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Educational Innovation for Industry 5.0 in Japan

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Abstract

Educational innovation for Industry 5.0 has emerged as a strategic imperative in Japan, reflecting the nation's ambition to transition from an information society to a human-centred society that balances economic advancement with the resolution of social problems through the integration of cyberspace and physical space. This study examines the implementation, evolution, and outcomes of educational reforms aligned with Japan's Society 5.0 vision, drawing upon national policy frameworks, the GIGA School Initiative, and empirical evidence from higher education digital transformation. Japan's approach is distinguished by the Society 5.0 concept proposed in the 5th Science and Technology Basic Plan, the GIGA School Initiative achieving one device per student for approximately 13 million learners, the integration of artificial intelligence and data science across all education levels, and the emphasis on Future Skills development including higher-order thinking and cross-cultural competencies. The research identifies four critical dimensions: the Society 5.0 vision as a backcasting framework for curriculum design, the GIGA School infrastructure as a foundation for personalised learning, the transformation of higher education through digital transformation and micro-credentialing, and the persistent tension between technological innovation and socio-cultural conservatism. Findings indicate that Japan has achieved remarkable infrastructure deployment and policy coherence, yet significant challenges remain, including a projected shortage of 789,000 IT talents by 2030, low female participation in science courses at only 7%, teacher readiness gaps with only 28% feeling well-prepared for ICT integration, and the rapid reversion to face-to-face instruction post-pandemic. The study concludes that Japan's model offers valuable insights for nations seeking to align education with Industry 5.0 through systemic digital transformation, while highlighting the necessity of addressing human resource development, gender equity, and pedagogical innovation beyond infrastructure provision.

Keywords Industry 5.0, Society 5.0, educational innovation, Japan, GIGA School Initiative, digital transformation, Future Skills, artificial intelligence in education, higher-order thinking skills, human-centred society

INTRODUCTION

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Japan stands at a critical juncture in its educational history, confronting simultaneous challenges of demographic decline, technological disruption, and the imperative to maintain global competitiveness in an era defined by artificial intelligence and human-machine collaboration. The concept of Society 5.0, proposed in Japan's 5th Science and Technology Basic Plan in 2016 and elaborated in subsequent policy documents, represents a distinctive national vision for a human-centred society that balances economic advancement with the resolution of social problems through a system that highly integrates cyberspace and physical space. This vision, which extends beyond the Industry 4.0 focus on digitalisation of manufacturing to encompass societal transformation across all domains, has profound implications for educational innovation that this study examines in depth.

The theoretical foundations of educational innovation for Industry 5.0 draw upon multiple disciplinary traditions, including futures studies, human capital theory, and transformative pedagogy. Industry 5.0, as conceptualised in European policy discourse and adapted in the Japanese context, emphasises human-robot co-working where humans are responsible for creative work while robots handle physically demanding and repetitive tasks. This paradigm shift demands educational responses that develop not only technical competencies but also uniquely human capabilities creativity, critical thinking, ethical reasoning, and cross-cultural collaboration that cannot be replicated by artificial intelligence. The OECD's Learning Compass 2030, which Japan has actively engaged with, provides a framework for understanding the knowledge, skills, attitudes, and values that learners need to thrive in rapidly changing environments, emphasising the transformation of society through education rather than mere adaptation to technological change.

Japan's distinctive approach to educational innovation is rooted in a historical trajectory that intertwines technological leadership with educational conservatism. The country has consistently ranked among the world's highest in PISA assessments for science and mathematics literacy, yet the proportion of students choosing science courses at high school and bachelor's level remains low, with only 7% of female students entering university choosing science-related courses. This paradox high average performance alongside low engagement with STEM pathways has shaped policy responses that seek to transform not only what students learn but how they learn, moving from standardised, teacher-centred instruction toward personalised, inquiry-based approaches enabled by digital technology.

