International Review of Management and Marketing

ISSN: 2146-4405

available at http: www.econjournals.com

International Review of Management and Marketing, 2026, 16(1), 21-29.

Aligning Skills with Industry 4.0: An Exploratory Study of IT Workforce Challenges in Kerala, India

Jishin George Oommen[1,2]*, M. Manimekalai[1], Noel Simon Roy[2], U. S. Nithya[3]

[1]Srimad Andavan Arts And Science College (Autonomous), Affiliated to Bharathidasan University, Tiruchirapalli, Tamil Nadu, India, [2]Rajagiri College of Social Sciences, Kochi, Kerala, India, [3]Sreenarayana College Kollam, Kerala, India. *Email: jishingectk@gmail.com

Received: 13 June 2025 **Accepted:** 03 October 2025 **DOI:** https://doi.org/10.32479/irmm.20829

ABSTRACT

The swift development of digital technologies has brought Industry 4.0 to life, revolutionizing industrial processes and expectations from the workforce. Along with the evolution of the global IT industry through innovations like artificial intelligence (AI), machine learning (ML), internet of things (IoT), cloud computing, and cyber-physical systems (CPS), it has become the need of the hour to synchronize workforce skills with these technological requirements. This research investigates the difficulties of IT professionals in Kerala in adopting Industry 4.0, emphasizing determining skill gaps, assessing training effectiveness, and determining organizational readiness. Adopting an exploratory and descriptive research approach, the research surveyed 410 IT professionals from different places of Kerala, a state of India using structured questionnaires. Statistical analysis was done using t-test, ANOVA, Chi-square, correlation, and regression through SPSS and Excel. The results demonstrate a moderate level of awareness of Industry 4.0 concepts but huge disparities in applied skills, especially among middle-career workers. The available academic curriculum and training programs were deemed not to be properly aligned with industry demands. The study highlights the need for cooperation between academia, industry, and government to update training schemes and embed Industry 4.0 technologies in mainstream education. Strategic efforts in skill enhancement, ongoing learning, and curriculum change are required to make Kerala's IT talent pool competitive and future-fit in the age of digital technology.

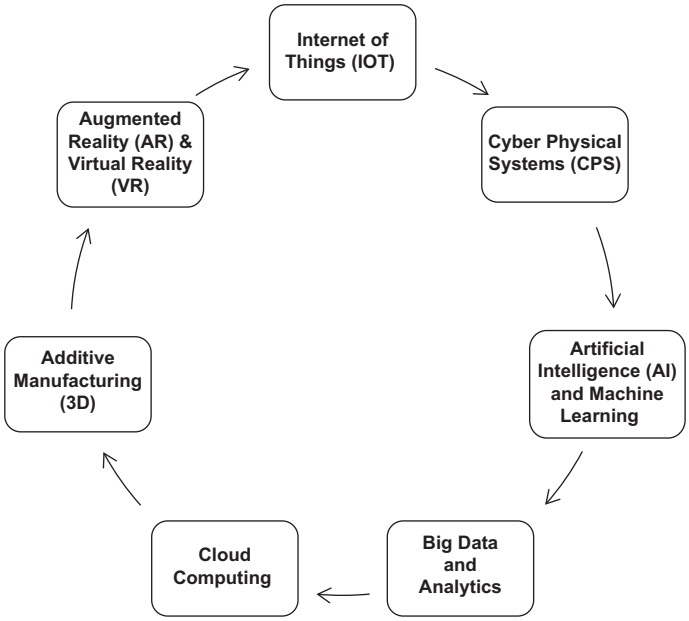
Keywords: Information Technology, Skill Gap, South Kerala-India, Industry 4.0, IT Workforce, IT Training Programs
JEL Classifications: J24, O32, L86

1. INTRODUCTION

The established industrial configuration is rapidly changing due to digital transformation, powered by ever-accelerating technology. So far, the world has undergone four industrial revolutions; the first revolved around steam engines that powered modern production, the second with electricity enabling mass production, the third with digital technologies and programmable logic systems, and now the fourth revolution, known as Industry 4.0, marks the integration of physical and digital systems through sensors and intelligent technologies (Um, 2019). Industry 4.0 represents a shift embracing "Cyber-Physical Systems (CPS), Artificial Intelligence (AI), Cloud Computing, Big Data, Machine-to-Machine (M2M) communication, Internet of Things (IoT), and Internet of Services (IoS)." The core technologies of Industry 4.0 are illustrated in Figure 1. According to Pierre Cléroux of BDC, "monitoring and controlling your machines and equipment in real time means installing sensors at every step of the production process" (Hermann et al. 2016).

Investing in "Information and Communication Technologies (ICTs)" has become a requirement for companies wishing to remain competitive. Such technologies improve effectiveness, maximize production capabilities, reduce communication throughout the organization, and enhance mobility (Alam et al., 2022). A cloud computing environment, for example, enables tremendous data storage and provides a better understanding of customers' needs, which contributes to customer satisfaction and responsiveness.

Figure 1: Core technologies of Industry 4.0



Cyber-Physical Systems (CPSs) connect the physical infrastructure of Industry 4.0 "deeply" into the digital world using internet-driven networking. Artificial intelligence (AI) technologies also impact several aspects of logistics and operations connected to buildings, social networks, and maintaining data security, and sophisticated functionality can be achieved. Numerous devices generate a fast and wide data flow from various sources that must be processed through extraction and reduction techniques to produce meaningful information. By leveraging cloud infrastructure, companies can seamlessly scale their operations without substantial upfront investments in physical hardware, thereby reducing capital expenditure and fostering innovation (Amajuoyi et al., 2024). "The Internet of Things (IoT)" often plays a critical role by consistently monitoring automation systems to optimize performance. Here, machines can communicate with one another, make adjustments automatically, or use AI technologies to make decisions (Nair, 2016). Smart factories are those that reduce human participation, while intelligent products can manage their production and logistics (Hozdić, 2015). As a result, companies need to adopt digital investment for a successful transition or risk stagnation and losing their competitive edge.

