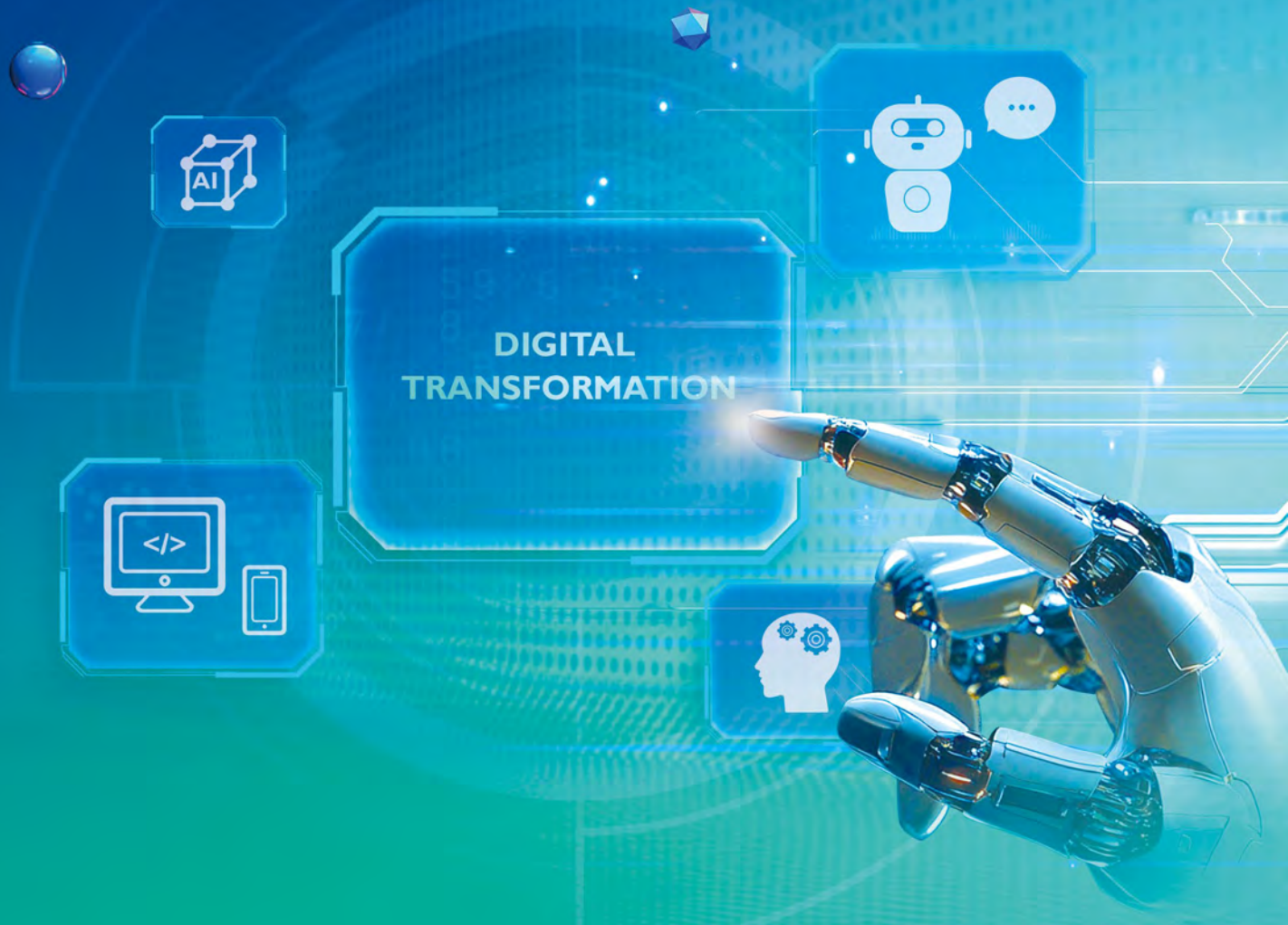
2024 GSENet Annual Report

Executive Summary

Global Understanding of Smart Education in the Context of Digital Transformation



August 18, 2024

Global Smart Education Network (GSENet)

Global Understanding of Smart Education in the Context of Digital Transformation

Published in 2024 by Smart Learning Institute of Beijing Normal University, 12F, Block A, Jingshi Technology Building, No. 12 Xueyuan South Road, Haidian District, Beijing, 100082, China

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Please cite the work as follows:

Huang, R.H., Liu, D.J., Kanwar, A.S., Zhan, T., Yang, J.F., Zhuang, R.X., Liu, M.Y., Adarkwah, M., Li, Z.S. (2024). Global Understanding of Smart Education in the Context of Digital Transformation. Beijing: Global Smart Education Network and Smart Learning Institute of Beijing Normal University

Global Understanding of Smart Education in the Context of Digital Transformation

Global Smart Education Network
Smart Learning Institute of Beijing Normal University

August 18, 2024

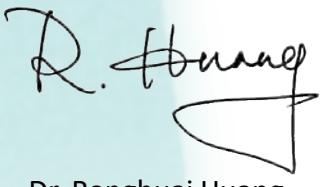
Foreword

The United Nations Sustainable Development Goal 4 (SDG4) focuses on ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all. The United Nations highlighted the importance of harnessing the digital revolution to benefit public education. Consequently, many countries are placing significant emphasis on digital education, actively developing national-level policy frameworks that utilize next-generation digital technologies to transform educational practices. In this context, smart education has emerged as a key component in national planning documents, aiming to promote educational equity and enhance the quality of education.

Following the joint UNESCO project on Rethinking and Redesigning National Smart Education Strategy (SmartEDU) initiated by UNESCO Institute for Information Technologies in Education (UNESCO IITE), Commonwealth of Learning (COL), International Society for Technology in Education (ISTE), Higher School of Economics (HSE), Beijing Normal University (BNU) since August 2020, this report aims to consolidate the global understanding of smart education in the context of digital transformation. We aim to investigate diverse perspectives from different countries and regions to build a global consensus, pinpoint the key areas of digital education policies for the advancement of smart education worldwide, illustrate the state of smart education through public datasets, and promote inclusiveness and equity within the realm of smart education.

Furthermore, this report strives to support educators, researchers, and practitioners in adapting and implementing smart education within their own contexts. We aspire to collaborate more closely with all partners to advance our shared mission, particularly in this digital education transformation times.

On behalf of SLIBNU and UNESCO IITE, we would like to thank our partners from China and abroad. Our special thanks go to the National Commission of the People's Republic of China for UNESCO for their incredible support during the realization of this publication. We also acknowledge with gratitude contributions for this publication from 111 international experts among 52 countries.



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Acknowledgements

We would like to express our profound gratitude to the many individuals and organizations whose contributions made the successful completion of this report possible. Their collective efforts, expertise, and unwavering dedication were vital in every stage of this project.

First and foremost, we extend our deepest appreciation to UNESCO headquarters, especially Miss Stefania Giannini, UNESCO Assistant Director-General for Education, Mr. Sobhi Tawil, Director of the Future of Learning and Innovation division, Mr. Fengchun Miao, Chief of the Unit for Technology and AI in education, and other experts from UNESCO, for your vision and insights in technology in education and the future of education, and all your support for the GSE conference and this report.

The report is finished under the leading of the UNESCO Institute for Information Technologies in Education (UNESCO IITE), the Smart Learning Institute of Beijing Normal University (SLIBNU), and Hangzhou Normal University (HZNU). Their visionary leadership and collaborative spirit were the driving forces behind this research. The support, resources, and guidance provided by these institutions were crucial to the successful execution of this report, and we are sincerely grateful for their contributions.

We also wish to acknowledge and thank the key researchers who played an essential role in the organization and leadership of this project. We are particularly indebted to Junfeng Yang from HZNU, Rongxia Zhuang from Beijing Normal University (BNU), and all the members who took part in the writing process of the report and who willingly gave support to the completion of the report. Their expertise, commitment, and collaborative efforts were instrumental in shaping the direction and outcomes of this work.

Finally, we recognize the hard work, dedication, and tireless efforts of all who contributed to the research, content development, and coordination of this report. It is through their combined efforts that this report has come to fruition, and we deeply appreciate their invaluable support in making this project a success.

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1 Common Understanding and Regional Adoption of Smart Education from a Global Perspective

The rapid development of digital technology, especially generative artificial intelligence, had a revolutionary impact on the digital transformation of education. Smart education aligns with the goal of digital transformation and emerges as a viable choice for promoting equitable, inclusive, and high-quality education. The concept of smart education remains fluid, dynamic, and contested, taking on various meanings across different spatial, institutional, and national contexts. This variability leads to divergent strategies in its adoption and implementation.

1.1 Global Understanding of Smart Education

1.1.1 The Role of Smart Education for Education Agenda 2030

The Sustainable Development Goal 4 (SDG4) aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all by 2030 (United Nations, 2015). However, the rapid pace of technological transformation puts pressure on education systems to adapt. As highlighted in the Global Education Monitoring Report 2023, many countries lack digital guidelines and struggle with integrating digital technology effectively into education systems (UNESCO, 2023).

The Transforming Education Summit by United Nations (2022) called on countries to fully harness the power of the digital revolution to drive global education reform and ensure the provision of high-quality education and lifelong learning for everyone (United Nations, 2022).

The concept of smart education aligns with UNESCO's Futures of Education initiative, which calls for action and innovative ideas to renew education (UNESCO, 2021). The development of smart education is a major endeavor in educational reform that requires systematic and scientific planning.

1.1.2 Investigation of Smart Education across the Five Regions

The concept of smart education is an evolving one and is understood differently across diverse institutional, national and regional contexts. Therefore, it is imperative to consolidate the various understandings of smart education from different countries and regions to form a global consensus.

- **Survey Process and Topic Identification**

A Delphi method and questionnaire were employed from March to July 2024 to gather insights from a broad range of educators, policymakers, and scholars from different regions, with the aim of developing a global understanding on smart education.

- **Participants**

The survey involved a total of 92 participants across 41 countries, covering the Asia and Pacific, Western Europe and North America, Eastern Europe, Africa, and the Latin America and the Caribbean regions (As shown in Appendix A).

Based on participants' affiliations, they were grouped into the following stakeholder categories: leading academics and scholars, renowned researchers from prestigious institutes, influential figures in non-profit organizations, key policymakers, and officials from regional and international organizations, among others.

