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CHALLENGES AND OPPORTUNITIES BASED ON INDUSTRY 4.0 POLICIES IN BRAZIL, INDIA, JAPAN, AND SWEDEN

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ABSTRACT

Public policies influence countries' economic sectors, such as the industrial sector. Industry 4.0 (I4.0) demands employees upskilling and can impact unemployment and HIE curricula. The paper compares I4.0 public policy issues related to the education and training of industrial workers, based on polar cases representing emerging countries (Brazil and India) and developed countries (Japan and Sweden). These countries have created policies to become independent and improve their innovation ecosystem. The I4.0 literature and white papers indicate different country-specificities. Research gaps related to workers' competency development in the I4.0 context; preparation of the students for I4.0 jobs, including the changes in the educational system, I4.0 and its effect on workers and the need to understand impacts on country education are discussed. The methodology applies theoretical review related to education, I4.0 policies, and compares I4.0 public policies from Brazil, India, Japan, and Sweden (white papers). Comparing how these different countries adjust to I4.0 may contribute to manufacturing sectors addressing this new digital context, contributing to theoretical advancement and informing policy and practice in higher education. The findings indicate education and upskilling concerns, and these countries are reviewing their Engineering Education towards increased digital transformation in the whole society.

Keywords: Industry 4.0/5.0; engineering higher education policy; cross-national; society 5.0; production2030; made in India

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INTRODUCTION

Countries have increased attention on new technologies implementation, e.g., simulation and robots, towards increased digitization and Industry 4.0 (I4.0) for products manufacturing (Alcácer and Cruz-Machado 2019). Industry 4.0 (I4.0) incorporates machines, workflow, and the smart networks used throughout the production and logistic systems (Sari et al., 2024).

Some countries apply the coined term Industry 4.0, such as Brazil, and there are different term applications from different countries (Valverde & Muniz Jr. 2023; Souza et al., 2025). While India uses the term Make in India in India (Nam and Steinhoff 2018), Japan has emphasised the terms Robotic Revolution Incentive and Society 5.0 (Cabinet Office 2021), and Produktion2030 is applied in Sweden (Digitaliseringsrådet 2024).

Hereafter, we use I4.0 to simplify, where I4.0 can produce customized goods produced in lower batches, and automation of repetitive tasks (Karre et al. 2017). I4.0 modifies the means of production through the value chain, and also influences productivity, workforce skill requirements, natural resources uses, social well-being, and income generation (OECD 2017). The European Commission related to sociotechnical approach with I4.0 implementation, which includes companies, society and employees (European Commission, 2024; Schuh et al. 2020; Muniz Jr. et al. 2024).

I4.0 influences workers employability , if they have access to reskilling, and necessary training (IndustriAll, 2017). A labour context, in which there is a reduction in wages, job reduction, and conflicts between people and automated processes. Retirement postponement and lack of qualified workers affect I4.0 implementation (Peruzzini and Pellicciari 2017).

Currently, the I4.0 literature moves from traditional technological focus to a human-centric focus, including well-being based on new ways of sustainable consumption, circular economic value creation and equality, which is named ‘Industry 5.0’ (European Commission, 2021; 2024; Eriksson et al. 2024; Garrido et al., 2024). There are new concepts related to I5.0, i.e., human-centric assembly (Wang 2022), Education 4.0 (González-Pérez and Ramírez-Montoya 2022), and social system for future manufacturing (Muniz Jr. et al. 2024; Ribeiro et al., 2024). The human-centric initiatives using digital technologies have in common a perspective of achieving society actors’ satisfaction from students, employees and citizens within HIE and schools, companies, and society (Muniz Jr. et al. 2024).