1.1. Relevance of Industry 4.0 to the IT Sector

The IT sector plays a pivotal role in enabling Industry 4.0 by constructing and maintaining the digital infrastructure necessary for its implementation. This includes networks, databases, cloud platforms, and APIs, with cloud service providers like Amazon Web Services, Microsoft Azure, and Google Cloud offering scalable data processing and analytics solutions (Lee et al., 2014). Additionally, IT professionals are at the forefront of data integration and analytics, developing systems to aggregate and analyze massive amounts of real-time data generated by Industry 4.0 technologies. By leveraging predictive analytics and machine learning, they help industries optimize efficiencies and make proactive decisions (Lu, 2017). With the rise of digital transformation, cybersecurity has also become crucial. IT experts implement measures such as encryption, block chain, multi-factor authentication, and intrusion detection systems to safeguard Industry 4.0 ecosystems from emerging vulnerabilities (Santos et al., 2017). Furthermore, the demand for tailored Industry 4.0 solutions—like enterprise resource planning (ERP), digital twins, and human-machine interface (HMI) tools—drives innovation in software and application development. Developers are responsible for designing, coding, testing, and deploying these applications across IT and non-IT enterprises. Artificial intelligence and automation are also integral, with IT professionals creating and managing AI-powered systems, including chatbot's and intelligent process automation, to support the autonomous operations envisioned by Industry 4.0 (Zhong et al., 2017). Finally, IT infrastructure enables cloud and edge computing solutions, facilitating distributed processing essential for time-sensitive industrial applications such as smart grids and autonomous vehicles (Shi et al., 2016).

1.2. Skill Requirements for Industry 4.0

Fourth industrial revolution not only changes the context of industries but also requires a new skill architecture for its workforce. The workforce must be future-ready with the correct ratio of technical (hard) skills and non-technical (soft) skills to be successful.

1.2.1. Technical skills

To thrive in the era of Industry 4.0, workers must possess a diverse set of technical skills. Data analytics and data literacy are essential, requiring proficiency in tools like Python, R, and SQL, along with a strong understanding of statistics. It is equally important to interpret data patterns and translate them into actionable insights (Wang et al., 2016). Programming and software development skills form another critical area, as designing and managing digital systems relies on knowledge of programming languages such as Python, Java, and C++, as well as sound software engineering principles. With increasing interconnectivity, cybersecurity competence has become vital. Protecting digital assets necessitates skills in ethical hacking, risk assessment, and implementing robust security measures (Santos et al., 2017). Additionally, expertise in cloud infrastructure management is crucial for deploying and maintaining scalable solutions, particularly through platforms like AWS, Microsoft Azure, and Google Cloud (Buyya et al., 2009). Finally, understanding artificial intelligence and machine learning—including techniques such as neural networks and natural language processing—enables professionals to develop intelligent systems and applications that drive automation and innovation in Industry 4.0 (Lu, 2017).

1.2.2. Soft skills

In the context of Industry 4.0, soft skills are as vital as technical expertise. Adaptability and learning agility have become essential, as professionals must remain flexible and committed to continuous learning to keep pace with rapid technological advancements (Schwab, 2016). Critical thinking and problem-solving are equally important, enabling employees to analyze complex systems and make sound decisions even when faced with incomplete or imperfect data. Effective communication and collaboration skills are crucial, especially in hybrid or remote work environments

where cross-functional teams and global projects require seamless interaction and teamwork (OECD, 2018). Moreover, creativity and innovation play a pivotal role in driving organizational change and maintaining competitiveness by fostering the development of new ideas and the improvement of existing systems.

Industry 4.0 is ushering in systemic and digital transformation of industries by pulling together smart, connected, and automated systems. However, while infrastructure is important, the successful adoption of these technologies is equally dependent on human capital as well. The future of work will increasingly require workers to have both high-level technical skills and crucial soft skills to be not only relevant but also to flourish within the Industrial 4.0 ecosystem. Educational institutions, policy makers, and industry must work together to reduce the gap in the emerging skill sets necessary to ensure sustainable development during the Industry 4.0 phase.

1.3. IT Sector in Kerala: An Overview

Kerala has long been recognized for its high literacy rate and availability of talented human resources and is now becoming an increasingly important regional player in India's Information Technology (IT) sector. While it was traditionally not thought of as a major IT state like Bengaluru or Hyderabad, Kerala has seen steady and strategic growth, with more growth likely in its southern regions and a fledgling subsector. A major impetus to the state's digital maturation and economic diversification, however, has been the establishment of dedicated IT infrastructure (the Technopark in Thiruvananthapuram and Info Park in Kochi) that has substantially speed up the growth of the IT sector there, especially in creating a competitive advantage in the service industry. Kerala's IT growth began in full length around the early 1990s with the establishment of Technopark in Thiruvananthapuram in 1990, which was India's first IT Park. KKerala's IT policy has emphasized sustainable development, knowledge-based employment, and equitable growth. Over the decades, the government has strategically expanded the initial cluster of IT infrastructure to other parts of the state, including InfoPark in Kochi (2004) and CyberPark in Kozhikode (2011) and created a decentralized and differentiated IT ecosystem (Government of Kerala, 2023). Kerala's information technology (IT) industry has taken advantage of its strong educational system, qualified talent pool, and supportive governance to attract domestic and international IT firms. The focus has been on software development, information technology-enabled services (ITES), artificial intelligence, and data analytics (NASSCOM, 2021). Through projects like the Digital University Kerala and the Kerala Startup Mission (KSUM), the state has also aggressively embraced innovative technology and businesses powered by creativity.