All participants evaluated the importance of each feature, and Kendall's coefficient of concordance, ranging from 0 to 1, was calculated to indicate the level of agreement among raters. The high coefficients reveal a strong consensus among experts on the critical role these features play in achieving smart education. The results particularly highlight the importance of sustainable educational reforms and multi-sectoral collaboration and in driving smart education initiatives.

- **Common Awareness of Smart Education**

Smart education, often perceived as an enhancement of current educational practices, is regarded as synonymous with both good education and future education [1]. As a term, smart education is continuously evolving, reflecting the dynamic nature of educational advancements over the past decades . This term aligns with the United Nations' vision of the future of education[2] .

Smart education systems can be depicted from two key perspectives: the performative features, which represent the vision of future education, and constructive features, which provide actionable steps towards realizing this vision (Huang et al., 2023). Through an analysis of experts' discourse and open-ended question responses, the performative and constructive features of smart education can each be categorized into five key points.

1.1.3 Performative Features: Smart Education as the Shared Vision of Education

- **Student-centered Teaching and Learning**

Student-centered learning is an instructional approach that places the student at the center of the learning process, emphasizing their active participation, engagement, and autonomy (Liu, 2017). The increasing integration of technology into classrooms has significantly influenced the evolution of teaching methods, educational models, and student learning environments.

- **Comprehensive Learning Assessment**

Learning assessment is crucial in the educational process as it influences the behaviors of both teachers and students, leading to enhanced engagement during instructional activities. Learning assessment methods should be diversified and categorized as assessment of learning, assessment for learning, and assessment as learning to facilitate holistic student growth.

- **Smart and Ubiquitous Learning Environment**

Learning environments are integral to the teaching and learning process, serving as crucial contexts that facilitate educational activities (Gao et al., 2017). A smart learning environment represents a sophisticated evolution of traditional digital learning settings, seamlessly merging physical and virtual elements to provide personalized learning support and services based on individual learner characteristics (Huang, 2014).

- **Culture of Continuous Improvement**

Educational culture is the foundation for guiding educational reform and should permeate all aspects of the education system. At the school level, continuous improvement is essential to adapt to educational changes (Liang & Huang, 2010).

1 Som Naidu's speech at the online workshop "Navigating the Future: Bridge Smart Education around the World" (Asia&Pacific). (2024). https://aiedchair.bnu.edu.cn/navigating-the-future%ef%bc%9abridging-smart-education-around-the-world/

1 Kanwar, A.'s speech at the online workshop "Navigating the Future: Bridge Smart Education around the World" (Asia&Pacific). (2024). https://aiedchair.bnu.edu.cn/navigating-the-future%ef%bc%9abridging-smart-education-around-the-world/

2 Carlos Alberto Pereira de Oliveira.'s speech at the online workshop "Navigating the Future: Bridge Smart Education around the World" (the Americas). (2024). https://aiedchair.bnu.edu.cn/navigating-the-future%ef%bc%9abridging-smart-education-around-the-world/

Effective school improvement reshapes the internal environment to achieve educational goals (Van Velzen et al., 1985).

- **Commitment to Inclusion and Equity in Education**

Inclusiveness and equity are fundamental pillars of high-quality education. Smart education must address the needs of both students and educators, promoting diverse representation in decision-making processes. Advancing inclusive, equitable, and resilient education requires involvement from various spheres, including learning, culture, and society.

1.1.4 Constructive Features: Sustainable Pathways to Achieve Smart Education

- **Social Learning Communities**

In the evolving landscape of contemporary education, the concept of social learning communities has become increasingly significant. In this community, students not only share knowledge and experiences within the group but also enhance their self-management, interpersonal communication, and teamwork abilities through interactions.

- **Ethical Adoption of ICT in Education**

Pursuing smart education necessitates a careful balance between safeguarding personal information and enabling authorized access. Ensuring algorithmic interpretability within education is paramount; this involves prioritizing reliability, control, transparency, and inclusivity (Wang et al., 2021).

- **Prioritization of Teacher Professional Development**

Professional development is more than just a necessity. It is the foundation for achieving educational quality and equity, particularly in diverse, technology-driven classrooms.

- **Sustainable Plan for Educational Reform**

In advancing educational excellence in the digital age, it is essential to address several interconnected areas that collectively enhance the capabilities of educators and the learning experiences of students.

- **Effective Multi-Sectoral Collaboration**

Intelligent technology has significantly enhanced multi-sectoral collaboration in public education, broadening the reach and impact of educational services (Zeng, 2017). Strategic partnerships between government agencies, businesses, education institutions, research organizations, and other stakeholders, can foster a collective approach to advancing education as a public good.

1.2 Focus of Smart Education Across Regions

In envisioning modernized digital learning ecosystems, national government leaders must adopt a multi-faceted strategy with four critical leverage points: transformative teaching and learning enabled through technology, smart learning environments conducive to smart education, forward-thinking governance and policy initiatives, and overarching considerations across the three leveraging points (UNSECO IITE, 2022).

1.2.1 Transformative Teaching and Learning Enabled through Technology

- **Asia and the Pacific**

The focus of the Asia-Pacific region is on integrating digital tools into culturally diverse curricula, which enhances teachers' technological capabilities and fosters personalized learning environments tailored to local needs. However, challenges such as the uneven development of infrastructure, varying levels of teachers' proficiency in integrating technology into teaching and learning, and the complexities of multilingual contexts impede the full realization of these transformative efforts. The digital divide exacerbated by inadequate access to devices and the high costs of connectivity,, in particular, remains a barrier to equitable access and effective implementation of technology in education.

- **Western Europe and North America**

In Western Europe and North America, the current focus is on fostering innovative, student-centered

learning environments that prioritize individuality and engagement. Through global best practices and cross-cultural exchanges, educators are continually developing their professional skills to effectively integrate smart education tools. Nevertheless, the region faces challenges such as over-reliance on technology and the persistent digital divide, which can hinder the equitable distribution of educational benefits. Comprehensive and continuous professional development remains critical to ensure that educators can fully harness the potential of these technologies.

- **Eastern Europe**

In Eastern Europe, the push for transformative teaching and learning through technology is characterized by the need for flexible and adaptive educational strategies. The region is working towards aligning educational programs with rapidly evolving pedagogical trends by adopting demand-driven, technology-enabled approaches.

- **Africa**

Africa is increasingly recognizing the potential of technology to enable transformative teaching and learning, yet Sub Saharan Africa faces significant hurdles in this endeavor. The focus is on overcoming the constraints posed by limited funding and resources to invest in technology and infrastructure, which are critical for fostering innovative educational practices. Teacher training and professional development are pivotal in bridging the skills gap and ensuring that educators can effectively use technology to enhance learning outcomes.

- **Latin America and the Caribbean**

Latin America and the Caribbean are actively exploring ways to use technology to drive transformative changes in teaching and learning. The region is rethinking curricula and pedagogy within a systemic vision that connects education more closely with societal needs. Despite these efforts, challenges remain, including the prohibitive costs of technology, especially for resource-constrained schools and districts. Ensuring the continuous maintenance and updating of technological infrastructure requires ongoing investment, and the variability in context, particularly in marginalized areas, adds further complexity.

1.2.2 Smart Learning Environments Conducive to Smart Education

- **Asia and the Pacific**

The Asia and the Pacific region are actively promoting the development of smart learning environments to meet the diverse learning needs of students. The focus is on designing and building interactive, technology-enhanced physical and virtual learning spaces. These environments aim to enhance student engagement and improve learning outcomes. However, key challenges include infrastructure development in remote areas, paucity of ongoing technical support for digital platforms and devices, and ensuring that both teachers and students have the capacity to effectively adapt to and fully utilize these smart learning environments.

- **Western Europe and North America**

Western Europe and North America place great emphasis on applying research-based, proven smart learning technologies, including AI with a focus on optimizing the educational process and enhancing personalized student experiences. These regions are committed to creating dynamic, interactive, and personalized smart learning environments that leverage technology to improve student outcomes. However, challenges include addressing ethical concerns in smart learning environments and providing leadership that can guide the educational transformation responsibly and transparently.

- **Eastern Europe**

Eastern European countries are focused on effectively integrating smart learning environments into education systems. The region emphasizes aligning educational policies with practice to support the widespread application of learning technologies. Efforts include enhancing the digital literacy of teachers and students, increasing public budgets, and developing long-term sustainability plans to ensure the continued effectiveness of smart learning environments. However, major challenges include entrenched traditional teaching

methods and the high costs associated with the technical support and maintenance of smart learning technologies.

- **Africa**

Africa is striving to build diverse smart learning environments to support the development of smart education. The primary focus is on addressing funding and resource allocation issues while emphasizing teacher training and the application of technology in smart learning environments. However, the high costs of developing and maintaining smart learning infrastructure, ensuring data privacy and addressing security issues remain key concerns.

- **Latin America and the Caribbean.**

Latin America and the Caribbean countries aim to ensure that every learner benefits from smart education. Many schools lack adequate infrastructure for seamless technology integration. Insufficient internet access, and outdated devices, hindering effective implementation. Developing digital resources with high quality, providing technical support, and maintaining devices incur high costs where budget constraints may hinder widespread adoption.

1.2.3 Forward-Thinking Governance and Policy Initiatives

- **Asia and the Pacific**

In Asia and the Pacific, forward-thinking governance and policy initiatives are at the forefront of advancing smart education. The region is focused on crafting and executing comprehensive education strategies that are supported by strong political commitment. These initiatives include fostering partnerships among educational institutions, technology companies, and research organizations to drive innovation. Despite of these efforts, the region faces challenges such as the need for extensive teacher training, substantial investments in technological infrastructure, and ensuring that policies are implemented in an equitable and sustainable manner.

- **Western Europe and North America**

Western Europe and North America region exemplify forward-thinking governance by involving practitioners in policy-making processes, thereby bridging the gap between theory and practice in smart education. These regions place a strong emphasis on certification and continuous professional development to uphold high standards.

- **Eastern Europe**

Eastern European countries are implementing forward-thinking governance and policy initiatives aimed at advancing smart education through digital transformation. These initiatives focus on ensuring equitable access to education, enhancing teacher professional development, innovating curricula, and fostering public-private partnerships.

