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The Strategic Role of Academia in Bridging Skill Gaps in the Era of Industry 4.0 and 5.0

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Abstract: *The rapid evolution of industrial paradigms from Industry 4.0 to Industry 5.0 is fundamentally transforming the nature of work, skill requirements, and human–machine collaboration. While Industry 4.0 emphasizes automation, artificial intelligence, and digital integration, Industry 5.0 shifts the focus toward machine-centricity, sustainability, and resilience. This transition has created significant skill gaps across sectors, necessitating continuous upskilling and reskilling of the workforce. This paper examines the strategic role of academia in addressing these emerging challenges by aligning educational frameworks with evolving industry demands.*

The study illustrates how academia can be leading enablers by innovating curriculum design, encouraging interdisciplinary education, and developing digital, cognitive and socio-emotional skills. It reinforces the importance of industry–university collaboration, experiential learning methodologies, and integrating futuristic tools such as artificial intelligence (AI), internet of things (IoT), and data analytics in pedagogy. Further, it reviews the policy support and institutional arrangements-incentives for creation of lifelong learning environments and sustaining workforce flexibility in current era.

This paper provides a framework that will enable academia to effectively bridge the skills gap and cultivate a workforce ready for the future. The function of such a proactive, collaborative and future oriented academic system is thus taken for granted as a necessary condition for lifelong employability and sustainable growth in the age of Industry 4.0 & 5.0 by providing a strong conceptual foundation..

Keywords: Skill Gaps, Industry 4.0, Artificial Intelligence(AI), Proactive Learning

I. INTRODUCTION

The Fourth Industrial Revolution (Industry 4.0) introduced transformative technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), and big data analytics. However, the rapid transition toward Industry 5.0 emphasizes human-centric innovation, where collaboration between humans and intelligent systems is paramount.

A critical challenge emerging from this transition is the significant gap between academic education and industry requirements. Traditional academic models often lag behind technological advancements, resulting in students who lack industry-relevant skills. This study is trying the highlight the contemporary issues that are a rising concern due to this rapid transition for Industry 4.0 to Industry 5.0. The workforce that are already in industry 4.0, they need to be re-skill or up-skill by identifying the skill gaps. Focus of this study is on the tomorrow's workforce , which are currently doing their academics in various academic institutes, and soon expected to join the industry

1.1 Research Problem

Academic ecosystems are not yet fully aligned with skills required by Industry 5.0. Skills required by Industry 5.0 require the focus on two extremes, whereas in the current scenario, academic systems are more aligned to intermediaries knowledge and skills layer. Approx 75%-85% of the total volume of tasks are being shifted to machines

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in industry 5.0, this amount may vary slightly from industry domain to industry domain. Below figure shows the human and machine participation percentage in the industry 5.0 ecosystem.

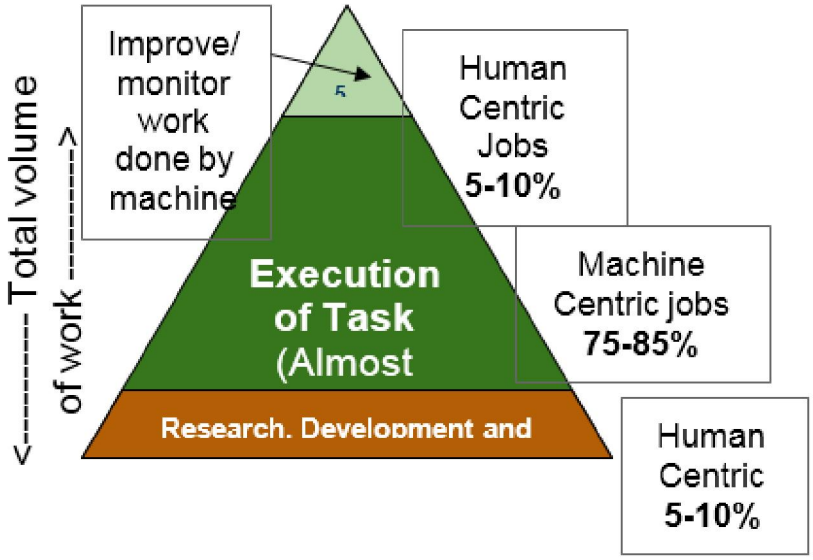


Figure 1: Workforce participation % of Human and machine Industry-5.0

Machine Centric Jobs:

The above image shows that, huge portion of tasks which is approx 75%-85% of the total task being done by industry are becoming Machine Centric in industry 4.0 and 5.0. Machine centric tasks are those tasks which are mainly carried out by machines or machines are at the core, humans have their bare minimum roles mainly in monitoring, controlling or supervising them. Examples of such machines or systems may be - automated machines, robots, humanoids, AI based tools and technologies.

Human Centric Jobs :

Human centric tasks are where humans are at the core and machines are being used as tools for assisting them. Examples of such tasks are - Research and Development activities to design, invent, improve the machines. It requires very deep knowledge and understanding of the domain, tools and technologies. Along with that a critical thinking, innovation, out of the box thinking and scientific approach are the essential attributes of such

The Problem Statement

During the study, researchers observed that the huge amount of work volume is being shifted from human centric to machine centric in industry 5.0. All the middle layer jobs, which currently require a huge amount of workforce, will be carried out by the machines. Human centric roles are still there, but only at the bottom layer which are mostly research and development related or at the top layers which are for further improvement of the work done by machine or to surpass the work done by machine. Both of these extreme layers require the workforces, which would be equipped with a very high level of knowledge, deep thinking and innovative approaches as core attributes.

Current education systems are more aligned with the workforce requirements of the middle layer, which was a huge amount of workforce requirement before industry 5.0. Academia needs to observe, understand, analyse these upcoming issues, and address them in order to match the requirements of Industry 4.0 and 5.0 by re-aligning their syllabus and course structures. Failing to do so will result in huge skill gaps followed by drastically increased unemployment in the

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near future. 2027 - 28 may see extreme unemployment issues, layoffs, recession due to this shift to Industry 5.0. AI is the major accelerator for this quick shifts.

1.2 Significance of Study

This study is significant because it highlights the growing mismatch between current academic systems and the workforce requirements of Industry 5.0, where nearly 75%–85% of execution-level tasks are shifting toward automation, AI, and machine-centric systems. The study emphasizes the urgent need for educational institutions to redesign curricula and skill development approaches to prepare students for future human-centric roles focused on innovation, research, critical thinking, and system enhancement. It also draws attention to the potential risks of increasing skill gaps, unemployment, and economic instability if academia fails to adapt to the rapidly evolving industrial landscape.

1.3 Objectives

The objective of this study is to analyse the changing workforce requirements in the era of Industry 4.0 and Industry 5.0, where a large volume of execution-level tasks are becoming machine-centric through AI, automation, robotics, and intelligent systems. The study aims to identify the gap between current academic structures and future industry skill demands, while emphasizing the need for education systems to focus on innovation, critical thinking, research orientation, and advanced technological competencies. It also seeks to provide insights and recommendations for academia to redesign curricula and skill-development approaches to prepare future-ready human resources and reduce upcoming unemployment and skill-gap challenges.

II. LITERATURE REVIEW

Existing research highlights the growing importance of digital transformation in education and workforce development. Workforces who are already in industry, and being affected due to rapid transition from Industry 4.0 to Industry 5.0 and need to be upskilled and reskill by identifying the skill gaps. This study is performing the study on the upcoming workforce, who are currently in educational institutions and will be soon joining the industry.

Studies emphasize that Industry 4.0 requires technical competencies such as programming, automation, and data analytics. Recent literature on Industry 5.0 focuses on human-AI collaboration, creativity, and problem-solving skills. Literature shows that current academic curricula are often outdated and lack practical exposure of AI at a level in which it's expected by industry 5.0

2.1 Research Gaps

During the study of available literature, we find that many researchers have highlighted the problems of the gap between academics and industry. Further, literature shows that this gap was always in existence and it cannot be practically reduced to zero, as institutes have their own limitations, their rigid syllabus structure, time limits and diversified students backgrounds. There are very limited studies, who have highlighted the role of academics in creating the workform for industry 5.0. So, the researcher observed that there is a need to conduct further study on this area to identify the strategic role of academia in preparing the workforce for industry 5.0.