The IT industry is an important part of Kerala's economy. The Kerala State IT Department has reported that the sector contributes more than 7% to the state's GDP and is one of the largest job providers in the private sector. In the year 2023, there are around 150,000 professionals directly employed by IT/ITES firms operating from IT parks across Kerala (Government of Kerala, 2023). The industry also supports a wider ecosystem of indirect employment in areas such as real estate, transport, education, healthcare, and hospitality. In addition, the influx of IT professionals has increased urbanization and consumption, which contributes to the growth of the local economies (Varma and Nair, 2021). Kerala's goal of equitable development in IT also created opportunities for semi-urban and rural areas through initiatives such as satellite IT parks and work-from-home opportunities, most prevalent after the COVID-19 pandemic.

As the global IT landscape is changing rapidly due to Industry 4.0 technologies, there has arisen a skill gap has arisen between the skills required by the industry and the skills available in the workforce. This skills gap is especially pronounced in regional IT hubs, like South Kerala, where, despite an ample supply of educated talent, there tends to be a mismatch between formal educational and the skill-specific, emerging needs of the IT industry (NASSCOM, 2022). In South Kerala, the awareness of Industry 4.0 concepts among IT professionals seems to be moderate, with many professionals aware of the terminology but few with a rich conceptual understanding or deep practical experience. While practitioners recognize terms like Artificial Intelligence, IoT, and Cloud Computing, few have practical exposure or experience on projects involving these technologies. Greater awareness was found among younger professionals and those working in startups or product-based service firms. Mid-career employees working in traditional service firms generally had less awareness of Industry 4.0 concepts. There are many reasons for this, in particular, lack of modern industry structure in academic curricula, outdated access to training in Industry 4.0 technologies and very limited industry-academia collaboration (Kerala Startup Mission, 2023; Sasidharan and Pillai, 2022).

Across industries, the digital transformation has increased the demand for newer digital skills, which include "Artificial Intelligence (AI), Machine Learning (ML), Cybersecurity, Data Analytics, Cloud Computing, and DevOps" (World Economic Forum, 2023). Unfortunately, the majority of job seekers—especially new graduates—continue to be trained in systems, programming languages, and theoretical knowledge that are now antiquated. According to Kerala State Planning Board (2022), as little as 30% of engineering graduates are employable in core IT Jobs. This evidence demonstrates the increasing disconnect between academic institutions and the current demands of industry. A gap between academic curriculum and industry expectations is generated by a lack of appropriate exposure to real-time industrial projects, internships, and current technological tools and equipment (Joseph, 2021). Current training programs in South Kerala have only a moderate success rate in bridging the Industry 4.0 skills gap, with ample room for improvement. While many private companies and Government initiatives focus on reskilling and upskilling, the likely issues that arise from the rationale and reach, as well as the content applicability and practical orientation of these training programs, have not met the needs of the growing IT industry in a time-sensitive way.

Numerous training modules cover basic digital literacy or generic programming but lack the specialized Industry 4.0 skills, including AI incorporation, cloud-native development, industrial IoT applications, cybersecurity architecture, and DevOps

automation. As a result, people emerge from these training modules without effectively learning the tools and frameworks, leading to proficiency in a real-time setting (Kerala IT Policy, 2023). Furthermore, the lack of collaboration between academia and industry means that training materials are often outdated and misaligned with necessary job requirements. Kerala Startup Mission (2023) found that over 60% of IT professionals feel current training initiatives do not prepare them to work in high-tech fields and that companies often retrain new employees following formal certification. While training initiatives themselves exist, they are presently constrained in their effectiveness by curriculum relevance, practical exposure, and access, particularly for semi-urban/rural populations. For training initiatives to make the most social impact, they need to be aligned with industry trends, have hands-on, modular training, and be revisited frequently.

1.4. Specific Challenges in Kerala

Despite the presence of prominent IT hubs like Techno park, the IT sector in South Kerala faces significant challenges in aligning workforce skills with Industry 4.0 demands. One major issue is the outdated curriculum and limited industry-academia collaboration. Educational institutions continue to emphasize rote learning over practical problem-solving, with new technologies seldom integrated into existing syllabi. As a result, organizations are compelled to invest in remedial training for employees to bridge these gaps (Sasidharan and Pillai, 2022). Another pressing concern is the shortage of mid-level skilled professionals, particularly those with expertise in enterprise cloud architecture, AI integration, and cybersecurity. Many professionals in the region are not engaged in continuous learning or up skilling due to constraints such as time, cost, and limited accessibility to quality training (Techno Park Annual Report, 2023). In addition to technical deficiencies, there is also a notable gap in soft skills. Communication, adaptability, teamwork, and client-handling abilities remain relatively weak among IT professionals, hampering their effectiveness in working with international clients and adopting agile methodologies (Kerala Startup Mission, 2023). Furthermore, the urban-rural divide in skill access exacerbates the issue. While initiatives to develop IT skills in smaller towns and rural areas have begun, most high-quality trainers, technological infrastructure, and mentorship services remain concentrated in urban centers like Thiruvananthapuram and Kochi. This geographic imbalance limits talent development and hinders equitable regional growth (Kerala IT Policy, 2023).