- **Africa**

In Africa, forward-thinking governance is crucial, particularly in creating equitable policy frameworks and effective resource allocation strategies. Governments in the region are focusing on addressing funding disparities, improving resource distribution, and advancing teacher professional development.

- **Latin America and the Caribbean**

Latin America and the Caribbean are advancing progressive governance and policy initiatives which focus on expanding access to education but also on transforming the quality of learning through the integration of intelligent technologies. A key priority within these strategies is ensuring that education systems are inclusive, catering to the diverse needs of all learners, including marginalized and disadvantaged groups.

1.2.4 Overarching Considerations Across All Leverage Points

- **Asia and the Pacific**

The Asia-Pacific region presents a complex educational landscape, marked by vast cultural and economic diversity. Countries in this region are at various stages of integrating inclusive practices and fostering continuous improvement in education. The focus is on leveraging technological innovations to enhance educational access and quality, particularly in remote areas. The region's challenges include bridging significant disparities in resource

allocation and infrastructure, adapting education systems to the demands of rapidly changing economies, and ensuring that educational practices are culturally responsive.

- **Western Europe and North America**

Western Europe and North America leads in educational innovation, with systems that emphasize inclusivity, equity, and continuous improvement. These regions are characterized by their strong educational infrastructure, robust policy frameworks, and advanced integration of technology into teaching and learning processes. However, even these regions face challenges, such as addressing the educational needs of increasingly diverse populations, closing achievement gaps related to socio-economic disparities, and adapting to the evolving demands of the 21st-century workforce. Collaborative efforts between government, private sector, and civil society are essential in maintaining and advancing the high educational standards in these regions.

- **Eastern Europe**

Eastern Europe is in the midst of educational transformation, driven by the need to modernize systems that were often shaped by complex factors. The focus in this region is on enhancing educational equity, particularly in response to the socio-economic disparities that exist between urban and rural areas, and within post-transition economies. Efforts are being made to modernize curricula, improve teacher training, and integrate digital technologies into classrooms. However, the region faces challenges, including brain drain, inadequate resource allocation issues, and the need to align educational outcomes with labor market demands in a rapidly changing economic environment.

- **Africa**

The educational aspirations of the African region are characterized by a dynamic blend of progress and challenges, particularly in the areas of inclusion and equity, continuous improvement culture, and multi-sectoral collaboration. Efforts are concentrated on overcoming the significant disparities in educational access and quality between urban and rural areas, with a strong focus on localized teacher training, community-driven educational initiatives, and the integration of culturally relevant curricula. However, issues such as underfunding and infrastructure deficits continue to impede progress.

- **Latin America and the Caribbean**

Latin America and the Caribbean region face educational challenges intertwined with socio-economic inequalities, political instability, and diverse linguistic and cultural contexts. The focus in this region is on expanding access to quality education, particularly for marginalized communities, and addressing the inequities that exist within and between countries. Governments and educational institutions are working to improve teacher training, invest in early childhood education, and integrate technology into classrooms to enhance learning outcomes. However, challenges such as high dropout rates, especially at the secondary level, inadequate infrastructure, and limited resources persist.

1.3 Adoption of Smart Education in Different Countries

The rapid advancement of technology has revolutionized education, transforming traditional learning into dynamic and interactive experiences. Modern education now leverages digital tools and platforms to enhance learning outcomes and engage students more meaningfully, extending beyond conventional classroom settings. Countries worldwide have embraced technological innovations to address educational challenges such as accessibility, equity, and quality. Advanced technologies like artificial intelligence, big data analytics, and virtual reality are redefining the educational landscape, demonstrating how technology can overcome these challenges and promote inclusive, equitable, and high-quality education for all.

Cases among countries illustrate the innovative approaches and successful pathways to construct smart education. These cases show the advantages.

of adaptive learning environments, which cater to individual student needs, ensuring no learner is left behind. Smart education fosters global collaboration and communication, breaking down geographical barriers and promoting cultural exchange. Additionally, data-driven insights from smart technologies enable continuous improvement in teaching strategies and learning materials, to enhance efficiency and effectiveness

1.3.1 Maldives: Access to Education

Country Overview. The Maldives consists of thousands of small islands located in the Indian Ocean. Out of over 1,200 islands, only 188 are inhabited. This means people live on fewer than 200 islands, with the capital located on one atoll, while other islands are geographically dispersed. Despite these geographical challenges, the Maldives has achieved universal education and met the Millennium Development Goals (MDGs) for primary education ahead of schedule. In 2002, the Maldives achieved universal primary education and now prioritizes SDG4. This commitment ensures inclusive and equitable quality education for students living on these dispersed islands. The capital city, Malé, is one of the most densely populated areas in the world, with over 250,000 people living in less than 2 square kilometers. Nearby islands have been connected, and Malé is now linked by a bridge constructed with the help of the Chinese government. The geographical vulnerability brings many challenges, including socio-economic disparities between the capital and the atolls, and various difficulties in providing education.

UNESCO Wenhui Award for "Telikilaas" Series. Despite these challenges, the Maldives strives to provide quality education to all students. Public education is offered even on islands with only 100 or 200 residents, and schools are constructed on each island. Technology integration is crucial to meet these needs. Before the pandemic, online teaching was already implemented to some extent. During the COVID-19 pandemic, when schools closed, online classes peaked. Teachers broadcast lessons via TV channels due to connectivity issues, starting on March 15, 2020. This initiative earned the Maldives' Ministry of Education the UNESCO Wenhui Award for Educational Innovation in the Asia-Pacific region. This case exemplifies the integration of technology and pedagogy, which is central to the definition of smart education.

Satellite Education Project. The Maldives has implemented a satellite schooling system to address educational needs in remote islands. Some islands have only one student due to low population, yet education is still provided. In 2022, Vice President Onagra launched the satellite education project. This initiative connects remote islands without public schools to a central hub in the capital via high-speed internet. Students use Chromebooks to attend online classes, while teachers are based at the central hub. Teacher assistants in these remote classrooms support students during lessons. Currently, there are six satellite schools and one central hub in the capital.

1.3.2 United Kingdom: Learning Design and Teachers Community

The United Kingdom has long been at the forefront of integrating digital technology in education. One exemplary initiative in University College London (UCL) showcases the UK's strategic approach to leveraging technology for teacher professional development.

Learning Designer Tool. One of the key innovations from this project is the Learning Designer tool. This digital platform allows teachers to design, evaluate, and improve various types of learning tasks. By collecting and analyzing feedback, educators can continuously refine their teaching methods, ensuring that they meet the evolving needs of their students. This tool demonstrates the application of digital technology to create a more dynamic and responsive educational environment.

The project has also addressed the needs of teachers in challenging contexts. For example, it uses digital video case studies to highlight the

experiences of teachers in difficult environments, such as refugee teacher communities in Lebanon. These case studies illustrate how digital communication methods can be a lifeline, providing essential support and resources to educators working under extreme conditions. This aspect of the project emphasizes the versatility and global applicability of digital tools in education.

Collaborative Learning through MOOCs. Collaboration is another cornerstone of the project. By designing co-developed Massive Open Online Courses (MOOC), the initiative fosters a community of practice among teachers. These MOOCs enable educators to learn from each other and to develop blended and online learning designs suitable for any subject and educational level. The collaborative aspect ensures that the knowledge and skills gained are diverse and comprehensive, benefiting from the collective expertise of the teaching community.

A significant future direction for the project is the integration of Artificial Intelligence (AI) in smart education. Experts advocate for AI tools that genuinely meet the needs of teachers and learners. Rather than simply assisting students in writing error-filled essays, AI should be challenged to support educational goals effectively. This includes providing digital tools that enhance learning outcomes and streamlining administrative tasks for educators.

1.3.3 China: Smart Education Platform in Minority Areas

Qinghai Province is located in the western part of China, in the northeastern region of the Qinghai-Tibet Plateau, also known as the "Roof of the World". The province has an average altitude of over 3,000 meters, stretching more than 1,200 kilometers from east to west and over 800 kilometers from north to south. However, from a nationwide perspective, Qinghai is still a relatively weak area in China's education quality development. In recent years, under the strong leadership of the provincial Party committee and the provincial government, Qinghai has significantly enhanced the level of digital education, establishing a relatively complete system for promoting digital education and achieving notable results.

National Smart Education Platform. The foundational environment for educational digitalization has been gradually optimized, and digital infrastructure has been continuously improved. Through the implementation of projects such as the Standardization Project, Comprehensive Renovation, and Improvement of Weak Links and Capacity Enhancement in Compulsory Education, the level of digital infrastructure in education has been further enhanced. This provides strong support for the application of the National Smart Education Platform and the regular conduct of digital teaching. The proportion of schools connected to the internet has reached 100%, with all schools having a bandwidth of over 100M. The proportion of schools with campus networks has reached 88.3%, and the proportion of classrooms equipped with multimedia networks has reached 100%. According to the "China Education Informatization Development Report 2022" released by the Ministry of Education, Qinghai Province ranks 24th nationwide in terms of digital infrastructure for basic education.

1.3.4 Argentina: National Integral Plan

The Ministry of Education of Argentina introduced the "National Integral Plan of Digital Education" (PLANIED) with a mission to integrate the educational community into the digital culture. This plan outlines several specific objectives to achieve this mission, including promoting digital literacy, fostering critical and creative use of Information and Communication Technologies (ICT), developing programming and computational thinking skills, encouraging participatory practices for responsible and supportive citizenship, strengthening educational institutions as drivers of knowledge in the digital society, and facilitating collaboration between students, teachers, schools, and communities through emerging communication and cultural practices.

The primary goals of the project were to improve students' English proficiency by utilizing AI technology and modern teaching tools to enhance their listening, speaking, reading, and writing skills. Additionally, the project aimed to enhance teachers' teaching capabilities by providing them with training and technical support to effectively use technology in their teaching practices. Ultimately, the project sought to build a sustainable education system by promoting the application of modern technology to improve overall educational quality.

Pedagogical Guidelines of Digital Education. The study focuses on two key aspects of PLANIED. The first aspect is the "Pedagogical Guidelines of Digital Education", which aims to promote innovation in teaching and quality learning for comprehensive education. This involves encouraging innovative teaching methods and integrating digital technologies into the curriculum to enhance the learning experience. The second aspect is the "Digital Educational Competence" section, which emphasizes the incorporation of digital technologies as educational resources within an innovative framework known as digital education. The goal here is to integrate teaching and learning processes into current and future cultural contexts to achieve meaningful educational outcomes.