2.2. Contribution of This Study

2.2.1 Proposing a hybrid skill model (core + AI integration)
2.2.2 Emphasizing continuous learning ecosystems
2.2.3 Proposing a Human-AI Collaboration Model

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III. METHODOLOGY

The methodology of this study is based on qualitative and analytical research approaches focusing on the evolving workforce structure in Industry 4.0 and Industry 5.0. The study involves observation and analysis of current industrial trends, automation practices, AI integration, and workforce participation patterns to understand the shift from human-centric to machine-centric tasks. Secondary data from research papers, industry reports, technological trends, and academic frameworks were reviewed to identify the gap between existing educational systems and future industry skill requirements. The study further analyses the impact of this transformation on employment patterns, skill demands, and academic preparedness to propose the need for curriculum and educational reforms aligned with Industry 5.0 requirements.

IV. RESULTS / FINDINGS

During the study, researcher has found many key point that need to be highlighted here, to deeply understand the problem and their possible solutions

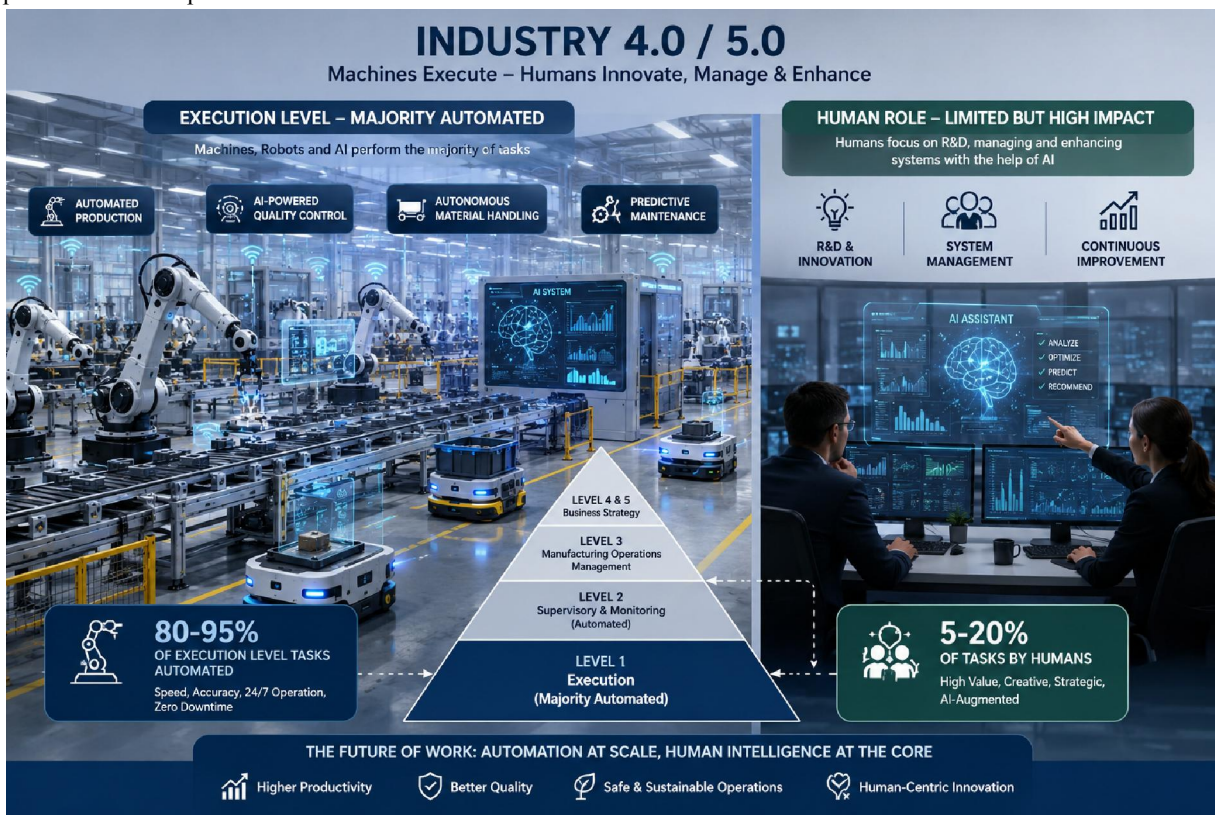


Figure 2 : Role based participation of Human and machine Industry-5.0

4.1 Limited integration of AI tools in mainstream education :

The industrial landscape is changing very fast, today we are talking about industry 5.0 which emphasizes human and machine collaboration, rather that using machines just as tools in the case of industry 4.0 ecosystem. Limited integration of AI tools in mainstream education remains a significant barrier to preparing students for the evolving demands of Industry 4.0 and 5.0. Despite rapid advancements in artificial intelligence, many educational institutions are not able to align themselves completely with the rapid changing AI landscape. One of the major reasons behind it is fast changing dynamics of AI, every week or month some AI products are being released by company. It is not possible to

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upgrade the academic syllabus so rapidly. Although, this gap results in graduates lacking exposure to real-world AI tools such as machine learning platforms, data analytics systems, and intelligent automation frameworks. Other contributing factors include inadequate infrastructure, lack of trained faculty, high implementation costs, and resistance to change within academic systems. Furthermore, curricula often fail to incorporate hands-on experience with AI-driven technologies, limiting students' ability to develop critical skills like problem-solving, adaptability, and human-AI collaboration. To address this issue, institutions must prioritize curriculum modernization, invest in faculty training, and foster industry partnerships to enable experiential learning and ensure students are equipped for the future workforce.