Public policies influence changes in countries’ economic sectors (i.e. industrial sector), especially when they align the regulatory framework nationally and internationally (Aguinis et al. 2020). Different countries’ specificities are explored in the I4.0 literature (Valverde and Muniz Jr., 2024; Souza et al., 2025), such as culture, upskilling, research & development, vocational training, and educational system. There are research opportunities related to i.e., preparation of the students for I4.0 jobs, including the changes in the educational system (Scavarda et al., 2019), I4.0 and its effect on workers (Jerman et al. 2020; Ribeiro et al., 2024), including workers’ competencies and skills development, Human Resources Management changes (Wibowo et al. 2020; Melo et al. 2022), Job description changes considering workers as users of I4.0 technologies (Ribeiro et al., 2024), and social issues caused by I4.0 implementation (Muniz Jr. et al., 2024). Research opportunities are aligned with the research-questions posed: How do different countries’ policies influence Education? Which opportunities and challenges link policies and education?

The paper compares I4.0 public policy issues related to the education and training of industrial workers, based on polar cases representing emerging countries (Brazil and India) and developed countries (Japan and Sweden). Understanding how emerging and developed countries are adapting to I4.0 is important for the global manufacturing sector which is dealing with digital transformation. I4.0 demands employees upskilling and influencing job profiles. This research is related to the Sustainable Development Goals (SDGs): 9. Industry, Innovation, and Infrastructure; 4. Quality Education; 8. Decent Work and Economic Growth. This research contributes to sustainable practices; discussion of policies that mitigate social issues; and guiding of new curricula affected by digital transformation.

METHODOLOGY

This section describes the methodology of the study including context, design and data selection. The methodology has two stages:

- Theoretical review to identify research gaps, definitions, and context related to Industry 4.0, policies, and education
- Comparison of Industry 4.0 public policies in Brazil (Industria 4.0, Brasil 2019), India (Make In India 2014, Nam and Steinhoff 2018), Japan (Society 5.0, Cabinet Office 2021), and Sweden (Produktion2030, Digitaliseringsrådet 2024).

Context and design of study

The study design selected two developed countries (Japan and Sweden) and two emerging countries (Brazil, India) for I4.0 policies education comparison (Table 1).

Table 1. Selected countries in numbers

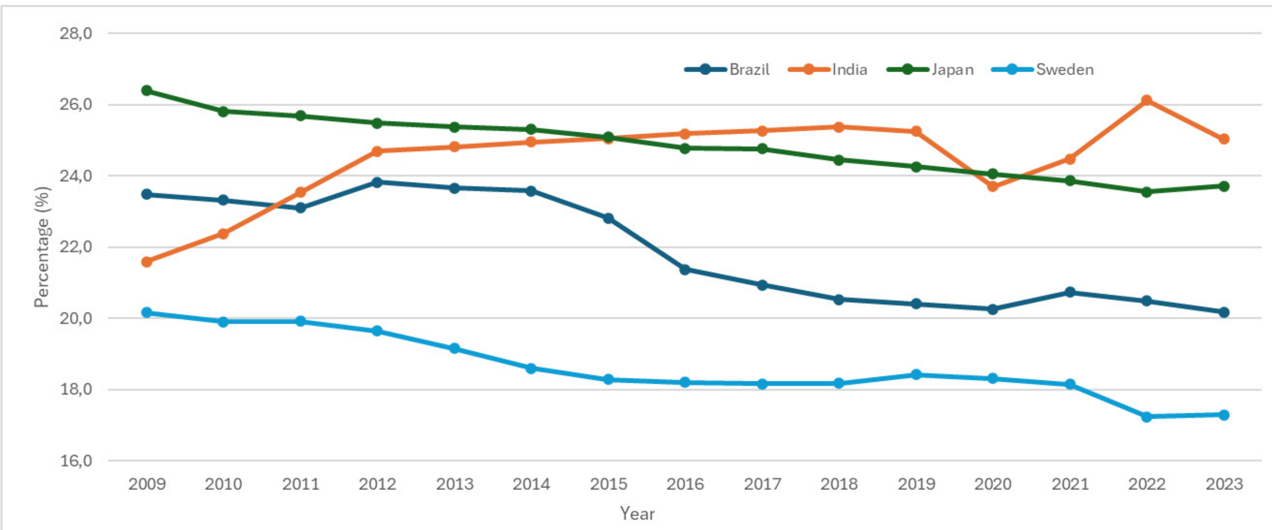
Country	GDP 2022 (US$)	Population 2022	Labor force 2023	Education Index 2021**	Adult education level 2022**
Brazil	1,920,095.78	215,313.50	108,695,239	0.70	40.94
India	3,416,645.83	1,417,173.17	593,729,164	0.55	77.74
Japan	4,256,410.76	125,124.99	69,278,589	0.87	56.13
Sweden	591,718.14	10,486.94	5,829,755	0.96	14.37