PLANIED by the Ministry of Education of Argentina represents a significant effort to modernize the educational system by embedding digital culture into the fabric of teaching and learning. Through its specific objectives and key focus areas, PLANIED seeks to equip students and teachers with the necessary skills and knowledge to thrive in a digital society, ensuring that educational institutions play a pivotal role in this transformation.

1.3.5 Morocco: Center of Educational Guidance and Planning

This case provides an overview of the digital transformation in education at the Center of Educational Guidance and Planning in Rabat, Morocco. An interview with a professor affiliated with the center highlights various policies and initiatives implemented to build ICT infrastructure and integrate technology into teaching and learning. The Moroccan government has launched a national strategy, the Generalization of Information and Communication Technology in Education, aimed at equipping schools with technological equipment and multimedia classrooms. As part of this strategy, over 11,000 schools have been connected to the Internet, and each school is equipped with multimedia classrooms. Additionally, a national e-learning platform has been developed for teachers and students to access free digital resources.

Personal Accounts for All Students. To ensure equitable access to digital resources, all students have a private digital space accessed through personal accounts. This space includes information about lessons, grades, guidance, and digital resources. The Ministry of Education has developed an ICT guide to assist teachers in using digital resources in their pedagogical practices. Despite these initiatives, challenges remain, such as the cost of digital equipment and the need for teacher training and support. To address these challenges, the Ministry of Education is building programs for school equipment and providing training for teachers.

"MASSAR" Large Scale System. The government has launched several national programs and systems, including a national program to develop the use of ICT in education to enhance learners' competencies and improve teachers' professional performance. Additionally, the "MASSAR system", a large-scale digital system, has been developed, and a national committee to promote digitalization in education has been established to oversee the strategy. The Moroccan educational system has also developed Learning Management Systems (LMS) to teachers and created different platforms of open educational resources (OER) to support both students and teachers. Moreover, the system is starting to develop standards for creating digital resources and e-textbooks, as well as using ICT in education.

2 Digital Education Policies to Achieve Smart Education Worldwide

2.1. Policies of Digital Education Coinciding with Smart Education

The SDG4 emphasizes the need to ensure inclusive and equitable quality education and promoting lifelong learning opportunities for all (UN, 2015). Various countries are working towards achieving this goal but face significant challenges in the process. One in three countries – and two in three low-income countries – do not meet either of the two minimum benchmarks on education finance; half of countries have no data on mathematics learning levels or the percentage of trained teachers in primary schools; a third have no data on completion or out-of-school rates (UIS, 2023).

The Transforming Education Summit (UN,2022) proposed that countries must place significant emphasis on digital education, actively developing national-level policy frameworks that leverage next-generation digital technologies to transform education. Meanwhile, smart education appeared in the planning documents at the national level to promote educational equity and improve educational quality. Smart education represents a bidirectional integration of technology and pedagogy, responding to the evolving demands of the ear, to expand the scope of education to meet the needs of sustainable development.

2.2. Inspection of Digital Education Policies for Smart Education

Various regions and countries have implemented digital education policies, focusing on macro considerations such as educational vision, equity, and culture, which form the central pathway towards smart education. Forty-eight digital education policies from different countries.

2.2.1 Collecting National Digital Education Policies

Researchers systematically gathered policies related to digital education and AI for education by searching for keywords such as “smart education”, “digital education”, “digital transformation”, “digitalization”, “educational technology policy”, “Artificial Intelligence”, and “Generative Artificial Intelligence” on official websites worldwide. A total of 48 policy documents were collected from 48 different countries. Table 2-1 showed typical digital education policies in each region.

Table 2-1 Typical digital education policies

Region	Country/ Organization	Policy Title	Published Time
Africa	Kenya	Policy on Information and Communication Technology in Education and Training	2021
Africa	Cameroon	ICT Policy and Strategic Framework for Basic Education In Cameroon	2022
Africa	Nigeria	Nigeria National Digital Learning Policy 2023	2023

America	Jamaica	ICT in Education Policy	2022
America	Canada	Digital Learning in Canada in 2022: A Changing Landscape	2022
America	Brazil	Law No. 14.533 of January 11, 2023-Institute a National Digital Education Policy	2023
America	Mexico	Country Digital Education Ecosystems and Governance	2023
America	United States	A Call to Action for Closing the Digital Access, Design, and Use Divides 2024 National Educational Technology Plan	2024
America	Columbia	Digital Transformation Plan 2024	2024
Asia & Pacific	Brunei Darussalam	Digital Transformation Plan 2023-2027	2022
Asia & Pacific	Singapore	Educational Technology Plan	2022
Asia & Pacific	Malaysia	Digital education policy	2023
Asia & Pacific	United Arab Emirates	Riving the Frontiers of Digital Education	2023
Asia & Pacific	New Zealand	Connected Ako Digital and Data For Learning Executive Summary	2024
Asia & Pacific	Turkiye	Ministry of national education annual newsletter	2024
Europe	Sweden	Country Digital Education Ecosystems and Governance	2023
Europe	France	Strategy For the Digitalization of Education 2023-2027	2023
Europe	Finland	Policies for the Digitalization of Education and Training Until 2027	2023
Europe	Malta	Digital Education Strategy 2024-2030	2024
Europe	North Macedonia	Ministry Of Education and Science Strategic Plan 2024-2026	2024
Europe	Slovak Republic	Recovery and Resilience Plan - DigEDU	2024

2.2.2 Analyzing Digital Education Policies from Six Considerations of Smart Education

Smart education is the development goal of digital education. In 2022, the UNESCO Institute for Information Technologies in Education released the Report on National Smart Education Framework (UNESCO IITE, 2022). Digital education policies could reflect the current state of development across six considerations under “Forward-Thinking Governance and Policy Initiatives” and “Overarching Considerations across the Framework” within the National Smart Education Framework. Accordingly, the digital education policies were analysed through the six aspects of the Framework to understand specific connotations and characteristic manifestations to advance the development of smart education.

- **Six Considerations of Smart Education**

One, **“Develop a National Vision and Plan”** refers to government leaders committing to a shared vision that underscores technology’s crucial role in ensuring students’ future success and improving the nation’s social and economic equity. Two, “**Build Infrastructure Capacity**” is a fundamental

requirement for the development of smart education. The establishment of a smart learning environment encompasses six aspects: ubiquitous network access, appropriate learning spaces, trustworthy learning tools, adaptive learning resources, reliable digital terminals, and a secure online environment. Three, "**Invest in Human Capacity**" includes government leaders funding educators' preparation, professional development, coaching, and mentoring opportunities to build human capacity around digital pedagogy. Four, "**Inclusion and equity**" form the cornerstone of high-quality learning, meeting the needs of both students and educators. Tailored instruction for students with special needs promotes their participation and integration in mainstream classes.

Five, "**Continuous Improvement Culture**" means educators and leaders collaborate with stakeholders to continuously collect and evaluate information on educational experiences. Six, "**Muti-Sector Cooperation and Partnerships**" requires that under the auspices of government leadership, a coalition of public enterprises, higher education institutions, and research organizations collaborate closely to establish strategic partnerships.

- **Policy Text Coding**

Ten researchers selected five policy documents each for in-depth study, and coded them according to the six considerations, as outlined in Table 2-2. Then, the researchers scored each policy based on the frequency and quality of initiatives in the policy documents.

Table 2-2 Coding process

Consideration	Policy	Original text	Indicator
Invest in Human Capacity	French: Strategy for the digitalization of education 2023-2027	"Integrating digital skills into educational curricula"	Enhance digital skills

2.3. Characteristics of Digital Education Policies in Terms of Smart Education

Based on the text analysis methods described above, the characteristics of digital education policies in the six considerations of smart education were identified, taking the critical stages of digital education into account.

2.3.1 The Critical Stages of Digital Education

In the age of AI, the digital transformation of education progresses through three distinct stages. **Digitization** is marked by the foundational setup of informational technologies and the initial application of such technologies, which focuses on acquiring smart devices, developing digital resources, constructing informational platforms, and experimenting with the use of various media (Yang & Qin, 2023). **Cyberization** centers on leveraging data to empower educational reform, which is characterized by fully integrated information platforms that support teaching, learning, administration, assessment, and evaluation, thereby enabling data-driven intelligent decision-making. **Intelligentization** involves the comprehensive reshaping of educational structures and processes through the use of artificial intelligence. It utilizes a synergy of cloud computing, the Internet of Things, and big data to adapt educational institutions to meet the needs of the digital-native generation and future societal demands, fundamentally altering organizational and pedagogical models.

2.3.2 The Key Characteristics of Digital Education Policies at Different Stages

Through the analysis of policy texts, it has been observed that the development of digital education

towards smart education exhibits characteristics across three distinct stages (see Figure 2-1). **For example, in the consideration of "Develop a National Vision and Plan", digitization** emphasizes the application of technology in learning environments and the establishment of online learning environments to support remote learning technologies**; cyberization** manifests in comprehensive intelligent platforms and data-driven educational environments, which supports seamless learning, continuously improving information and communication technology infrastructure and systems to support teaching in both schools and homes; intelligentization supports the development of a high-performing digital education ecosystem, integrating cross-departmental resources and technologies to deliver top-quality global education services.