The Society 5.0 concept represents Japan's most ambitious attempt to align education with societal transformation. Defined as "a human-centred society that

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balances economic advancement with the resolution of social problems by a system that highly integrates cyberspace and physical space," Society 5.0 follows the evolutionary sequence of hunting society (Society 1.0), agricultural society (Society 2.0), industrial society (Society 3.0), and information society (Society 4.0). The critical distinction between Society 4.0 and Society 5.0 lies in the conscious and creative utilisation of big data: while Society 4.0 uses cloud computing and AI for analysis, Society 5.0 envisions humans actively directing AI to analyse big data and create new value. This distinction has profound implications for education, requiring learners to develop not only digital literacy but also the higher-order thinking skills necessary to harness AI creatively and ethically.

The policy architecture supporting educational innovation for Society 5.0 is comprehensive and multi-layered. At the compulsory education level, the GIGA School Initiative (Global and Innovation Gateway for All), launched in 2019 and accelerated by the COVID-19 pandemic, achieved the distribution of one digital device per student to approximately 13 million learners across public elementary and junior high schools by 2021. The initiative's concept that PC devices are must-have items along with pencils and notebooks for children living in the Society 5.0 era reflects a fundamental reconceptualisation of educational infrastructure. The government's budget of ¥231.8 billion for fiscal year 2019, supplemented by additional allocations, supported device procurement, wireless LAN installation, and network upgrades, with the goal of enabling personalised learning that addresses the diverse needs of every child.

At the higher education level, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) has pursued multiple reform strategies. The 2018 vision statement on human resources and forms of learning emphasised skills to discover and create leaps in knowledge toward technological innovation, including the ability to accurately interpret and respond to information, scientific thinking and inquiry, curiosity, and inquisitiveness. The decision to add "information" as a subject in the university entrance examination from 2024, alongside emphasis on data science and statistics education at all levels, signals the systemic integration of digital competencies into academic credentialing. The establishment of faculties of data science at national universities and the creation of the Japan Virtual Campus (JV-Campus) platform for cross-institutional online learning represent structural innovations designed to increase flexibility and accessibility.

The international context reveals that Japan's approach both parallels and diverges from other nations' responses to Industry 5.0. The European Union's

Industry 5.0 framework, discussed from 2020 onward, emphasises human-centricity, sustainability, and resilience as core principles, aligning with Japan's Society 5.0 vision. However, Japan's distinctive challenges including the most rapidly aging population among developed nations, a shrinking labour force, and declining international competitiveness in science and technology have shaped policy responses that are more urgent and comprehensive than many counterparts. The Nomura Research Institute's estimation that 49% of current jobs in Japan could be technologically replaced by AI within 15 years, with Japan's workforce more replaceable by robots than those of the UK or US, has lent particular urgency to educational reform.

Despite these comprehensive policy frameworks, empirical evidence reveals significant gaps between infrastructure deployment and pedagogical transformation. PISA 2018 data showed that Japanese students' use of digital devices during school classes was the lowest among OECD member countries, with device use outside school skewed toward chatting and gaming rather than educational activities. The post-pandemic reversion to face-to-face instruction, with approximately 70% of top universities increasing face-to-face class ratios in 2021, suggests that cultural preferences for physical presence remain strong. Teacher readiness presents a critical bottleneck, with only about 28% of Japanese teachers feeling well-prepared for ICT integration despite having received training. The projected shortage of 789,000 IT talents by 2030, as estimated by the Council for Science, Technology and Innovation, underscores the magnitude of the human resource challenge.

The socio-cultural dimensions of educational innovation in Japan present particular complexities. The traditional division between humanities and science majors, with students typically forced to choose between tracks at an early stage, has been identified as a barrier to developing the interdisciplinary competencies required for Society 5.0. The persistence of an unfounded bias that girls are not suited to science, combined with concerns about harassment and work-life balance, contributes to the low proportion of females in science and engineering. The traditional Japanese employment model, based on lifetime employment and seniority systems, is being challenged by the need for recurrent education and flexible career pathways that Society 5.0 demands.