* *The Education Index* is measured by the adult literacy rate (with two-thirds weighting) and the combined primary, secondary, and tertiary gross enrollment ratio (with one-third weighting). Source: World Population Review (2021). Education Index by Country. Available at: https://worldpopulationreview.com/country-rankings/education-index-by-country

** *Adult education level* **indicator is defined as the highest level of education completed by the 25-64 year-old population.** There are three levels: below upper-secondary, upper secondary, and tertiary education. Upper secondary education typically follows the completion of lower secondary schooling. Lower secondary education completes the provision of basic education, usually in a more subject-oriented way and with more specialized teachers. The indicator is measured as a percentage of the same-age population; for tertiary and upper secondary, data are also broken down by gender. Source: Source: OECD Data (2022). Available at: https://data.oecd.org/eduatt/adult-education-level.htm

The selected countries' profiles of industrial employment trends are shown in Table 2, indicating that only India is increasing industrial employment. India's strength is increasing in terms of production capacity and industrialization transforming from a resource-based economy towards an economy based on mechanized manufacturing and technical competences as well as the increase of skilled labour (Dahlman et al. 2004).

Pimentel (2018, p.20) indicates that employability is influenced by policies, capable of training and education, as well as incentive private initiative. A strong national industry generates employment and income, but for workers to occupy these jobs they need to be qualified or re-qualified. Policies supporting moving from innovative conditions for education and (re)qualification of workers request a better educational system, and capacity to adapt to industrial changes and, thus, alleviate systemic inequalities (IndustriALL 2017).



Graphic 1. Brazil, India, Japan, and Sweden - industrial employment (Percentage vs 2009-2022).
Source: International Monetary Fund (2025, modeled ILO estimate)

Brazil took a different direction from that of countries such as Germany, the US, and China, deactivating or weakening industrial policy instruments. Japan considers actions to improve medium and small-sized enterprises besides the big-sized ones, and Sweden has a similar focus (Valverde and Muniz Jr. 2023).

Data Selection

An article searching was conducted in the Scopus (2018-2022) based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Moher et al. 2009), which supports traceability. A set composed of 14 papers was selected after titles and abstracts reading (see details of exclusion criteria in Table 2), and white papers.

Further, official white papers relating to policies (see references), for the countries researched in the study were analysed related to education and training aspects.

Table 2. Papers selection protocol.

Item	Description	Total
Search string (Title, Abstract, keyword)	"Industr* 4.0" OR "Industr* 5.0" AND Educat* AND "Polic*"	174
Doctype & Language	Articles in English	94
Categories	Brazil* OR India* OR Japan* OR Swed*	14