	Digitization	Cyberization	Intelligentization
Develop a national vision plan	• Set visions for technology in learning • Establish online learning environments	• Comprehensive intelligent platforms • Learning anytime, anywhere	• High-performing digital education ecosystem • High-quality, personalized education • Provide top-notch digital services
Build infrastructure capacity	• High-speed Internet connection • Introduce digital tools	• Sustainable and inclusive digital offer • Improve digital services	• Builde smart classrooms, virtual spaces • Everyone have a mobile device
Invest in human capacity	• Enhance ICT skills • Explore effective training methods	• Foster digital literacy • Popularize Programming Education • Match education programs with employment needs	• Cultivate AI literacy • Offer AI courses • Innovative AI Application • Develop digital citizens
Inclusion and equity	• Equal access to learning opportunities • Tackle gender stereotypes and bias	• Putting digital at the service of Inclusive schools • Personalized Resource Support	• Close the digital divide • Ensure that smart education is tailored to meet the diverse needs of all learners
Continuous improvement culture	• Sustainable economic investment • Update digital teaching methods and resources	• Develop a comprehensive guide for technology application in teaching • Build digital ecosystems	• Develop plans to adapt to the school's digital ecosystem regularly • Building a model district for smart education
Multi- sector cooperation and partnerships	• Provide funding and technology for digital education • Clarification of sectoral responsibilities	• Encourage organizations to share and use data widely • Engage businesses for school tech purchases and integration	• Regulate and govern the application of emerging technologies • Strengthen international cooperation • Promote research and innovation

Figure 2-1 Characteristics of digital education policies in three stages and six considerations

2.4. Regional Focus on Digital Education Policies

2.4.1 Asia-Pacific Region

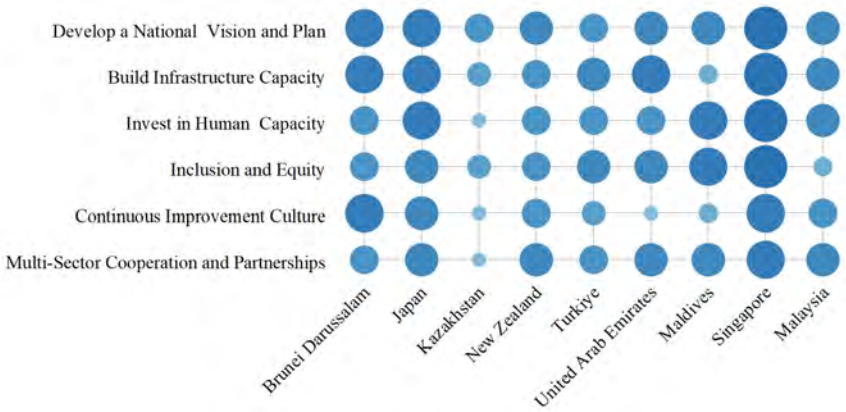


Figure 2-2 Bubble chart of 9 policies from the Asia-Pacific region across 6 considerations

As shown in Figure 2-2, governments in this region pay vital attention to the development of the vision and plan of digital education, with Singapore and Japan's policies coinciding well with all the six considerations of smart education.

Under the consideration 'Develop a National Vision and Plan', Japan's Roadmap on the Utilization of Data in Education 2022 explicitly articulates the vision for digital education in Japan, which is to establish a society where individuals can engage in learning at their own discretion, at any time and in any location, with any other person. This vision is to be achieved by ensuring the breadth, quality, and integrated use of data. The roadmap proposes a comprehensive architectural design to facilitate the full utilization of ICT, support learner-centered educational transformation, and optimize the flow and accumulation of educational data (Ministry of Education, Culture, Sports, Science and Technology of Japan, 2022). Regarding consideration Invest in Human Capacity, Singapore's Educational Technology Plan (2020-2030) proposes providing digital training for teachers, cultivating them to become designers and facilitators of technology-mediated learning experiences and offers technical courses such as robotics programming and application development to students, for enhancing their digital skills (Ministry of Education of Singapore, 2020).

In relation to 'Continuous Improvement Culture', Brunei Darussalam has established specialized institutions to oversee digital education plans, ensuring that each step aligns with set goals and standards. Regular evaluations and reviews help identify and address issues, enhancing plan implementation. This systematic supervision mechanism ensures smooth progress at all stages and allows necessary adjustments and optimizations based on real-world conditions (Ministry of Education in Brunei, 2022).

Overall, while digital education in the Asia-Pacific region is advancing rapidly, maximizing its potential requires overcoming existing technological and resource related barriers. Through collaborative efforts among multi-sectoral stakeholders including governments, businesses, and international organizations, the region has the potential to achieve educational equity and inclusivity, fostering social and economic prosperity.

2.4.2 European Region

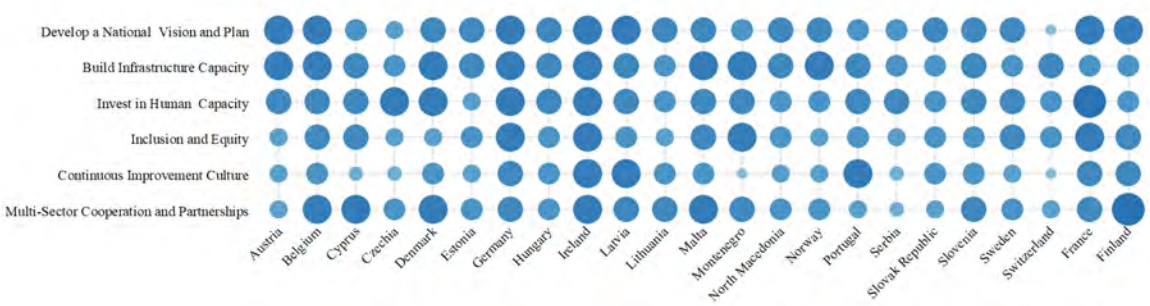


Figure 2-3 Bubble chart of 23 policies from the European region across 6 considerations

Digital education has attracted widespread attention in Europe, becoming a key pathway to improving educational quality. The European Union's Digital Education Action Plan (2021-2027) reflects this trend (European Union, 2020), with the aim to enhance quality and inclusivity through cooperation among member states. The plan emphasizes developing high-performance digital education ecosystems and enhancing citizens' digital skills and competencies.

As shown in Figure 2-3, the European region generally emphasizes the development of national visions and plans, infrastructure construction, and investment in human resources. Ireland demonstrates the most balanced performance

across all considerations.

Under the consideration 'Build Infrastructure Capacity', Malta's Digital Education Strategy 2024 – 2030, which scored highly, outlines six key measures: (1) providing tablets and laptops to all secondary students from Year 7 to Year 11 as part of the One Tablet Per Child project; (2) allocating resources and spaces for shared technicians in academies and dedicated spaces for ICT or digital literacy in primary schools; (3) supplying Malta's Digital Content Software and Resources; (4) offering accessible digital books and resources; (5) creating a digital library for all secondary students; and (6) utilizing the MySchool platform for e-assessment and e-portfolios to track student progress, along with supporting schools with training and informational sessions to enhance digital education infrastructure and effectiveness (Ministry for Education and Employment of Malta, 2024).

Regarding the consideration 'Inclusion and Equity', Ireland's Digital Strategy for Schools to 2027 highlights three main points: (1) the implementation of the Delivering Equality of Opportunity in Schools program and ICT grants to support schools serving learners at risk of educational disadvantage; (2) a teaching and learning framework for lower secondary schools that mandates common curriculum specifications and short courses across schools, ensuring equitable learning opportunities for all students; (3) collaboration among the National Council for Curriculum and Assessment, the National Council for Special Education, and the Department of Education to leverage digital technology for educational inclusion in special schools and to provide assistive technology recommendations (Department of Education in Ireland, 2022).

Special initiatives include Germany's partnerships with businesses to enhance education quality (Germany Ministry of Education and Research, 2021), the provision of free digital skills training in Cyprus (Ministry of Education, Culture, Sport and Youth in Cyprus, 2021), and Switzerland's exploration of blockchain technology has improved credential verification and management transparency and efficiency (OECD, 2023).

Overall, digital education in Europe is developing rapidly, supported by strong policies and international cooperation. With continuous efforts and innovation, Europe aims to build a high-quality, inclusive, and sustainable digital education ecosystem. Europe's achievements in digital education provide valuable lessons for global digital education development.

2.4.3 American Region

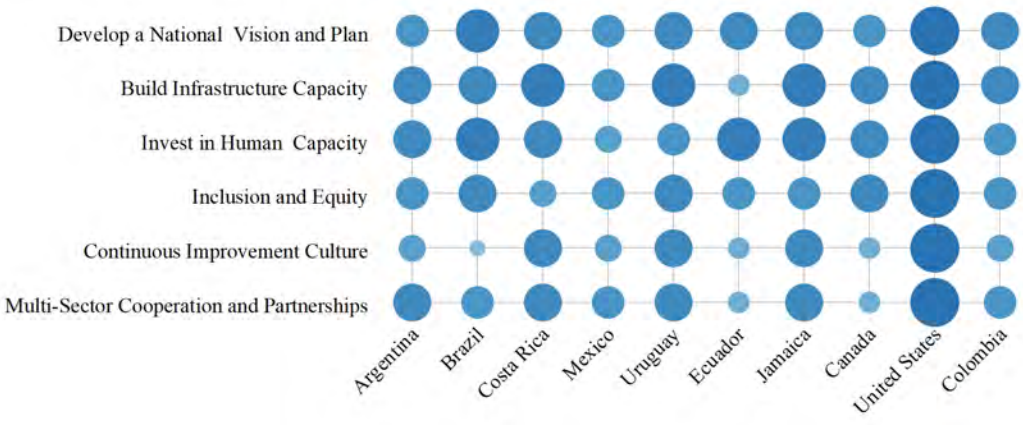


Figure 2-4 Bubble chart of 10 policies from the American region across 6 considerations

As is shown in Figure 2-4, governments in this region raise certain concerns in the development of the vision and plan and infrastructure construction, with the United States's policy coinciding well with all the six considerations of smart education.

In the consideration of Inclusion and Equity, the U.S. National Educational Technology Plan 2024 addresses three key digital divides from the perspectives of content, teachers, and students: the Digital Access Divide, the Digital Design Divide, and the Digital Use Divide. The Digital Access Divide focuses on the unequal opportunities for students to access digital resources; the Digital Design Divide highlights the challenges teachers face in designing and implementing digital education; and the Digital Use Divide concentrates on the disparities in how students use digital tools and technologies for learning (U.S. Office of Educational Technology, 2024).

Overall, the United States policy mentions comprehensive initiatives and advanced technological applications for the development of digital education. In contrast, while certain Latin American countries have begun to introduce digital technologies, the region still needs to improve its infrastructure and digital literacy levels. Increased investment, infrastructure enhancement, and raising digital literacy of teachers and students are crucial for the effective development of digital education in Latin America.