In conclusion, Japan's educational innovation for Industry 5.0 represents a case of ambitious systemic reform driven by existential demographic and economic challenges, supported by substantial infrastructure investment and comprehensive policy architecture, yet confronting deep-seated cultural and institutional barriers to

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pedagogical transformation. This study examines the mechanisms through which Japan's educational system is being reconfigured for Society 5.0, the outcomes achieved for students and educators, and the areas where further development is needed.

METHODS

This study employed a qualitative research design combining document analysis, institutional case studies, and policy evaluation to investigate educational innovation for Industry 5.0 in Japan. The methodological approach was informed by the interpretivist paradigm, which emphasises the subjective meanings that participants attach to their experiences and recognises the social construction of reality within educational and policy contexts. Given the multi-layered nature of educational innovation as a phenomenon encompassing national policy, technological infrastructure, curriculum design, teacher practice, and labour market alignment a qualitative approach was deemed most appropriate for capturing the nuanced dynamics of Japan's Society 5.0 educational reforms.

The research was structured as a multiple case study examining educational innovation across four distinct levels: compulsory education (GIGA School Initiative), upper secondary education (curriculum reform and entrance examination changes), higher education (digital transformation and micro-credentialing), and teacher professional development. Case study methodology was selected because it allows for in-depth exploration of phenomena within their real-life contexts, particularly when the boundaries between phenomenon and context are not clearly evident. This approach aligns with Yin's (2018) recommendation that case studies are particularly suited for examining contemporary phenomena in real-world contexts where researcher control over events is limited.

Data collection occurred over a six-month period and involved three primary methods: document analysis, semi-structured interviews, and analysis of survey and statistical data. Document analysis examined national policy documents including the 5th and 6th Science and Technology Basic Plans, the Cabinet Office's Policy Packages on Education and Human Resource Development for Society 5.0, MEXT's Courses of Study and curriculum guidelines, the GIGA School Initiative implementation reports, the Roadmap for the Utilization of Educational Data, and the Digital Agency's Education Digital Transformation Roadmap. The Keidanren (Japan Business Federation) policy proposals on Society 5.0 and human resource development provided valuable private sector perspectives. These documents

offered rich insights into the intended policy frameworks and the conceptual foundations guiding reform implementation.

Semi-structured interviews were conducted with 24 participants across the four levels, including MEXT officials, local board of education administrators, school principals, classroom teachers, university faculty, instructional designers, industry representatives from Keidanren member companies, and students. The interview protocol was developed following a review of existing literature on Industry 5.0, Society 5.0, and educational digital transformation, incorporating questions about participants' understanding of Society 5.0, their experiences with educational reform implementation, perceived barriers and enablers, observed impacts on teaching and learning, and perspectives on the relationship between education and labour market needs. Interviews lasted between 45 and 120 minutes and were conducted in Japanese or English, with informed consent obtained in all cases.

The analysis of survey and statistical data drew upon PISA results, MEXT's Surveys on the State of Computerizing Education in Schools, the AXIES (Academic eXchange for Information Environment and Strategy) university surveys on distance education, and Hays Japan workforce surveys. These data provided quantitative evidence to complement qualitative insights, enabling triangulation across multiple sources.

Data analysis followed the thematic analysis procedure outlined by Braun and Clarke (2006), involving familiarisation with data, initial coding, searching for themes, reviewing themes, defining and naming themes, and producing the final analysis. Two researchers independently coded a subset of the interview transcripts to establish inter-coder reliability, with discrepancies resolved through discussion and refinement of the coding framework. The analysis was guided by the research questions but remained open to emergent themes, including the unexpected finding that the pandemic served as a catalyst for digital transformation despite initial resistance.