COMPARISON OF THE STUDIED COUNTRIES' EDUCATION POLICIES AND INDUSTRY 4.0

The educational practices in Humanities courses prepare their students to have a higher engagement in their learning process. Differently, Natural Science and Engineering courses are more focused on replicating knowledge reproduction. For instance, engineering courses need to pay more attention to skills related to reading, writing, discussion and interpretation of texts, which develops communication skills, generates knowledge, and creates meaning for individuals (Sageev and Romanowski 2001), and to reduce factual information and passive classes for a better understanding of the contents (Lujan and DiCarlo, 2006). The teaching process should encourage students to develop self learning, and be able to solve problems (Muniz Jr., et al., 2017). The classes should change for more active learning to support these scenarios. Many countries discuss I4.0 education, implementing actions related to strengthening students' I4.0 skills. It has been expected that engineers have higher technical skills to work in society (Hissey 2000). Professional skills such as creativity, teamwork, decision-making, leadership, negotiation, conflict resolution, analytical thinking, and understanding of social issues and globalization are relevant for engineers' careers (Melo et al. 2022). Move from a traditional resolution of problems to an active learning approach, including involving students in solutions to social issues, and innovation in different contexts, from creation to solutions implementation (Zhou 2012; Novais et al. 2017).

Society has placed increasing attention on I4.0 and these digital, intelligent, networked systems are immersed in different contexts, economies, sectors and industries around the world. Engineering aims at systems efficiency, productivity, effectiveness, resilience, robustness, adaptiveness, and sustainability. Emerging economies face difficulties related to implementation of I4.0 related to infrastructure, education, culture (Dalenogare et al., 2018). The current literature I4.0 is moving from a technology-oriented approach to a human-centric approach.

4.1 Brazil

The Brazilian Ministry of Science, Technology, Innovations and Communications (MCTIC) formalized, in April 2019, the Chamber of Industry 4.0 (Chamber I4.0) that prepared and published the 'Action Plan for the Brazilian Chamber of Industry 4.0 in Brazil: 2019-2022' which objective was to induce the use of concepts and practices related to I4.0. Concerning I4.0 Education, the Brazilian Plan indicates actions fostering educational skills and abilities for the I4.0, which include promoting training and (re)qualification of educators, students, and workers in skills and abilities for the I4.0. Specifically, the industry encourages their workers' continued education towards developing competencies and skills for new work requirements (Melo et al. 2022), and engineering courses update their curriculums to prepare I4.0 employees based on active learning (Brasil 2019).

Brazilian National Confederation of Industry (CNI) indicates that education and training influence productivity and competitiveness. CNI also highlights that the unsatisfactory quality of basic education and low technical and professional training are barriers to productivity growth and company competitiveness. Despite its islands of excellence, higher education in Brazil is far from fulfilling the demands of the manufacturing sector and the best world references for quality, which places the country at a disadvantageous position in terms of its ability to innovate and compete (CNI 2018, p.76) in order to establish policies aimed at l4.0, the Institute for Studies in Industrial Development - IEDI (Furtado 2017) indicates strategic actions related to 5. train professionals focused on the main vectors of I4.0.; 6. support advanced scientific skills training programs for I4.0; 7. attract highly trained human resources; 8. Train human resources articulated to the formation of appropriate technological bases for the construction and dissemination of solutions

4.2 India

India applies the "Make in India (MII)" policy to encourage companies to develop, manufacture, and assemble products indigenously. MII products promote the facilitation of investment and innovation, enhance competence development, and protect Intellectual Property Rights (IPR) (Make In India 2014; Nam and Steinhoff, 2018). Additionally, the MII program aims to improve India's rank in the global market by easing the business index in terms of making the administrative process easier and destroying the unnecessary rules and regulations associated with the manufacturing sector (Make in India – Objectives, Vision and Achievements 2019). Through the MII initiative, the Indian Govern aims to take the GDP to 25% by 2022 (Market, 2018). The MII focuses on 25 sectors, including automobiles, aviation, defense, manufacturing electrical machinery, IT and BPM, oil and gas, renewable energy, and hospitality and wellness. These Make in India policies have been designed to facilitate foreign direct investments, and new initiatives to increase innovation, protect intellectual property rights, and build best-in-class manufacturing infrastructure (Make In India Programme, All About The Manufacture in India Initiative, 2021). India is keen on adopting I4.0 and has taken several initiatives. For example, Smart Advanced Manufacturing and Rapid Transformation Hub (SAMARTH) - Udyog Bharat 4.0 is a 21st-century skill for implementing I4.0 initiated with the department of heavy industry. The focus is to create awareness among Indian manufacturing industries by having demonstration centres and enhancing competitiveness in the Indian capital goods sector to meet I4.0 standards. In addition, the Indian governor has approved Common Engineering Facility Centre (CEFC), which extends services to promote innovation and adoption of I4.0 technologies to increase global competitiveness of Indian industries.