2.4.4 African Region

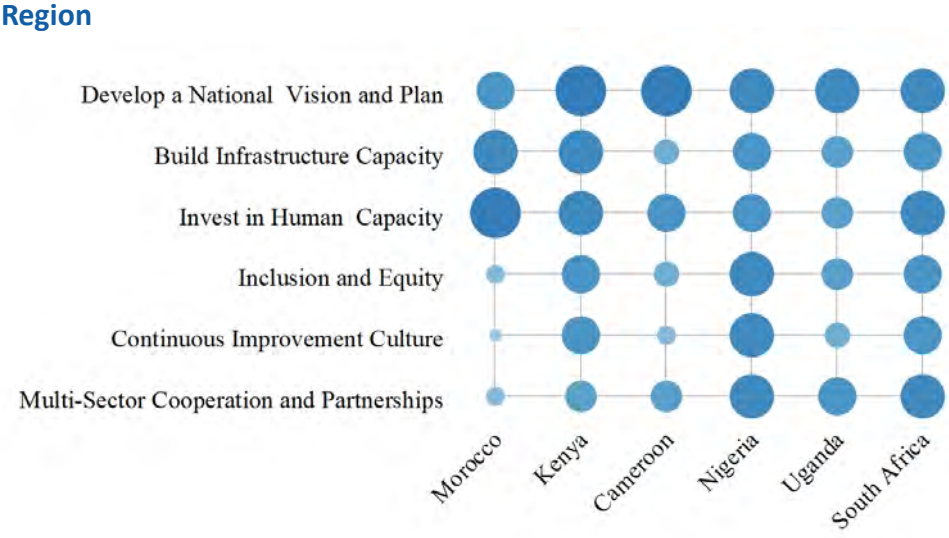


Figure 2-5 Bubble chart of 6 policies from the African region across 6 considerations

As shown in Figure 2-5, governments in this region pay crucial attention to the development of the vision and plan, but there is a significant disparity among countries in other considerations. Nigeria's policy coincides well with all the six considerations of smart education.

In Nigeria, the "Data Science Nigeria" initiative seeks to bridge the digital skills gap by providing extensive training in data science and analytics. Targeting students at various educational levels, the program equips them with essential skills to meet the country's increasing demand for data professionals. Through workshops, boot camps, and online courses, Data Science Nigeria cultivates a culture of innovation and analytical thinking, preparing students for future careers in the digital economy (Nigeria Ministry of Education, 2021).

Kenya's Policy on Information and Communication Technology in Education and Training details the Develop a National Vision and Plan, which includes aims such as fostering a "digitally enabled society for sustainable development" and integrating ICT in education to enhance learning outcomes (Ministry of Education in Kenya, 2021).

Overall, digital education in Africa is gradually advancing, albeit unevenly. However, to achieve widespread adoption and high-quality development, further enhancement of infrastructure, policy support, and international cooperation is necessary. Addressing challenges such as inadequate electricity andnetwork infrastructure, high data costs, and a shortage of digital skills is critical. With these measures, Africa has the potential to achieve more equitable and high-quality digital education in the future.

3 Status of Smart Education through the Lens of Public Datasets

In fast-tracking progress towards achieving SDG 4, quality education, stands out as a critical priority. To achieve this, organizations and nations across the world have been investing in the digital transformation of education, evidenced by the development of digital learning platforms, strategic investments in human resources, and the implementation of comprehensive educational governance frameworks.

The proliferation of survey data on digital education in recent years highlights an emerging need for a more analytical approach. To this end, this section is committed to constructing an indicator framework for smart education, based on the five performative and five constructive features, for establishing a GSE dataset, compiled from public data sources worldwide. The subsequent analysis will concentrate on tracking the current state of smart education and the interplay among the various features and indicators

3.1 Key Indicators of Smart Education at the National Level

After a consensus was reached among leading experts on the performative and constructive features that define smart education, a series of rigorous group deliberations, followed leading to a meticulous cross-validation. This methodological approach culminated in the formulation of a Framework for Tracking Smart Education (Excerpted in Table 3-1, full version in Appendix B). The connection between the key features of smart education and measurable operational indicators was established by identifying and translating these features into actionable metrics. The resulting indicators are systematically classified into ten distinct categories, each corresponding to one of the ten key features of smart education. These categories serve to encapsulate the multifaceted dimensions of smart education, ensuring a comprehensive and nuanced tracking mechanism.

Table 3-1 Indicators list of smart education

	Primary Indicator		Sub-Indicator
PF1	Beneficial Approach to Student-centered Learning	PF1.1	Efficacy of Technology in Educational Settings
		PF1.2	Strategies of Active Learning and Creativity Development
		PF1.3	Student Agency in Diverse Educational Settings
PF2	Evidence-based Assessment for Comprehensive Student Development	PF2.1	Comprehensiveness of Assessing Student Performance
		PF2.2	Impact of Assessment for Learning

- To evaluate the "Student-centered teaching and learning" feature, the PF1 indicator will focus on how effectively a country or region implements the integration of technology in educational settings promotes active learning, fosters creativity, and empowers student agency, ensuring that each learner takes an active role in their educational journey.

  - ***PF1.1 Efficacy of Technology in Educational Settings:*** Teachers use technology in educational environments to enhance student learning outcomes.

  - ***PF1.2 Strategies of Active Learning and Creativity Development:*** Students' learning experiences and innovation skills enhanced through active learning strategies and creativity development.

  - ***PF1.3 Student Agency in Diverse Educational Settings:*** Students take ownership and actively participate in the learning process across diverse educational environments.

- For the "Learning assessment for whole education" feature, the PF2 indicator will evaluate the comprehensiveness of assessing student performance, combined with the utilization of assessment for learning strategies, to provide targeted feedback that supports holistic growth.

  - ***PF2.1 Comprehensiveness of Assessing Student Performance:*** Assessments for students cover a broad range of competencies, providing a holistic view of student development.

  - ***PF2.2 Impact of Assessment for Learning:*** Assessments are used to inform and improve ongoing teaching and learning processes, thereby enhancing student outcomes.

- The "Ubiquitous and Smart Learning Environment" feature is closely tied to the PF3 indicator, which evaluates reliable digital tools and seamless connectivity in learning environments to ensure continuous, personalized, and secure access to learning resources.

  - ***PF3.1 Seamless and Quality Connectivity in different schools:*** Schools maintain high-quality, uninterrupted and secure internet connections, facilitating smooth access to digital resources across diverse educational environments.

  - ***PF3.2 Provision of Personalized Digital Learning Resources:*** Digital learning materials that meet the unique needs and learning styles of each student.

  - ***PF3.3 Availability of Trustworthy Digital Devices for Teaching and Learning:*** Reliable and secure digital devices that support effective learning processes and ensure safety and functionality in educational settings.

- The "Culture of Continuous Improvement" feature is intrinsically linked to the PF4 indicator which evaluates how effectively schools navigate challenges through the effective integration of digital tools and practices, supported by strong leadership, data-driven decision-making, and continuous professional development.

  - ***PF4.1 School-Level E-Leadership and Evidence-based Decision-making:*** School leaders have the ability to drive improvement through the strategic use of digital technology and make decisions based on evidence.

  - ***PF4.2 Effectiveness of Differentiated Teacher Professional Development:*** Teachers have diverse and tailored professional growth opportunities within the school environment and through collaboration with external entities and various professionals.

  - ***PF4.3 Forward-thinking Responsible Consideration for Navigating School Challenges:***

School's proactive and responsible approach to addressing future challenges, ensuring a balance between immediate needs and long-term goals in the digital transformation process.

The "Commitment to Inclusion and Equity in Education" feature is directly aligned with the PF5 indicator, which is specifically designed to evaluate how effectively educational systems are fostering an inclusive and equitable environment for all students regardless of backgrounds, abilities, or gender.

PF5.1 Humanistic Approaches for Supporting Students with Special Needs: Humanistic approaches support students with special needs by emphasizing individualized care, empathy, and inclusion in their learning journey.

PF5.2 Effectiveness of Promoting Gender Equality Beyond Schools: Initiatives and strategies that extend efforts to achieve gender equality beyond the educational environment.

PF5.3 Accessibility of Supportive Learning Environments beyond Schools for All: Everyone can access inclusive learning resources and support outside of traditional school settings.

PF5.4 Distribution of Educational Resources among Regions: Allocation and equitable sharing of educational materials, funding and opportunities across different geographic areas.

The "Social Learning Communities" feature is closely connected to the CF1 indicator, Social Learning and Emotional Development for Students, which describes how students use technology to interact effectively with others, manage their emotions, and build healthy relationships, enhancing their social learning and emotional growth in a connected, digital environment.

CF1.1 Technology Engagement for Cultural Education and Diversity: Use of technology to promote and support the learning and appreciation of diverse cultures and to foster cultural understanding.

CF1.2 Social Networking Involvement for Emotional Skills Development: Use of social networks to enhance and nurture individuals' emotional and social skills through online interactions and connections.

CF1.3 Student Digital Literacy Contributions to Social Community: Students' ability to effectively use digital tools and platforms enhances and supports the development of social learning.

The "Ethical Adoption of ICT in Education" feature is closely aligned with the CF2 indicator which assesses how well a secure environment is provided for students to use technology, ensuring the protection of their privacy and the security of data, while supporting ethical and effective learning practices.

CF2.1 Privacy Protection for All Students and Teachers: Personal information is securely handled, safeguarding the confidentiality and integrity of data within educational environments.

CF2.2 Data Security Level for Learning and Educational Systems: Sensitive educational data is protected from unauthorized access, breaches, and cyber threats, ensuring safe and reliable operations.

The "Prioritization of Teacher Professional Development" feature is directly reflected in the CF3 indicator, which evaluates the extent to which educational systems prioritize and support the continuous learning and skill enhancement for both pre-service teachers and in-service teachers.

- ***CF3.1 Wholesome Capacity Building for Teachers:*** Teachers possess comprehensive skills and knowledge to effectively address diverse classroom challenges and foster student growth.

- ***CF3.2 Digital Competency of Pre-service Teachers:*** Pre-service teachers effectively use digital tools and technologies in educational settings, integrating them into teaching practices.

- ***CF3.3 Digital Competency of teachers:*** Teachers effectively use digital tools and technologies in educational settings, integrating them into teaching practices

The "Sustainable Plan for Education Reform" feature is intrinsically connected to the CF4 indicator. Government policies provide consistent and long-term financial investment to support the ongoing transformation and development of education.

- ***CF4.1 Long-term Funding for Educational Digitalized Infrastructure:*** Sustained financial support for the development, maintenance, and upgrading of digital technologies and resources in educational institutions.

- ***CF4.2 Performance-oriented Digital Learning and Educational Resource Development:*** Collaborative creation and distribution of high-quality educational resources that are freely accessible.