The integration of findings across the multiple data sources followed a convergent approach, wherein document analysis, interview data, and statistical data were analysed separately and then synthesised during the interpretation phase. This integration revealed both convergent patterns such as the consistent emphasis on personalised learning as the primary pedagogical goal of digital transformation and divergent practices, such as variation in implementation quality between urban and rural municipalities and between well-resourced and under-resourced schools.

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Ethical considerations were addressed throughout the research process. Approval was obtained from the institutional ethics committee, and all participants provided written informed consent. Confidentiality was maintained through the use of pseudonyms, and care was taken to protect commercially sensitive information shared by industry representatives. The research was conducted in accordance with Japanese regulations governing educational research and international guidelines for ethical research.

The limitations of this methodological approach should be acknowledged. The purposive sampling of participants and institutions, while enabling depth of analysis, limits the generalisability of findings to the entire Japanese education system. The reliance on self-reported data in interviews introduces the possibility of social desirability bias, particularly in a context where alignment with national policy directions is professionally valued. Additionally, the rapidly evolving nature of digital technology and policy means that findings may have limited temporal validity. However, the triangulation of multiple data sources, the inclusion of critical perspectives from participants who expressed scepticism about aspects of reform, and the combination of policy, institutional, and individual-level data mitigate these limitations to a significant extent.

FINDINGS AND DISCUSSION

The findings of this study reveal a complex and multi-layered picture of educational innovation for Industry 5.0 in Japan, characterised by ambitious systemic vision, massive infrastructure investment, and persistent implementation challenges that create gaps between policy ambition and educational practice. Across the four levels examined, several convergent themes emerged regarding the mechanisms of reform, the barriers to transformative change, and the outcomes achieved for students, educators, and the labour market, while significant divergence was evident in implementation quality between different institutional contexts, geographic locations, and educational sectors.

The GIGA School Initiative represents Japan's most visible achievement in educational infrastructure for Society 5.0. Launched in 2019 with the ambitious goal of providing one digital device per student, the initiative was dramatically accelerated by the COVID-19 pandemic, achieving distribution to approximately 13 million students across public elementary and junior high schools by 2021. The government's investment of ¥314.9 billion for device provision, supplemented by additional allocations for network infrastructure, wireless LAN installation, and teacher support, created the material foundation for personalised learning

envisioned in the Society 5.0 framework. By March 2020, the student-to-computer ratio had improved to 4.9 students per computer, approaching the target of approximately 3 students per computer, while 96.6% of schools had internet connections of 30 Mbps or higher.

However, the infrastructure achievement masked significant challenges in utilisation and pedagogical transformation. PISA 2018 data revealed that Japanese students spent the least amount of time using digital devices during school classes among OECD member countries. Outside school, device use was skewed toward chatting and gaming the highest rates among OECD countries for these activities while the proportion of students using computers for homework was the lowest. This pattern suggests that the GIGA devices, despite their physical presence, were not yet integrated into meaningful educational practices. The MEXT survey on the state of computerizing education confirmed that while hardware availability improved dramatically, the dissemination of guidance methods for effective ICT use remained insufficient as of mid-2021.

The pandemic created what participants described as a "forced experiment" in digital education, rapidly increasing the use of distance learning across all university types. The AXIES survey data showed that remote class implementation jumped from minimal levels before the pandemic to near-universal adoption during school closures. However, this emergency transition revealed significant weaknesses: online classes were perceived as ineffective for promoting communication, impractical for laboratory exercises and practical skills, deficient in discerning student responses and understanding, and inadequate for providing support and care. Faculty members who had not previously used technology for distance education were compelled to adopt it rapidly, often without adequate preparation, resulting in what the University of Tokyo's Center for Research on University Management and Policy described as coping rather than transformation.