The skills gap in the Information Technology landscape in South Kerala is a major challenge for sustaining the sector's growth. Addressing the skills gap requires collaboration across three essential areas: Developing the curriculum to be more relevant, promoting reskilling opportunities, and investing in digital infrastructure. The gap can be closed through upgrading both these technical abilities and soft skills to prepare the IT workforce to fulfill the skills required by the digital era, Industry 4.0.

2. LITERATURE REVIEW

Marlapudi and Lenka (2025) identified Industry 4.0 competences for manufacturing and prioritized developing them among the workforce to give the company a competitive edge. "Multi-criteria decision-making (MCDM) technique, Analytic Hierarchy Process (AHP)," prioritized competencies in the study. Literature review and expert input identified competencies, which experts ranked by relevance through pairwise comparisons. Industry 4.0 workers need seven competency categories with 21 subgroups. Priority was given to industry-specific and digital-technical abilities, then to business and cognitive competencies. Although they are less common, core/generic competencies serve as the foundation for more recent and specialized competencies. To better understand competency needs, research on competencies across sectors and talent development systems was necessary due to the necessity for empirical studies in early-adopting organizations of Industry 4.0. To narrow skill gaps, the research offered guidance to enterprises, educators, and legislators on talent management, workforce training, and curriculum aligned with Industry 4.0. By developing a workforce with digital skills, it might support India's "Make in India" goals. A structured, empirically validated framework for prioritizing Industry 4.0 competencies in Indian industry was presented in this research. To contextualize competence demands, it rates competencies based on expert feedback and AHP. It promoted human capital theory and Industry 4.0 competency mapping. Bonsale and Chavan (2024) focused on the importance of soft skills in today's workforce, this study examined the interplay between the two paradigm shifts known as Indian Education 4.0 and Industry 4.0. Soft skills, such as the ability to communicate effectively, work well with others, and think critically, were becoming more important as India struggles to adapt to the digitalization of its education and business systems. This study examined in depth how the requirements of Industry 4.0 were compatible with Education 4.0, which had been enhanced with state-of-the-art technology. This study delved deeply into the topic of how educational frameworks help students acquire soft skills, which are essential for success in today's competitive job market. The complex relationship between education and industry in India was better understood with the help of real-world case studies, viewpoints from the industry, and evaluations of soft skills. Educators, employers, and legislators in India used the results to better understand the changing nature of the contemporary workforce and how to successfully include soft skills into the Education 4.0 paradigm.

Dhanya and Krishnakumar (2024) stated that the IT industry offered a plethora of job and career prospects. IT had given educated and urban Indian women a plethora of new professional options. It gave women and men, minorities, and those with disabilities equal opportunities. The growing number of female professionals was another noteworthy aspect. IT's introduction had the potential to alter how people think about employment, particularly women. In those days, women were becoming more and more prevalent in the IT industry. More women were entering this field as a result of recently developed trends like work from home and flexible scheduling. This incentivized women to enroll in professional programs that guarantee stable employment. Information technology was the most promising field for young, educated, urban women. The legitimate complaint was that these positions take advantage of young Indians with their degrees. Many people in the IT industry were doing low-level labor and underutilizing their higher degree credentials. Despite their

attractive veneer, many of the professions were grueling, repetitive, health-risky, and heavily monitored. There were several concerns about IT-related employment, even though they have altered the nature of professional options for young, educated individuals. One was that individuals are exploited and denigrated in these positions. The majority of workers' basic rights were violated, according to the current report. Miah et al. (2024) aimed to fill a gap in our understanding of how Industry 4.0 has altered the skill sets and employability of South Asian workers. This study examined 48 peer-reviewed articles to find out what drives success, what obstacles were in the way, and what skills were necessary. Articles published between 2013 and 2022 were located using keyword searches on the Web of Science database. Pareto principles and the PRISMA 2020 statement for systematic reviews and meta-analyses were used to perform the review. Industry 4.0's efficiency and production were enhanced by nine key success elements, including digital skills, artificial intelligence, and big data analytics. In addition, it detailed six distinct problems that need fixing to reach full potential, including training and development, budgetary restrictions, and regulatory concerns. Furthermore, the study classified five distinct abilities, including digital, social, technical, and occupationally relevant abilities that were crucial in today's dynamic job market. To help with industry and policy strategy, the "Industry 4.0 SEI Framework" gives stakeholders a bird's-eye view of the dynamics of Industry 4.0.

Pillai and Paul (2023) described that in light of the continuous technological transformation, this essay seemed to investigate the dynamics of employment relations (ER) in India's IT industry. The research team used the grounded theory method to glean insights from 32 IT sector workers, ranging from entry-level to mid-career professionals, as well as project/product managers and representatives from upper management. According to the research, four factors influence ER in India's IT sector: (1) labor regulations; (2) pay and human resources; (3) organizations and unions; and (4) health and safety on the job. Jobs that rely on specialized expertise necessitate revisions to existing labor regulations. Because every job is unique and different, there was a great deal of variation in compensation and HR management approaches. In this field, a non-political union could be effective. Tech workers' well-being and safety must be prioritized. According to the results, IT workspaces were evolving, HR in IT was becoming less important as a result of growing outsourcing, and freelancers were becoming more common in the future. There were new theoretical and conceptual developments in the field of ER as a result of this work. It summarized the ER motivators in India's IT sector. Human resource management, the convergence-divergence paradigm, and decent labor were all areas that the essay helped to advance. Joseph and Anish (2022) determined that this exploratory study was to identify social work education issues in Kerala. Key Person interviews with nine Social Work Educators selected through a purposive sample with inclusion criteria were used to obtain data. Nine topics emerged from qualitative data thematic analysis. Prevalence of misconceptions about the profession, general perception of less employment opportunities for the profession in the local context, mushrooming of Social Work Educational Institutions, lack of adherence to quality standards by the institutions, presence of students with less attitude and aptitude, less practice exposure to students in a supervised environment, and less field and practice exposure and experience among the education. Synthesizing essential informant facts yielded narrative summaries for each subject. These topics were analyzed using the cause-effect relationship and depicted as an issue tree to show the interconnectedness of the challenges. Problem tree analysis showed the lack of a regulatory system to accredit and license social workers and social work educational institutions as the underlying cause of the problems.