4.3 Japan

In 2016, a Cabinet Decision endorsed the 5th Science and Technology Basic Plan where the concept of Society 5.0 was first coined as “a human-centered society in which economic development and the resolution of social issues are compatible with each other through a highly integrated system of cyberspace and physical space” (Cabinet Office, 2016). In 2020, the Basic Law was substantially amended to include “humanities and social sciences’’ into the provisions of national policies on science and technology and to position “innovation” as one of the pillars. The notion of innovation here is not limited to corporate product development activities but also includes broad social change and value creation taken charge by various agencies (Cabinet Office, 2021).

While a lack of talent for digital innovations has long been claimed in the industry (Keidanren, 2020), companies tend to avoid encouraging recurring education and taking second jobs in fear of losing employees. Workers are also unmotivated to learn due to the seniority system of the company and society’s lacking acknowledgment of life-long learning. Therefore, the strategy created by The Council for Science, Technology, and Innovation (CSTI) not only involves STEAM education in elementary and secondary education but also enhancement of recurrent education and the mobility of human resources. This is a major step away from the standardised education that has been prevalent in Japan in the background of social homogeneity, as well as the rigid job market based upon the company’s life-long employment system.

The strategy is broken down into a yearly action plan called the Integrated Innovation Strategy (Cabinet Office, 2021). The Integrated Innovation Strategy 2022 set forth 3 pillars: a). enhancement of knowledge bases (research capabilities) and human resource development, b). creation of an innovation ecosystem, c). strategic promotion of advanced science and technologies.

Further action plan developed by the CSTI Working Group for Education and Human Resource Development emphasises a need for new “thinkings and ideas” in human-centered Society 5.0. Specifically, abstract thinking is necessary to handle situations with no answers and create solutions out of silos toward non-linear innovation. Likewise, the ability to collaborate across expertise and industries are mentioned as critical to throw open Japanese companies which have long cherished internal communication and bonding (Council for Science,Technology and Innovation, 2022).

4.4 Sweden

In 2017 the Swedish government established the “Swedish National Digitalisation Council”, situated in the governmental office (Digitaliseringsrådet 2024). The aim of the Swedish government’s digitalisation strategy is that Sweden shall be world leading at applying opportunities created by digitalization. The strategy is centred around five objectives: digital competence, digital innovation, digital security, digital infrastructure, and digital management. The Swedish National Digitalisation