4.2 Lack of interdisciplinary and application-based learning :

The lack of interdisciplinary and application-based learning remains a critical limitation in contemporary education systems, particularly in the context of rapidly evolving industrial landscapes. Traditional academic structures often operate in silos, where disciplines such as computer science, engineering, management, and social sciences are taught independently, limiting students' ability to integrate knowledge across domains. However, Industry 4.0 and 5.0 demand professionals who can combine technical expertise with problem-solving, creativity, and contextual understanding. Moreover, the emphasis on theoretical instruction over practical application restricts students' exposure to real-world challenges, reducing their readiness for industry roles. Without hands-on experience in using modern tools, including AI-driven technologies, learners struggle to translate conceptual knowledge into actionable solutions. This gap highlights the urgent need for academia to adopt interdisciplinary curricula and experiential learning models, such as project-based learning, industry collaborations, and simulation environments, to foster holistic skill development and enhance employability in a dynamic, technology-driven world.

4.3 Insufficient focus on human-AI synergy

The insufficient focus on human–AI synergy represents a critical gap in current educational and organizational frameworks, particularly in the transition toward Industry 5.0. While significant emphasis has been placed on developing artificial intelligence capabilities and automation, comparatively less attention has been given to how humans can effectively collaborate with these intelligent systems. This imbalance often leads to either over-reliance on AI or underutilization of its potential, limiting overall productivity and innovation. Human–AI synergy requires the integration of human cognitive strengths—such as creativity, critical thinking, and ethical judgment—with AI's capabilities in data processing, pattern recognition, and predictive analytics. However, most academic curricula and corporate training programs continue to treat AI as a standalone technical skill rather than a collaborative tool. Bridging this gap demands a paradigm shift toward designing learning environments and workflows that promote co-working between humans and AI, enabling individuals to augment, interpret, and refine AI-driven outcomes effectively.

There is a need for an *AI first approach* through which AI should be used as a tool to save time and apply human creativity on the top of them to maintain human superiority.