2.1. Research Objectives

- To identify the gap between the current IT workforce skills and Industry 4.0 requirements in Kerala.
- To assess the level of awareness of Industry 4.0 concepts among IT professionals in Kerala.
- To analyze the preparedness of IT companies in Kerala for adopting Industry 4.0 technologies.
- To evaluate the effectiveness of existing training programs in bridging the skills gap for Industry 4.0.
- To explore the challenges the IT workforce faces in adapting to Industry 4.0 changes.
- To examine the role of educational qualifications in preparing professionals for Industry 4.0.

2.2. Hypotheses

- H_1: There is a significant relationship between years of experience and awareness of Industry 4.0 technologies among IT professionals.
- H_2: Existing training programs are insufficient in equipping IT professionals with Industry 4.0-related skills.
- H_3: Organizations that conduct regular up skilling programs have a workforce better aligned with Industry 4.0 requirements.
- H_4: Higher educational qualifications positively correlate with preparedness for Industry 4.0 challenges.
- H_5: Lack of training and inadequate institutional support are major challenges in adapting to Industry 4.0 technologies.

3. METHODOLOGY

To collect data and develop a nuanced understanding of *"Aligning Skills with Industry 4.0: An Exploratory Study of IT Workforce Challenges in Kerala,"* this study employed an exploratory and descriptive research design. The objective was to examine the practical knowledge, skill requirements, and existing gaps among IT professionals in the context of Industry 4.0 technologies. The study was conducted across key IT hubs in Kerala, including Thiruvananthapuram, Kollam, Pathanamthitta, and Alappuzha. The target population comprised IT professionals employed in established organizations as well as in emerging startup firms within these cities. A purposive sampling method was adopted to ensure the inclusion of participants with relevant experience and exposure to Industry 4.0 concepts and technologies. The questionnaire development process involved a detailed review of existing literature on Industry 4.0 skill requirements, including frameworks from sources such as the World Economic Forum, NASSCOM, and academic research on digital transformation and workforce readiness. The questionnaire was structured to capture:

- Demographic and professional information (age, gender, education, work experience, current role).
- Awareness and understanding of Industry 4.0 technologies (e.g., AI, IoT, cloud computing, cybersecurity).
- Assessment of technical and soft skills in relation to Industry 4.0 demands.
- Perceptions of the effectiveness of current training programs and organizational readiness.
- Institutional support and upskilling practices.

The items included both closed-ended questions using Likert scales and multiple-choice options to facilitate quantitative analysis, as well as a few open-ended questions for qualitative insights. A pilot test was conducted with a small group of IT professionals (n = 15) to refine the clarity, reliability, and relevance of the questionnaire items. Revisions were made based on feedback before full-scale data collection commenced. The final questionnaire was administered between January and March 2024. A total of 410 valid responses were collected. These responses reflected a diverse range of organizational functions and technological exposure levels. Data were analyzed using Microsoft Excel and the Statistical Package for the Social Sciences (SPSS). The study employed a variety of statistical techniques, including t-tests, ANOVA, Chi-square tests, correlation analysis, and regression analysis. These techniques were used to test hypotheses and draw conclusions about skill levels, training effectiveness, and the preparedness of IT professionals for Industry 4.0. This methodology ensured both breadth and depth in capturing the dynamics of skill gaps and professional readiness in the context of ongoing digital transformation in Kerala's IT sector.

4. RESULTS

4.1. Demographic Profile of Respondents

The sample for this study consisted of 410 IT professionals working in various organizations across South Kerala. The respondents were categorized based on age, gender, years of experience, and education level, which are summarized in Table 1. The age distribution showed that 45% of respondents were in the 31-40 age group, 41% were in the 20-30 years range, and 14% were in the 41-50 years category. In terms of gender, 56% of the respondents were male, and 44% were female, indicating a slightly higher proportion of male participants. Regarding professional experience, 38% of the participants had 1-5 years of experience, 42% had 6-10 years, and 20% had more than 10 years of experience in the IT sector. As for educational qualifications, 65% held a Bachelor's degree, 28% held a Master's degree, and 7% were PhD holders. This demographic breakdown is essential to understand how different groups of professionals perceive and prepare for Industry 4.0.

Table 1: Demographic profile of respondents

Demographic variable	Category	Frequency	Percentage
Age	20-30	169	41
	31-40	184	45
	41-50	57	14
Gender	Male	230	56
	Female	180	44
Years of experience	1-5	157	38
	6-10	173	42
	10+	80	20
Education level	Bachelor's	267	65
	Master's	115	28
	Doctorate	28	7

4.2. Relationship between Years of Experience and Awareness of Industry 4.0

A Pearson's correlation analysis was conducted to examine the relationship between years of experience and awareness of Industry 4.0 technologies. The results revealed a positive and significant correlation ($r = 0.55$, $P = 0.001$). This suggests that as the years of experience of IT professionals increase, their awareness of Industry 4.0 technologies also improves. The correlation was stronger for individuals with more than 10 years of experience, reflecting their greater familiarity with emerging technologies in the IT sector. These results are summarized in Table 2 and visually represented in Figure 2.