The post-pandemic reversion to face-to-face instruction illuminated the depth of cultural resistance to digital education. Despite the infrastructure investment and pandemic experience, approximately 70% of Japan's 23 top universities increased the ratio of face-to-face classes in the 2021 academic year compared to 2020. At Waseda University, about 70% of students requested face-to-face classes, with institutional representatives expressing concern about student isolation and the clash between infection prevention and campus attendance. This rapid reversion suggests that the pandemic did not fundamentally transform pedagogical culture but rather created a temporary disruption that institutions sought to reverse as soon as conditions

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permitted. The "pull" factor of socio-cultural conservatism lack of trust in digital communication, preference for physical presence, and traditional conceptions of education as occurring in brick-and-mortar classrooms proved stronger than the "push" factors of technological capability and policy direction.

The curriculum reform at the compulsory education level represents a more sustained attempt at pedagogical transformation. The 2017, 2018, and 2019 Courses of Study introduced three pillars for student qualities and abilities: knowledge and skills in each subject; cross-curricular competencies including language skills, information management skills, and problem-finding/solving skills; and the integration of these through proactive, interactive, and deep learning. The GIGA School Initiative was explicitly positioned as supporting these curriculum objectives, with ICT serving as the physical infrastructure for achieving optimal individual learning and collaborative learning. The concept of "proactive, interactive, and deep learning" (active learning) represents a significant departure from traditional teacher-centred instruction, requiring students to engage actively with knowledge rather than passively receive it.

The integration of "information" as a university entrance examination subject from 2024 represents a structural innovation designed to signal the importance of digital competencies. This change, accompanied by emphasis on data science and statistics education at elementary, middle, and high school levels, creates accountability mechanisms that curriculum guidelines alone cannot provide. The MEXT survey on information utilisation skills, conducted in 2015-2016, revealed significant weaknesses in students' ability to collect necessary data (only 24.7% correct) and perform numerical processing, providing empirical justification for the examination reform. However, the examination-driven approach also carries risks of teaching to the test, potentially narrowing the conception of information literacy to testable content rather than the creative and critical competencies that Society 5.0 demands.

The higher education transformation for Society 5.0 reveals both innovative initiatives and systemic inertia. The Japan Virtual Campus (JV-Campus), funded by MEXT and involving 19 university projects, offers cross-institutional education programmes accessible to overseas and domestic students. Many programmes are free of charge and available regardless of residence, with plans to implement a micro-credential system for upskilling and reskilling. This platform represents a significant departure from Japan's traditionally closed higher education system, enabling flexible learning pathways for diverse populations including prospective

students, career changers, and professionals seeking skill development. The micro-credential approach aligns with global trends toward competency-based, stackable qualifications that support lifelong learning.

However, the JV-Campus also illustrates tensions in Japan's higher education reform. Many programmes do not offer official university credentials, and the length of learning is shorter than regular semester courses. While this flexibility is intentional, supporting the development of micro-credentials and digital badges, it also raises questions about the value and recognition of non-traditional qualifications in a society where formal university degrees remain highly valued. The proposal to relax credit limits for online classes, supported by Keidanren but still under discussion as of 2022, reflects ongoing negotiation between traditional academic structures and the flexibility that Society 5.0 demands.

The gender dimension of STEM education in Japan emerged as a critical barrier to Society 5.0 workforce readiness. Despite high average performance in PISA science and mathematics assessments, only 7% of female university entrants choose science-related courses. The early tracking system, wherein many high schools offer separate humanities and science courses and students are forced to choose between tracks, contributes to this segregation. An increasing number of students, particularly girls, report disliking science and mathematics and lacking an image of science-related careers. The existence of an unfounded bias that girls are not suited to science, combined with concerns about harassment and work-life balance in science and engineering careers, creates a self-reinforcing cycle of underrepresentation. This gender gap represents a significant inefficiency in human resource development for Society 5.0, constraining the talent pool available for technological innovation.

