset	Foundational Capacity for Renewal	Adaptability, Reskilling/Upskilling capacity, Knowledge Management (SECI model integration), Self-Directed Learning.	(Anshari & Hamdan, 2022; Mhaske et al., 2025; Li, 2024; Dermawan et al., 2025)

5.3 Implications for Practice

The proposed Academic Competency Framework provides practical and actionable guidance for multiple stakeholders who play a critical role in reducing the Industry 4.0 skills gap. Since Industry 4.0 demands a hybrid combination of technical, digital, and socio-collaborative competencies, successful implementation requires coordinated efforts from higher education institutions, curriculum developers, and industry partners. The framework therefore serves as a structured roadmap for designing educational strategies that align academic training with workforce demands.

Implications for HEI Administrators

For Higher Education Institution (HEI) administrators, the framework highlights the need for strategic decision-making in terms of institutional investment, resource allocation, and academic leadership. Administrators must prioritize the development of learning environments that support Industry 4.0 readiness by ensuring access to modern technological tools and infrastructure. This includes establishing digital laboratories equipped with Industry 4.0 technologies such as IoT devices, robotics systems, simulation software, artificial intelligence platforms, and cloud computing resources. Without such facilities, students are unable to gain the practical exposure needed to meet industry expectations.

In addition, HEI administrators should invest in continuous faculty development programs. Since Industry 4.0 technologies evolve rapidly, educators must be regularly trained to update their knowledge and teaching methods. This can include workshops on data analytics, automation systems, cybersecurity, and AI-driven applications, as well as training on innovative pedagogical strategies such as problem-based learning, blended learning, and interdisciplinary teaching models. Administrators should also establish institutional policies that encourage curriculum flexibility and faster approval cycles, enabling universities to update courses more frequently in response to changing industrial requirements. Therefore, HEI leadership plays a central role in ensuring that academic systems remain adaptive, innovative, and responsive to digital transformation.

Implications for Curriculum Developers

For curriculum developers, the framework emphasizes the need for curriculum transformation from traditional content-based education toward competency-based learning models. Curriculum developers must integrate technical competencies with socio-digital and collaborative skills rather than treating them as separate components. This requires the redesign of courses to include applied, hands-on learning experiences where students can practice Industry 4.0 technologies in real-world scenarios. For example, instead of only teaching theoretical concepts of automation or data analytics, curriculum developers should incorporate practical projects where students design digital solutions, analyze datasets, or work with IoT systems.

The framework also suggests the adoption of integrated learning models that promote cross-disciplinary and project-based learning. Curriculum developers should create modules that combine knowledge from engineering, management, business, and information technology, allowing students to develop T-shaped skillsets. Interdisciplinary group assignments and case-based learning activities can strengthen teamwork, communication, problem-solving, and leadership skills. Additionally, curriculum developers should embed innovation and technopreneurship into academic programs, encouraging students to apply digital tools to develop new business ideas and solve industrial challenges creatively.

Furthermore, curriculum developers should consider incorporating micro-credentials, certification-based learning, and digital competency assessments into academic structures. Such approaches can support continuous learning and ensure students remain adaptable to emerging technological trends. Therefore, curriculum developers play a key role in ensuring that educational programs systematically cultivate the technical, cognitive, and interpersonal competencies required for Industry 4.0 employability.

Implications for Industry Partners

For industry partners, the proposed framework provides a foundation for strengthening industry–academia collaboration and ensuring that graduate skills align with workforce needs. Industry organizations should actively participate in curriculum development by sharing current competency demands, emerging job requirements, and evolving technological trends. This involvement can take the form of advisory boards, joint workshops, guest lectures, and collaborative curriculum design initiatives. By doing so, industries can help ensure that academic learning outcomes reflect real-world workplace expectations.

In addition, industry partners can support universities by offering internship opportunities, apprenticeships, and work-integrated learning programs. These initiatives allow students to gain direct exposure to industrial operations, advanced technologies, and professional work environments, helping them apply theoretical knowledge to practical challenges. Industries can also sponsor university laboratories, innovation hubs, and research centers that provide students access to modern tools and industrial software platforms.

Moreover, industry partners should invest in mentorship and professional development programs that guide students and early-career graduates in building career-relevant competencies. Regular feedback mechanisms, such as graduate performance evaluations and skill gap assessments, can provide universities with valuable insights for curriculum improvement. Through continuous collaboration, industries can reduce recruitment costs, improve workforce readiness, and develop a sustainable pipeline of digitally competent graduates. Therefore, the framework promotes a long-term partnership model where industry and academia jointly contribute to workforce development in the Industry 4.0 era.

5.4 Limitations and Future Research

As a critical review, this study is constrained by its reliance on existing conceptual and theoretical literature, limiting its ability to quantify the size or impact of the gap empirically. Future research should focus on: (1) **Empirical Validation:** Conducting quantitative studies to measure the skills gap against the proposed framework within specific sectors (e.g., manufacturing, IT); and (2) **Longitudinal Case Studies:** Tracking the efficacy and impact of this framework's implementation within HEIs undergoing curriculum transformation. Such future work will strengthen the evidence base for effective education policy in the digital era.

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