Council's missions are to: Track digitization development in Sweden and the rest of the world, promote an active digitization policy, and suggest possibilities in the digital and fast-moving world to support the Swedish government with strategic analysis (Digitaliseringsrådet 2024). The Swedish government is stressing digitalization politics, which involves "using and promoting the opportunities that digitization brings for society: for individuals, business, civil society, and public administration" (Digitaliseringspolitik 2024). It is also emphasized that digitalization politics work to promote digital competence and digital leadership. However, the need for competence development for individuals in the era of digitalization is not stressed explicitly as one of the aims. However, such aspects have been stressed by the Swedish government in other forms, e.g., in 2019 the government gave an assignment to the "Swedish Higher Education Authority" (Universitetskanslerämbetet, 2024) and to the "Swedish Agency for Economic and Regional Growth" (Tillväxtverket 2024) to analyse and propose how the supply of expertise of digital skills can be developed both in the short and long term. The aspects of the need for new knowledge related to Industry 4.0 has been highlighted also by other institutions and associations. For example, the "Association of Swedish Engineering Industries" with 4300 member companies (Teknikföretagen 2024), has reported that one of the largest challenges in digital transformation is the lack of competence and skills, and in relation to this the lack of relevant education and training to meet the demands of new knowledge (Teknikföretagen 2016). It is emphasized that there is a continuous and growing need for a variety of initiatives for competence development for current and future manufacturing personnel. Research funding bodies have designed calls that focus on developing higher education initiatives, in line with Education 4.0, i.e., competence development directed towards industrial participants. The Knowledge Foundation (2022) especially has focused on several large funding calls. Also, "Sweden's Innovation Agency" (Vinnova 2024) has brought forward financing of initiatives for Education 4.0. The Swedish policies for Industry 4.0 are specifically emphasized by Production2030 (2024) a strategic innovation programme. The Production2030 initiative focuses greatly on Education 4.0, where they drive: a national research school with courses available for PhD students and company employees, a national education package with engineering courses at master level, on topics within Industry 4.0 available for all technical universities, and up-skilling for future manufacturing through web-based courses aimed for professionals with an engineering background (Produktion2030, 2024).

DISCUSSION

Understanding of Human-centric approach (I5.0) supports upskilling, learning organizations, continuous improvement and knowledge sharing in the companies (Ribeiro et al., 2022). Education means it is not only imparting knowledge, but it also enhances the individual's thinking ability, helping the individual to promote the standard of living and positioning in the global competitiveness which is aligned with several of the SDGs of the UN. The challenges refer to broader issues in educational and political spheres, therefore, they need dialogue and partnerships in different dimensions. Table 3 summarizes the policies of Brazil, India, Japan, and Sweden

Table 3. Comparison of Policies between countries (Brazil, India, Japan, and Sweden)

Country Policies	Funding bodies	Socio-Political target	Projects
Industry 4.0 (Brazil, 2016)	Brazilian investment to build laboratories to drive the IoT, which target a regulatory framework to: a) promote the establishment and dissemination of technical regulations and standards related to I4.0; b) encourage the provision of appropriate infrastructure and technological environments to support I4.0; c) promote the use of financial instruments to allow small suppliers to obtain financing for the construction of access networks.	Increase Brazilian independence in the primary sector, diversifying the economy.	• National M2M and IoT Communication Plan • Brazilian Digitization Program for creation and implementation of Strategic Business Plan • Agenda for a Brazilian Industry 4.0
Make in India (India, 2014)	Seeks to attract international investment and strengthen India's industrial sector by decreasing bureaucracy	Positioning India as a international player in Manufacturing, prioritizing funding in 25 sectors of Indian industry, decreasing dependence on Indian services sector	Industrial and Economic Corridors
STI Basic Plan (Japan, 1996/2021)	Government investment through research funds for disruptive innovation, scientific and technological innovation, and public/private R&D, which support 1) Changing into a sustainable and resilient society through the merging of cyberspace and physical space, 2) Creation of "knowledge" as a source of value-add by searching a more advanced society, and 3) HR Development and citizens to support a more advanced society.	Shifting the aging society into an innovative and sustainable society by harnessing diversity through technical and social transformation, strengthening the competitiveness of Japanese industry	• Moonshot Research and Development Program • Cross-ministerial Strategic Innovation Promotion - SIP Program • Public/Private R&D Investment Strategic Expansion - PRISM Program
Production2030 (Sweden, 2013)	A strategic innovation program with support from the research financing bodies Vinnova - Sweden's innovation agency; The Swedish energy agency; Formas - Swedish government research council for sustainable development	Renew and strengthen the competitiveness of the Swedish industry, to remain an attractive country of production, through innovative knowledge, strong collaborations, and cutting-edge technology.	• research and innovation projects • test and demonstration projects • idea projects