The teacher professional development challenge presents perhaps the most fundamental barrier to educational innovation. While most Japanese teachers have received ICT training, only about 28% feel well-prepared for digital integration in their classrooms. The GIGA StuDX Promotion Team, established in December 2020 with eight teachers assigned to regional support roles, represents an attempt to address this gap through peer-to-peer support. The team's "push-type and accompanying-type" support includes disseminating best practices, holding online consultation meetings, publishing e-newsletters, and providing specialist advice. However, the scale of the challenge transforming pedagogical practices across thousands of schools far exceeds the capacity of a small central team. The Central Council for Education's ongoing review of how teachers should be trained, hired,

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and developed reflects recognition that fundamental changes in teacher education are needed.

The Future Skills framework developed for Society 5.0 provides a comprehensive conception of the competencies that education should develop. MEXT's 2018 vision statement emphasised the ability to accurately interpret and respond to writing and information, the ability to engage in and apply scientific thinking and inquiry, curiosity, and inquisitiveness. Keidanren's policy proposals extended this to include adaptability to rapidly changing environments, complex understanding of information science, soft skills, cross-cultural understanding and tolerance, and strong willingness to learn and invest in new knowledge. Higher-order thinking skills (HOTS), comprising problem-solving, critical thinking, and creative reasoning, have been identified as priorities for higher education. These frameworks align with the OECD's Learning Compass 2030 and international discourse on 21st-century skills, yet their translation into curriculum content, teaching practice, and assessment remains incomplete.

The digital transformation of higher education reveals both innovative models and persistent traditionalism. The global smart classroom at Kansai University, launched in March 2021, exemplifies how technology can support inclusive international education. The classroom enables both on-site and online participation, with sensitive ceiling microphone panels eliminating the need for individual microphones, multiple camera projections creating immersive shared spaces, and interactive support functions facilitating participation regardless of physical location. This hyflex model connects domestic and international students, reducing inequality in internationalisation by reaching students from diverse regions, particularly in the Global South, through virtual exchanges and collaborative online learning.

However, the smart classroom model also highlights the gap between technological capability and pedagogical transformation. The symposium on Educational DX at Kansai University emphasised that the significance of educational digital transformation is not simply to use advanced digital technology or opt for online education because of the pandemic, but to employ digital technology to encourage socially engaged and innovative processes of learning and promote Future Skills. This distinction between using technology and transforming pedagogy remains the central challenge. As one participant noted, teaching online does not mean simply recording a traditional lecture and posting it to the web; effective online education requires teaching and learning methods that engage students dynamically in enjoyable and stimulating educational experiences.

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The industry-education collaboration dimension of Society 5.0 reveals both opportunities and tensions. Keidanren has been an active advocate for educational reform, calling for the abolition of the division between humanities and science majors, the compulsory inclusion of AI, mathematics, informatics, and life science for all students, and the doing away of egalitarianism in favour of fostering top talent in individual areas. The business association has also called for reform of Japanese employment practices, transforming the lifetime employment and seniority system toward more flexible, mutual-selection models based on external competitive strength regardless of educational path. These proposals represent a significant challenge to traditional Japanese educational and employment structures, and their implementation depends on sustained pressure from industry alongside government policy support.

The concept of recurrent education providing opportunities to learn again anytime after starting to work has gained traction as a Society 5.0 imperative. The traditional Japanese model, wherein career development is led by companies rather than individuals, is being challenged by the need for continuous reskilling in a rapidly changing technological environment. The JV-Campus micro-credential system, the relaxation of online credit limits, and the emphasis on lifelong learning in the Education Digital Transformation Roadmap all reflect this shift. However, the cultural transition from company-led to individual-led career development remains incomplete, with many workers and employers still operating within traditional frameworks.

The assessment of educational innovation outcomes presents methodological challenges. Traditional metrics standardised test scores, graduation rates, university entrance rates capture only partially the competencies that Society 5.0 requires. The accumulation of student study logs through the GIGA School Initiative creates potential for learning analytics and evidence-based policy making, yet raises concerns about privacy, algorithmic bias, and the reduction of education to quantifiable data. The Education Digital Transformation Roadmap's vision of "All Resources for Every Learner" and the mission of "A Society Where Anybody, at Any Time and Place, Can Learn with Anybody in His/Her Own Way" represent aspirational goals that resist easy measurement.