4.4 Weak industry-academia collaboration

Weak industry–academia collaboration remains a critical barrier in addressing the evolving skill demands of Industry 4.0 and 5.0. Academic institutions often operate in isolation from industry, resulting in curricula that are misaligned with real-world requirements. This disconnect leads to graduates who possess theoretical knowledge but lack practical exposure, industry-relevant skills, and familiarity with emerging technologies such as AI tools and intelligent systems. On the other hand, industries face challenges in finding job-ready talent, increasing their dependency on costly training and onboarding programs. The absence of structured partnerships, limited internship opportunities, and insufficient involvement of industry experts in curriculum design further widen this gap. In the context of Industry 5.0, where human-AI collaboration is essential, the need for strong synergy between academia and industry becomes even more

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crucial. Strengthening this collaboration through joint programs, live projects, and continuous feedback mechanisms is essential for developing a future-ready workforce.

Strong industry partnerships are required to minimize the issue. A Lifelong learning must be institutionalized with a strong foundational concepts

4.5 Skills required in Industry 4.0 vs 5.0

Below table presents a summarised view of key skills transition, that are required in Industry 4.0 to 5.0

Table 1: Skill Evolution from Industry 4.0 to 5.0

Skill Category	Industry 4.0 Requirement	Industry 5.0 Requirement
Technical Skills	Automation, Coding	AI Integration, System Thinking
Cognitive Skills	Analytical Thinking	Critical Thinking, Creativity
Human Skills	Communication	Emotional Intelligence, Collaboration
Learning Approach	Static Learning	Lifelong Learning

4.6 Academia vs Industry Gap

Below table presents the gaps between academia and Industry.

Table 2: Gap Between Academia and Industry

Parameter	Academia	Industry 5.0
Curriculum	Theoretical	Practical + Adaptive
Tools Exposure	Limited	Advanced AI Tools
Learning Approach	Exam-Oriented	Problem-Solving Oriented
Skill Focus	General Knowledge	Specialized + AI-Augmented Skills

4.6 Human-AI Collaboration Model

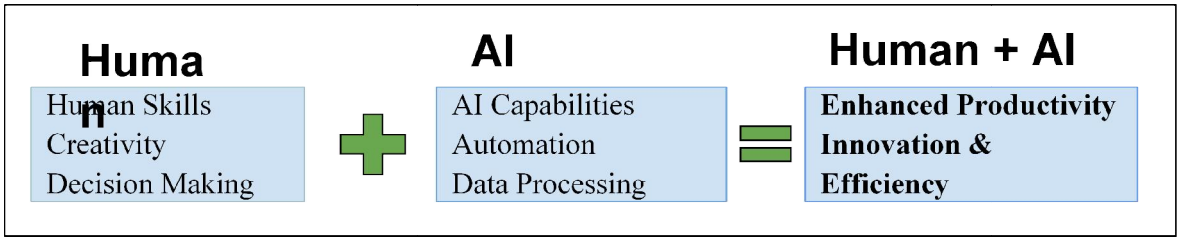


Figure 3: Human-AI Synergy in Industry 5.0

4.7 Key Findings

There are Significant mismatch between skill taught in academia vs needed by industry

Increasing demand for AI-integrated domain expertise

Workforce requires continuous upskilling and reskilling

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Academia must shift from knowledge delivery to capability building

V. DISCUSSION

The findings clearly indicate that Industry 5.0 demands a paradigm shift in education systems.

Interpretation

Traditional teaching methods are insufficient

Students must develop deep domain knowledge + AI adaptability

Human intelligence must complement AI capabilities

Limitations

Based on secondary data

Lack of empirical validation

Rapidly evolving technology landscape

VI. CONCLUSION

This study highlights the critical role of academia in addressing skill gaps in the transition from Industry 4.0 to Industry 5.0. The research confirms that the future workforce must possess a combination of *strong foundational knowledge, domain specialization, and AI integration capabilities*. Academia must:

Focus on conceptual depth

Promote interdisciplinary learning

Integrate AI tools into education

Encourage continuous upskilling and reskilling

Ultimately, a collaborative, adaptive, and innovation-driven academic ecosystem is essential to prepare a workforce capable of thriving in the human-centric and AI-driven Industry 5.0 era. One important observation that researchers came across is about the **"China's Dark Factory",** where everything is being done by an automotive machine without even a single human. As only machines, robots and humanoids are working there, so there is no light required in the factory, that's why it's called a **dark factory**. But trigger an another debate on workforce requirement in future industrial evolution or Industry-6.0 or so

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