4.3. Effectiveness of Existing Training Programs

The effectiveness of existing training programs in equipping IT professionals with Industry 4.0-related skills was tested using an independent t-test as shown in Table 3. The results showed a significant difference between those who had undergone training and those who had not ($t = 3.14$, $P = 0.001$). IT professionals who participated in training programs scored higher on awareness of Industry 4.0 technologies (mean = 4.2) compared to those who did not participate in any training (mean = 2.9). These findings suggest that while the existing training programs are somewhat effective, there is still room for improvement in fully preparing professionals for the challenges of Industry 4.0.

4.4. Regular Upskilling and Alignment with Industry 4.0

A one-way ANOVA was conducted to analyze whether regular upskilling programs influence the alignment of IT professionals with Industry 4.0. The results indicated that organizations with regular upskilling programs had a significantly higher alignment with Industry 4.0 technologies ($F = 6.45$, $P < 0.0001$). Professionals from organizations with regular upskilling programs reported greater preparedness for Industry 4.0, with a mean score of 4.5, compared to 2.8 for those in organizations without such programs. These findings are presented in Table 4 and illustrated in Figure 3. This emphasizes the critical role of ongoing professional development in maintaining workforce readiness for Industry 4.0.

4.5. Educational Qualifications and Preparedness for Industry 4.0

Pearson's correlation was again used to assess the relationship between educational qualifications and preparedness for Industry 4.0. The analysis showed a strong positive correlation ($r = 0.63$, $P = 0.000$), indicating that higher educational qualifications are associated with greater preparedness for Industry 4.0 challenges. IT professionals with Master's or Doctorate degrees demonstrated better preparedness compared to those with only a Bachelor's degree. These results are summarized in Table 5 and visually represented in Figure 4. This suggests that advanced education

Figure 2: Years of experience versus awareness of Industry 4.0

Figure 3: Alignment with Industry 4.0 based on upskilling programs

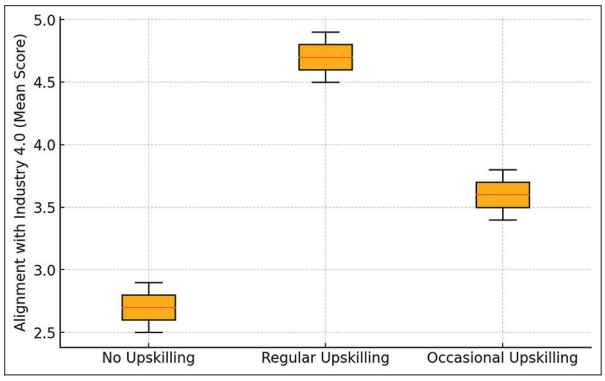
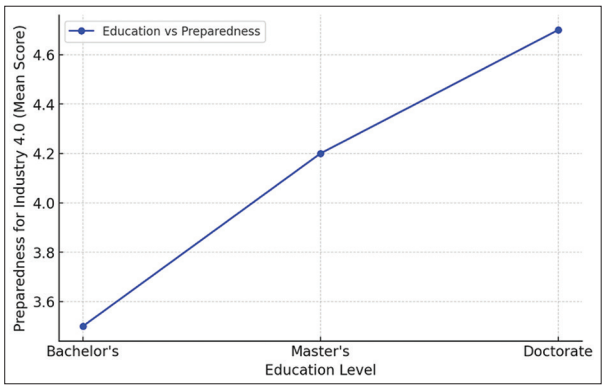


Figure 4: Educational qualifications and preparedness for Industry 4.0



provides individuals with the knowledge and skills needed to face the challenges brought by Industry 4.0 technologies.

4.6. Institutional Support and Challenges in Adapting to Industry 4.0

The relationship between institutional support and the challenges faced in adapting to Industry 4.0 was tested using a Chi-square analysis. The results indicated that lack of institutional support was significantly associated with increased challenges faced by IT professionals ($\chi^2 = 14.25$, $P = 0.001$). Respondents from organizations with low institutional support reported higher levels of difficulty in adapting to Industry 4.0 compared to those from organizations with high support. These results are presented in Table 6. This highlights the need for stronger institutional backing to support professionals in their adaptation to new technologies.

Table 2: Correlation between years of experience and awareness of Industry 4.0

Years of experience	Awareness of Industry 4.0 (Mean)	Correlation coefficient (r)	Sig. (P-value)
1-5	3.5	0.45	0.002
6-10	4.2	0.60	0.001
10+	4.8	0.70	0.000

Table 3: Training effectiveness in bridging skills gap

Group	Mean score (training effectiveness)	t-value	df	Sig. (P-value)
Trained	4.2	3.14	408	0.001
Not trained	2.9			

Table 4: Alignment with Industry 4.0 based on upskilling programs

Group	Mean score (alignment with Industry 4.0)	F-value	df	Sig. (P-value)
No upskilling	2.8	6.45	2,407	0.000
Regular upskilling	4.5			
Occasional upskilling	3.6			