Table 4. Opportunities and challenges related to country policies for Education 4.0

Country	Opportunities	Challenges
Brazil	The Brazilian policies are aligned with SDG (ODS BRASIL, 2021), and include finance support and technology transfer cooperation. Specifically for the SDG 4 targets: • increase the amount of employees (adult and teenagers), both gender, who have relevant technical and vocational skills, for employment, decent jobs, and entrepreneurship, through education for sustainable development and sustainable lifestyles, human rights, gender equality, increasing of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and culture's contribution to sustainable development. • increase certificated professors, including international cooperation for academic training in emerging countries in partnership with developed countries	Investments to modernize manufacturing plants, technological infrastructure, and training of employees; and, secondly, to provide the necessary conditions to allow the participation of different industrial segments in the elaboration of technical standards that regulate the technological activities developed under I4.0. A partnership between Universities and Companies (SDG-17) to enable the upskilling of workers and educate the new workforce (i.e. Industrial master/doctorate) **a)** increase competitiveness and productivity of Brazilian companies through I4.0; **b)** introduce the use of I4.0 technologies in small and medium-sized companies; **c)** guarantee instruments so that technology-based company solutions can be offered and made available directly to companies; **d)** ensure stability and volume of resources at an affordable cost for the implementation of initiatives aimed at I4.0; **e)** avoid overlapping efforts by public and private institutions to solve the needs and demands of I4.0 in the country
India	The vision of India's higher education policy: • Quality, one or more specialized areas of interest, good thoughtful individuals having creativity, inquisitive, scientific temper, spirit of service, and ethical and constitutional values. • Optimal learning environments, support for students, and Internationalization. • Flexibility for the students to choose the different subjects in the stream. • Delivering high-quality higher education with equity and inclusion. • Higher education autonomous institutions empowered to drive excellence. It means that Higher education Institutions (HEI) shall develop and enunciate the Institutional development Plan (IDP) based on Innovation in teaching, development of innovative Pedagogy skills, quality and impact of research, professional development activities, and the transparency in recruitment process. Key objectives of Make in India (MII): • Job creation and skill enhancement. • MII initiative motivates Indian manufacturing into a Global center for manufacturing. • India has become a hub for foreign investors with a 76% increment in Foreign Direct Investment (FDI) from the year 2020 to 2021 (USD 12.09 billion) to FY 2021–22. • Indian economy is rising with an estimation of 7% Gross Domestic Product (GDP) during the years 2022 –2023 (Chaudhary and Pandey, 2023)	non-availability of digital strategy and technology, and lack of senior management support systems, industries think it is risky to invest in technologies and employee recruitment and training (Pasi, Mahajan, and Rane 2021). Increase of the Gross Enrolment Ratio (GER) in higher education institutes to 50% until 2035. To achieve this India requires 3.3 million more teachers based on the teacher-student ratio of 1:15 (Paras, 2022). The policy also intends to boost the education budget by up to 6% of the GDP. Challenges for MII are poor infrastructure, the GoI made a shift from the previous tax regime, and carrying forward the input credits into GST, power failures, and brownouts are very common endemics particularly in summer (Kumar, 2019).

Table 4. Cont.