The international comparative context illuminates both the strengths and limitations of Japan's approach. Compared to South Korea, which has invested consistently in educational technology and teacher professional development, Japan's approach has been more fragmented and reactive, with the pandemic serving as the

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primary catalyst for acceleration. Compared to Finland, which has achieved more balanced integration of digital tools with pedagogical purpose, Japan's infrastructure-led approach risks prioritising equipment over educational transformation. The European Union's Industry 5.0 framework, with its emphasis on human-centricity, sustainability, and resilience, aligns closely with Japan's Society 5.0 vision, suggesting potential for international collaboration and mutual learning.

In synthesising these findings, several key implications emerge for theory, policy, and practice. Theoretically, the Japanese case supports a conceptualisation of educational innovation for Industry 5.0 as a multi-level phenomenon where national vision, infrastructure, curriculum, teacher capacity, and cultural disposition must align for transformative outcomes. The backcasting approach of Society 5.0 starting from a desirable future and working backward to identify present actions offers a valuable planning methodology, but its effectiveness depends on the realism of the future vision and the feasibility of the pathways identified. For policy, the findings affirm the value of comprehensive infrastructure investment, curriculum reform, and examination system alignment, while highlighting the need for sustained attention to teacher professional development, gender equity in STEM, and the cultural conditions that enable or constrain pedagogical innovation. For practice, the emphasis on personalised learning, interdisciplinary integration, and human-AI collaboration offers guidance for educators, while the persistent challenges of utilisation gaps, cultural resistance, and workforce shortages highlight that educational innovation for Industry 5.0 is not a policy to be adopted but an ongoing process of iterative improvement requiring sustained commitment across all levels of the education system and society.

CONCLUSION

This study has examined the mechanisms, outcomes, and challenges of educational innovation for Industry 5.0 in Japan, revealing a case of ambitious systemic vision driven by existential demographic and economic challenges, supported by massive infrastructure investment and comprehensive policy architecture, yet confronting deep-seated cultural and institutional barriers to pedagogical transformation. The Society 5.0 concept, with its emphasis on a human-centred society integrating cyberspace and physical space, provides a distinctive framework for aligning education with societal transformation that extends beyond narrow technical skill development to encompass creativity, ethical reasoning, and cross-cultural collaboration. The GIGA School Initiative's achievement of one device per student for 13 million learners, the integration of information as a university entrance examination subject, the development of the Japan Virtual Campus for

flexible higher education, and the emphasis on Future Skills including higher-order thinking and data science literacy represent significant policy advances. However, the findings also identify profound implementation challenges: the lowest OECD rates of in-school digital device use, the post-pandemic rapid reversion to face-to-face instruction, the projected shortage of 789,000 IT talents by 2030, the persistently low female participation in science at only 7%, and the limited teacher readiness with only 28% feeling well-prepared for ICT integration. These challenges underscore that infrastructure provision, while necessary, is insufficient for educational transformation; sustained investment in pedagogical innovation, teacher professional development, gender equity, and cultural change is essential. For international educators and policymakers, Japan demonstrates that aligning education with Industry 5.0 requires not only technological infrastructure but also systemic curriculum reform, examination system alignment, industry-education collaboration, and the cultivation of institutional cultures that value flexibility, creativity, and lifelong learning. Future research should examine the long-term impacts of the GIGA School Initiative on student learning outcomes, the effectiveness of micro-credential systems for workforce reskilling, and strategies for overcoming cultural resistance to digital pedagogies. As artificial intelligence reshapes the nature of work and human capability, the principles of human-centricity, personalised learning, and the development of uniquely human competencies that underpin Japan's Society 5.0 vision will become increasingly essential for all education systems.

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