Table 5: Correlation between education level and preparedness for Industry 4.0

Education level	Preparedness for Industry 4.0 (mean)	Correlation coefficient (r)	Sig. (P-value)
Bachelor's	3.5	0.35	0.01
Master's	4.2	0.50	0.004
Doctorate	4.7	0.60	0.000

Table 6: Challenges faced due to lack of institutional support

Support level	Lack of training (count)	Inadequate support (count)	Chi-square	df	Sig. (P-value)
High support	20	30	14.25	2	0.001
Medium support	60	90			
Low support	100	120			

5. RESULT AND DISCUSSION

5.1. Results

- Demographics: Majority of participants were aged 31-40 (45%), with 56% male and 44% female. Most held Bachelor's degrees (65%), with 28% Master's and 7% Doctorate.
- Experience versus awareness: A significant positive correlation was found between years of experience and awareness of Industry 4.0 ($r = 0.55$, $P = 0.001$).
- Training effectiveness: Participants who underwent training showed significantly higher awareness ($t = 3.14$, $P = 0.001$).
- Upskilling and preparedness: Organizations with regular upskilling programs scored higher on Industry 4.0 preparedness ($F = 6.45$, $P < 0.0001$).

- Education level correlation: Higher educational qualifications correlated positively with preparedness ($r = 0.63$, $P = 0.000$).
- Institutional support: Lack of support was significantly linked to adaptation challenges (Chi-square = 14.25, $P = 0.001$).

5.2. Discussion

This study explored the skill discrepancies among IT professionals, and how these discrepancies affect organizational performance. The findings indicate a significant mismatch between the skill sets possessed by professionals and those demanded by employers, particularly in emerging technologies, project management, and soft skills. These gaps hinder productivity, innovation, and employee satisfaction, ultimately affecting the competitiveness of IT firms.

The results also emphasize the critical role of continuous learning and upskilling. Firms that invested in structured training programs reported better alignment between role requirements and employee capabilities, leading to improved project outcomes and reduced turnover. Moreover, the role of educational institutions in preparing graduates for real-world demands was found to be insufficient, with a noticeable disconnect between academic curricula and industry requirements.

Another significant insight is the influence of management strategies in addressing skill gaps. Companies with proactive human resource planning and strong collaboration with educational providers were more effective in minimizing these gaps. The research underscores the necessity of a multi-stakeholder approach involving firms, educators, and policymakers to bridge these persistent skill discrepancies

5.2.1. Practical contributions

- For employers: This study provides actionable insights for IT companies, highlighting the importance of regularly assessing employee competencies and aligning them with current and future technological demands.
- For educational institutions: It underscores the need to revise curricula to incorporate practical, industry-relevant skills, and promote partnerships with IT firms for internships and workshops.
- For policymakers: The study supports the development of regional skill development initiatives focused on IT sectors, including incentives for industry-academia collaboration.
- For professionals: The findings encourage IT professionals to proactively pursue up skilling and certification in emerging technologies to enhance employability and adaptability.

5.2.2. Theoretical contributions

- This study extends the literature on skill gaps by focusing on a specific regional tech hub, adding a localized dimension to the global discourse on workforce readiness.
- It contributes to human capital theory by empirically validating the link between employee skill alignment and firm performance.
- The research introduces a conceptual framework that integrates organizational behavior, talent management, and educational theory to explain the dynamics of skill development and application in the IT industry.

5.2.2.1. Future research directions

Several avenues for future research emerge from this study:

1. Longitudinal studies: Future research could examine how skill gaps evolve over time and how organizational interventions influence these trends.
2. Comparative analyses: Conducting similar studies across other Indian IT hubs (e.g., Technopark, Bangalore, Hyderabad) would help generalize the findings and identify region-specific dynamics.
3. Sectoral expansion: While this study focused on IT, other knowledge-intensive sectors such as biotechnology or fintech could be analyzed for similar discrepancies.
4. Educational reform impact: Research could investigate the impact of specific educational reforms or skill development programs on graduate employability and organizational performance.
5. Employee perspective: Qualitative studies focusing on employees' lived experiences regarding skill mismatch and career progression could enrich understanding from a human-centered lens.

6. CONCLUSION

This research paper thoroughly examines the preparedness of IT professionals in Kerala for Industry 4.0. The findings show a moderate level of awareness by professionals in the region of Industry 4.0 technologies, but indicate there are many substantial gaps in practitioners in practical skills, especially mid-career. While training programs and educational initiatives do exist, they have become outdated or not readily applicable or appropriate for current industry expectations. Statistical analysis shows that years of experience, higher educational qualifications, and continual up skilling lead to more readiness for Industry 4.0; however, the lack of support from institutions and low exposure to up-to-date tools or experience with global practices are major stumbling blocks. To rectify these issues, this research paper highlights the immediate need for joint efforts from academia, industry, and government to reform curricula and begin incorporating experiential learning modules, while establishing a culture of continuous learning. Through focused and ongoing efforts, Kerala's IT workforce can prepare to operate effectively as Industry 4.0 continues to reshape the private sector in the digital age.

The findings of this study provide valuable insights into the current state of the IT workforce in South Kerala regarding Industry 4.0 preparedness. There is a significant positive relationship between years of experience and awareness of Industry 4.0 technologies, with more experienced professionals demonstrating higher awareness. Training programs were found to be effective, though insufficient, and organizations with regular upskilling programs showed better alignment with Industry 4.0. Additionally, educational qualifications were positively correlated with preparedness for Industry 4.0, and lack of institutional support emerged as a key challenge for adapting to these technologies. These findings underscore the importance of continuous education

and strong institutional support to ensure that IT professionals are well-prepared to meet the demands of Industry 4.0.