- ***CF4.3 Evidence-based Innovation and Technology Adoption:*** Systematic integration of innovative technologies into practice, guided by rigorous research and data-driven analysis.

- ***CF4.4 Educational Funding and Initiatives at the National Level:*** Allocation of financial resources and the implementation of strategic programs by the government to support and enhance the education system across the country.

The "Effective Multi-sectoral Collaboration" feature is closely aligned with the CF5 indicator, Effective Collaboration among Multi-sector Stakeholders in Education, which assesses how well educational systems facilitate and sustain cooperation among various sectors, including government, industry, the private sector, academia, and non-governmental organizations.

- ***CF5.1 Activeness of E-Participation Engagement for Decision-making:*** Stakeholders actively engage in digital platforms, contributing to informed and inclusive decision-making processes through online participation and collaboration.

- ***CF5.2 Accessibility to Government Online Services:*** All students and teachers can access and use government services provided through digital platforms.

- ***CF5.3 Effectiveness of Regulated data sharing across multiple sectors:*** Different industries and organizations exchange data securely and efficiently under established regulations.

3.2 Public Data Sources for Tracking Smart Education Worldwide

The Framework for Tracking Smart Education is designed to track the implementation and effectiveness of smart education. This framework comprises 10 primary indicators, each meticulously aligned with one of the ten key features that define smart education.To ensure a thorough and nuanced analysis, these primary indicators are further subdivided into 30 sub-indicators, providing a more granular perspective on specific aspects of smart education.

In order to track smart education, public data was drawn from multiple reports or webpages related to the digital transformation of education from OECD, UNESCO, Portulans Institute and Oxford Saïd Business School, The International Telecommunication Union, and the World Bank.

Data from the reports such as PISA Results 2022, SDG4 data, The Network Readiness Index 2023, World Bank Open Data, ITU DataHub, and TALIS Results 2018, which was used to compile the Global Smart Education (GSE) dataset covering 81 countries and regions.

The GSE dataset is rigorously compared with 30 sub-indicators to ensure that the indicators can be reflected by the observing points. As a result, the framework encompasses a total of 58 observing points (Excerpted in Table 3-2, full version in Appendix C). These observing points serve as critical reference metrics, enabling stakeholders to assess the progress, challenges, and overall impact of smart education initiatives across different contexts and regions.

Table 3-2 Observing points with data source for smart education indicators

	Sub-indicator	Observing Point	Data source
PF1.1	Efficacy of Technology in Educational Settings	a. Teacher competency in digital pedagogy	PISA 2022
		b. Application of digital resources across subjects	PISA 2022
PF1.2	Strategies of Active Learning and Creativity Development	a. Student curiosity	PISA 2022
		b. Flexible and adaptive teaching strategies	TALIS 2018
		c. Cognitive ability development through multiple strategies	TALIS 2018
		d. Responsive instruction and support	PISA 2022
PF1.3	Student Agency in Diverse Educational Settings	a. Student confidence for self-directed learning	PISA 2022
PF2.1	Comprehensiveness of Assessing Student Performance	a. Student performance and outcomes	PISA 2022
		b. Standardized and teacher-developed assessments	PISA 2022
		c. National learning assessments implementation	UIS
PF2.2	Impact of Assessment for Learning	a. Diverse assessment and teacher feedback	TALIS 2018
		b. Multi-source feedback for students	PISA 2022
PF3.1	Seamless and Quality Connectivity in different schools	a. Internet bandwidth and subscriptions	ITU, World Bank
		b. Comprehensive internet access and cybersecurity	ITU, World Bank, NRI, UIS
PF3.2	Provision of Personalized Digital Learning Resources	a. Utilization of digital learning resources	PISA2022
PF3.3	Availability of Trustworthy Digital Devices for teaching and learning	a. Digital device availability for education	PISA2022
PF4.1	School-Level E-Leadership and Evidence-based Decision-making	a. School autonomy	PISA2022
		b. Curriculum and resource decision-making	PISA2022
		c. Teacher involvement in school governance	TALIS2018

CF4.1	Long-term Funding for Educational Digitalized Infrastructure	a. Investment in emerging educational technologies	NRI2023
		b. Government support for technology investment	NRI2023
		c. Spending on educational software	NRI2023
		d. Investment in IT services for education	NRI2023
CF4.2	Performance-oriented Digital Learning and Educational Resource Development	a. Open source contribution and content availability	NRI2023
		b. Opportunities of degree program offerings	Study Portal
CF4.3	Evidence-based Innovation and Technology Adoption	a. Adoption of emerging educational technologies	NRI2023
		b. R&D investment relative to GDP	World bank
CF4.4	Educational Funding and Initiatives at National Level	a. Government expenditure on education as a percentage of GDP (%)	UIS
		b. Per-Pupil funding in secondary education	World bank
CF5.1	Activeness of E-Participation Engagement for Decision-making	a. E-Participation in educational decision-Making	NRI2023
CF5.2	Accessibility to Government Online Services	a. Accessibility to government online services	UIS
CF5.3	Effectiveness of Regulated Data Sharing across Multiple Sectors	a. Management data flow for collaborative planning	UIS

Table 3-3 (full version in Appendix D) offers a detailed explanation of all observing points, providing comprehensive guidance for interpreting the data, with the aim to enhance understanding and ensure accurate analysis of the data.

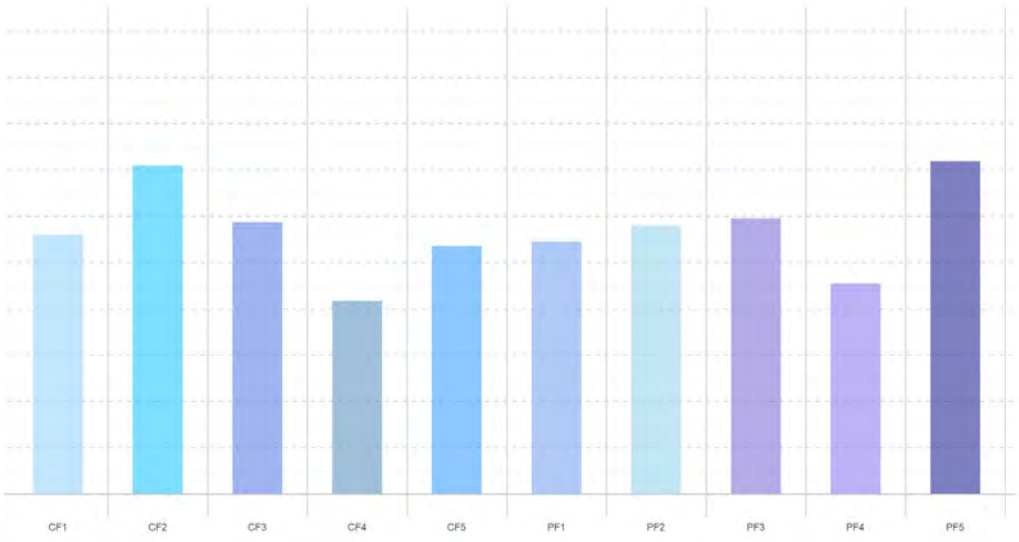
Table 3-3 Notes for observing points of smart education indicators

PF1.1 Efficacy of Technology in Educational Settings	
a.	**Teacher competency in digital pedagogy** teachers have the necessary technical and pedagogical skills to integrate digital devices in instruction and have sufficient time to prepare lessons by using digital devices.
b.	**Application of digital resources across subjects** digital resources are used in various subject lessons.
PF1.2 Strategies of Active Learning and Creativity Development	
a.	**Student curiosity** students' curiosity of learning
b.	**Flexible and adaptive teaching strategies** teachers' flexible instruction strategies including crafting good questions for students and use of a variety of assessments strategies.
c.	**Cognitive ability development through multiple strategies** teachers assign tasks that require critical thinking and present challenges without obvious solutions.

CF5.2 Accessibility to Government Online Services	
a.	**Accessibility to government online services** Government's provides online services as a public good.
CF5.3 Effectiveness of Regulated data sharing across multiple sectors	
a.	**Management data flow for collaborative planning** Government's policies in place for the release and use of open data

3.3 Current Status of Smart Education from Different Countries

3.3.1 Overall Development Level of Smart Education



Note: CF1 Social Learning and Emotional Development for Students; CF2 Responsible Digital Technology in Education; CF3 Prioritization of Teacher Professional Development; CF4 National-level Policy Sustainability of Educational Digital Transformation; CF5 Effective Collaboration Among Multi-sector Stakeholders in Education PF1 Beneficial Approach to Student-centered Learning; PF2 Evidence-based Assessment for Comprehensive Student Development; PF3 Ubiquitous Trustworthy Learning Environments; PF4 Sustainability of School Improvement with Digital Technology; PF5 Commitment to Inclusion and Equity in Education

Figure 3-1 Overall development of 10 indicators for smart education

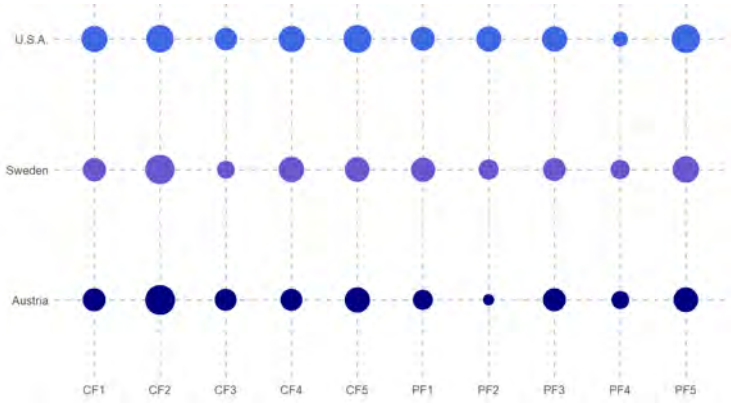
Figure 3-1 shows the status of ten indicators of the performative and constructive features of smart education highlighting their strengths and also the need for their improvement in some educational contexts. It can be observed there are fluctuations in the scores of the subdimensions of the performative and constructive features of smart education with some points ranking higher or lower. For example, it is seen that PF5 (Commitment to Inclusion and Equity in Education) and CF2 (Responsible Digital Technology in Education) appear better than CF4 (National-level Policy Sustainability of Educational Digital Transformation).