Country	Opportunities	Challenges
Japan	• Early focus on social issues in addition to the I4.0. • Incorporating humanity and social science as part of science. • Attempting to abolish the humanities /Sciences division in education. • Explicit emphasis on dealing with Ethical, Legal, and Social Implications/Issues (ELSI) by converging natural science with humanities and social science. • Aiming toward recurrent education. • Realizing "engineering education for all" by strengthening STEAM education in elementary, middle, and high school education. • Encouraging young and female researchers to pursue academic careers.	• The convergence of humanity and social science is expected to be led by natural science researchers, not the other way around. • The disadvantage of international collaboration is due to the language barrier. • Less attention on PBL, work-integrated learning, and soft skills.
Sweden	Swedish Higher Education Institutes are free of charge (no course fees) for all Swedish citizens. This means that up-skilling and re-skilling offered within Engineering Education 4.0 can be offered free of charge. • Sweden has a strong tradition of supporting lifelong learning and competence development (including public education). • Part time courses, and online or blended education for competence development has been offered by Swedish HEIs over many years. • The importance of learning and being at the front of digitalization development is highlighted by the Swedish government. Specifically, the governmental body of the "Swedish National Digitalisation Council" demonstrates this intention. • Many Swedish research financiers, over some years, have emphasized calls focusing on increased digitalization and technologies within I4.0. • Research and development funding calls for (Engineering) Education 4.0 have been offered, at least to some extent.	• The Swedish Higher Education Institutions are each given a limited number of university credits to be distributed among all programs on all levels at each university. Adding new courses and curriculums focusing on competence development concerning I4.0 will compete with regular program education. • Difficulty sharing courses across universities to include expertise from different areas (Eriksson et al. 2022). This is due to the rigid academic Swedish Higher Educational system, which means the financing forms make it difficult to collaborate and share courses. • Existing education for lifelong learning, may not be on sufficiently advanced and deep level as is necessary for novel technologies. • Only lately the aspects of complementing I4.0 with I5.0 have come to rise in Sweden. Meaning, the human-centric implications may need more focus in the coming years. • However, there are examples in some subject areas of validating real competence. There is no uniform system for validation of real competence for industrial participants related to getting access to lifelong learning.

CONCLUSION

Searching for Research & Development independence and incentive ways for digital transformation, Brazil, India, Sweden, and Japan have created I4.0 policies. These countries influence I4.0 competences development based on education, and Table 4 indicates similarities related to opportunities and challenges among the policies developed by these countries. These four countries are expanding industrial digital transformation and the related social impact. A Society 5.0 implementation, more human-centered, was early perceived and relatively more advanced in Japan, while the European Union, including for Sweden, the relevance in adopting a technological transformation approach more based on the I5.0 view has been simultaneously increasing along I4.0 concepts implementation, which became more evident from 2021 onwards. Even considering the existence of various initiatives to meet the demands generated by the technological transformation for new competences and the development of a compatible Engineering Education 4.0, the findings indicate that a connection between the related aspects of I4.0 and I5.0 still represent a challenge for future research initiatives. An Engineering Education 4.0 design, considering both the new technological paradigm disseminated in the I4.0 movement and the human-centered approach proposed by the I5.0, is also highlighted as imperative when considering the policies developed by these countries.

Further Research

Additional research is suggested to understand how the perspective of integrating humans and its capacity for critical thinking, emphasized by I5.0 can be incorporated in engineering education to obtain a holistic view during the technological transformation. This will not only focus the attention on the technological aspects but also consider what is required from both blue and white-collar employees, highlighting management perspectives of I4.0 implementation. Further, it is relevant to identify what is recruited from new curriculums in engineering programs more focused on technological transformation, and how the education for regular engineering students and both blue and white collars employees i.e., lifelong learning and Work Integrated Learning (WIL) can be designed to facilitate digital transformation, greater, and more successful implementation of I4.0 technologies and digital transformation. Further research Comparing the relationship among HIE, Industry, and Local Research agencies is indicated.

Practical & Theoretical Implications

The paper supports engineering course coordinators in understanding how the digital transformation can influence the education 4.0 considering a cross-countries comparison perspective related to People, Organisation, and Society, indicating related challenges and opportunities. Usually discussed in individual and fragmented terms in the related literature, different elements of both I4.0 and I5.0 approaches interacting with the technological transformation (i.e. competencies, managerial practices, innovation, knowledge management, and learning) are addressed by the findings of this paper, supporting the parts involved on the necessary initiatives to make the technological transformation viable and sustainable (i.e. governments, policymakers,unions representatives, industrial managers, and HEIs), to enable actions in an integrated way.

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