REFERENCES

Alam, K., Ali, M.A., Erdiaw-Kwasie, M., Shahiduzzaman, M., Velayutham, E., Murray, P.A., Wiesner, R. (2022), Impact of ICTs on innovation and performance of firms: Do start-ups, regional proximity and skills matter?. Sustainability, 14(10), 5801.

Amajuoyi, C.P., Nwobodo, L.K., Adegbola, M.D. (2024), Transforming business scalability and operational flexibility with advanced cloud computing technologies. Computer science and it research journal, 5(6), 1469-1487.

Bonsale, G., Chavan, H. (2024), Synergizing Indian education 4.0 with industry 4.0: A comprehensive exploration of the vital role of soft skills in the modern workforce. Journal of the School of Language, Literature and Culture Studies, 10, 1-26.

Buyya, R., Yeo, C.S., Venugopal, S., Broberg, J., Brandic, I. (2009), Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility. Future Generation Computer Systems, 25(6), 599-616.

Dhanya, M., Krishnakumar, R. (2024), Working conditions of IT professionals in Kerala: A study based on select fundamental rights. Arimaa Nokku Journal, 18(4), 71-75.

Government of Kerala. (2023), Kerala IT Policy 2023. Department of Electronics and Information Technology. Available from: https://it.kerala.gov.in

Hermann, M., Pentek, T., Otto, B. (2016), Design Principles for Industrie 4.0 Scenarios. In: 2016 49th Hawaii International Conference on System Sciences (HICSS). IEEE. p3928-3937.

Hozdić, E. (2015), Smart factory for industry 4.0: A review. International Journal of Modern Manufacturing Technologies, 7(1), 28-35.

Joseph, D., Anish, K.R. (2022), Challenges to social work education in Kerala: An exploratory problem analysis. BCM Journal of Social Work, 18(2), 139-158.

Joseph, K.J. (2021), Skill Development and Innovation in the IT Sector: Challenges in Kerala. Kerala: Centre for Development Studies.

Kerala IT Policy. (2023), Kerala Digital Policy 2023. Government of Kerala. Available from: https://it.kerala.gov.in

Kerala Startup Mission. (2023), Annual Performance Report. Available from: https://startupmission.kerala.gov.in

Kerala State Planning Board. (2022), Economic Review 2022. Government of Kerala. Available from: https://spb.kerala.gov.in

Lee, J., Bagheri, B., Kao, H.A. (2014), A cyber-physical systems architecture for Industry 4.0-based manufacturing systems. Manufacturing Letters, 3, 18-23.

Lu, Y. (2017), Industry 4.0: A survey on technologies, applications and open research issues. Journal of Industrial Information Integration, 6, 1-10.

Marlapudi, K., Lenka, U. (2025), Enhancing human capital for Industry 4.0: A case of Indian manufacturing sector. Journal of Intellectual Capital, 26(2), 446-468.

Miah, M.T., Erdei-Gally, S., Dancs, A., Fekete-Farkas, M. (2024), A systematic review of Industry 4.0 technology on workforce employability and skills: Driving Success factors and challenges in South Asia. Economies, 12(2), 35.

Nair, A. (2016), Applications of AI in Internet of Things (IoT): A Comprehensive Study. International Journal of Artificial Intelligence and Machine Learning, 6(3).

NASSCOM. (2021), The IT-BPM Sector in India: Strategic Review. New Delhi: National Association of Software and Services Companies.

National Association of Software and Services Companies. (2022), Technology sector in India 2022: Strategic review. NASSCOM. Available from: https://nasscom.in/knowledge-center/publications/technology-sector-india-2022-strategic-review

OECD. (2018), The Future of Education and Skills: Education 2030. United States: OECD Publishing.

Pillai, R., Paul, B. (2023), Industry 4.0 and the changing employment relations: A case of the Indian information technology industry. NHRD Network Journal, 16(1), 92-110.

Santos, R., de Souza, F.B., de Carvalho, D.B. (2017), Cybersecurity in industry 4.0: Challenges and approaches. Procedia Manufacturing, 11, 1086-1091.

Sasidharan, S., Pillai, R. (2022), Bridging the employability gap in the IT sector of Kerala. Journal of Regional Workforce Development, 10(2), 89-103.

Schwab, K. (2016), The Fourth Industrial Revolution. Switzerland: World Economic Forum.

Shi, W., Cao, J., Zhang, Q., Li, Y., Xu, L. (2016), Edge computing: Vision and challenges. IEEE Internet of Things Journal, 3(5), 637-646.

Technopark. (2023), Annual Report. Available from: https://www.technopark.org

Technopark. (2024), Annual report 2023-24. Available from: https://technopark.in/storage/documents/354.pdf

Um, J.S. (2019), Introduction to the fourth industrial revolution. In: Drones as Cyber-Physical Systems: Concepts and Applications for the Fourth Industrial Revolution. Berlin: Springer. p1-20.

Varma, A., Nair, S. (2021), Economic impact of Technopark in the Kerala region. International Journal of Regional Development, 8(1), 45-59.

Wang, S., Wan, J., Li, D., Zhang, C. (2016), Implementing smart factory of Industry 4.0: An outlook. International Journal of Distributed Sensor Networks, 12(1), 1-10.

World Economic Forum. (2023), The Future of Jobs Report. Available from: https://www.weforum.org/reports

Zhong, R.Y., Xu, X., Klotz, E., Newman, S.T. (2017), Intelligent manufacturing in the context of Industry 4.0: A review. Engineering, 3(5), 616-630.