Among 81 countries and regions, various countries generally emphasize equitable, inclusive, and quality education, as well as the achievement of SDG benchmarks. In the information age, countries also focus on the responsible integration of information technology into teaching to promote the digital transformation of education. However, the sustainability of school improvement with digital technology and national-level policy for the sustainability of educational digital transformation will remain key areas of focus for all countries.

Educational systems should also pay heed to areas where they observed low scores such as

"National-Level Policy Sustainability of Educational Digital Transformation". Establishing a consensus on a sustainable development vision aimed at the digital transformation of education is critical for setting the strategic direction of educational initiatives. This vision should incorporate innovative green technologies, green curriculum, green skills to outline long-term goals for creating an environmentally sustainable and educationally effective system. Engaging stakeholders, including educators, policymakers, and community members, in the development of this vision, ensures that the goals are comprehensive and widely supported. This unified approach not only aligns efforts across different sectors but also fosters a shared commitment to sustainable practices and educational excellence. Thus, there is a need for effective educational governance and policy.

3.3.2 Comparison of Smart Education among Three Selected Countries



Note: CF1 Social Learning and Emotional Development for Students; CF2 Responsible Digital Technology in Education; CF3 Prioritization of Teacher Professional Development; CF4 National-level Policy Sustainability of Educational Digital Transformation; CF5 Effective Collaboration Among Multi-sector Stakeholders in Education PF1 Beneficial Approach to Student-centered Learning; PF2 Evidence-based Assessment for Comprehensive Student Development; PF3 Ubiquitous Trustworthy Learning Environments; PF4 Sustainability of School Improvement with Digital Technology; PF5 Commitment to Inclusion and Equity in Education

Figure 3-2 Comparison of smart education among three selected countries

The graph highlights a comparative analysis of how three countries (Austria, Sweden, and the USA) performed in the ten indicators of the performative and constructive features of the smart education framework. For example, Austria shows notable peaks in certain areas such as CF2 (Responsible Digital Technology in Education) but a decline in PF2 (Evidence-based Assessment for Comprehensive Student Development), while the USA may have more consistent but lower scores in other areas such as PF4 (Sustainability of School Improvement with Digital Technology). Sweden is highest in CF2 (Responsible Digital Technology in Education) and lowest in CF3 (Prioritization of Teacher Professional Development).

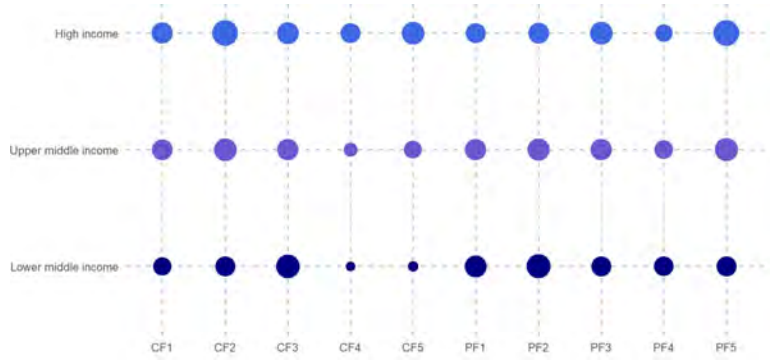
It can be acknowledged that there are regional differences regarding subdimensions of the performative and constructive features of smart education such as the CF3 (Prioritization of Teacher Professional Development) and CF2 (Responsible Digital Technology in Education). The high pedagogical standards in this digital era, which have raised the need for teachers to gain diverse competencies, call for the need to engage them in continuous professional development programs. Having low scores in areas such as teacher professional development risks compromising educational quality. This in turn affects learning assessment and the construction of smart and ubiquitous learning spaces as evidenced by the relatively low scores among the countries.

Evidently, providing continuous professional development opportunities is vital for keeping teachers abreast of the latest technological advancements and pedagogical strategies. Ongoing training, workshops, and professional learning communities enable educators to stay current with emerging technologies and best practices. Fostering a culture of lifelong learning and adaptability is

crucial for maintaining high-quality education in an ever-evolving digital landscape. This can be accomplished through the strategic implementation of technological policies that equip teachers to effectively use digital devices, offer online learning support, and provide incentives for participation in professional training programs focused on successful technology integration.

It is recommended that regional differences are addressed with tailored educational approaches that ensure that the unique needs of various communities are met. Educational strategies should be adapted to local contexts, considering economic conditions, cultural practices, and specific challenges faced by different regions. By implementing targeted interventions and leveraging local resources, schools can provide relevant and effective education that resonates with the community.

3.3.3 Comparison of Smart Education among Three Income-Level-Country Groups



Note: CF1 Social Learning and Emotional Development for Students; CF2 Responsible Digital Technology in Education; CF3 Prioritization of Teacher Professional Development; CF4 National-level Policy Sustainability of Educational Digital Transformation; CF5 Effective Collaboration Among Multi-sector Stakeholders in Education PF1 Beneficial Approach to Student-centered Learning; PF2 Evidence-based Assessment for Comprehensive Student Development; PF3 Ubiquitous Trustworthy Learning Environments; PF4 Sustainability of School Improvement with Digital Technology; PF5 Commitment to Inclusion and Equity in Education

Figure 3-3 Comparison of smart education among three income-level-country groups

The figure illustrates how different income levels across the ten indicators of the performative and constructive features of smart education impact the implementation of smart education. The high-income group generally scores higher across the various subdimensions such as CF2 (Responsible Digital Technology in Education) and CF5 (Effective Collaboration among Multi-Sector Stakeholders in Education). Scores for upper-middle-income countries are often lower than high-income countries but show improvement in certain areas such as CF3 (Prioritization of Teacher Professional Development) and PF2 (Evidence-based Assessment for Comprehensive Student Development). The lower-middle-income group typically scores the lowest in CF4 (National-level Policy Sustainability of Educational Digital Transformation) and CF5 (Effective Collaboration among Multi-Sector Stakeholders in Education). It appears that high-income countries are better equipped to adopt and sustain smart education practices, while upper and lower-middle-income countries may face challenges but also have opportunities for growth through strategic investments and reforms.

Allocating financial resources and dedicated time for training allows educators to focus on enhancing their digital competencies without additional stress. This practical support is necessary to implement these initiatives effectively, empowering teachers to create dynamic and engaging learning environments for their students.

Moreover, securing and managing financial resources effectively is essential to support the vision for sustainable development. This includes adequate and prioritized funding allocation, ensuring that financial resources are directed towards high-impact areas and critical needs, such as government expenditure per secondary student.

Sustainable financial planning involves forecasting future financial requirements, identifying potential risks, and developing strategies to mitigate these risks. Innovative funding mechanisms, such as public-private partnerships, grants, and alternative funding sources, should be explored to diversify income streams and enhance financial resilience. This comprehensive financial strategy ensures long-term stability and continuous support for educational improvements. Additionally, there is a need for a national policies across the countries to safeguard and reimagine the futures of education in this intelligent era. For example, there have been calls by several researchers, education leaders, and international organizations such as UNESCO for the need to develop institutional AI policies to regulate the responsible use of AI in education.

3.4 Relationships among Performative, Constructive Features and Quality of Education

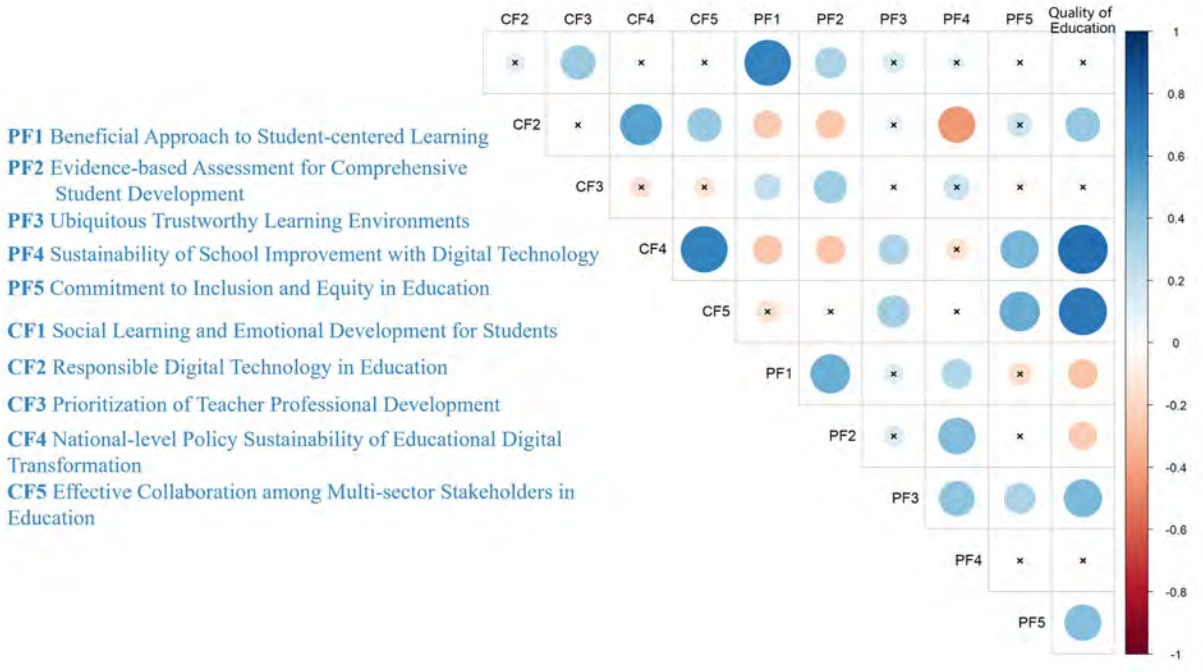


Figure 3-4 Relationships among performative, constructive features and quality of education

The quality of education indicator is a combination of the SDG4 Benchmark indicators, PISA scores and the average of each country's rankings in the top three universities in the QS University Rankings.

Through the analysis of the correlation between the performative, constructive features and variable of the quality of education, it was found that two performative features CF4 (National-level Policy Sustainability of Educational Digital Transformation) and CF5 (Effective Collaboration among Multi-sector Stakeholders in Education) are significantly correlated with the Quality of Education, with correlation coefficients above 0.7, indicating a strong positive relationship. Both coefficients passed the significance test, and under a 0.01 confidence level, this correlation can be considered to be statistically significant. In addition, the other three variables, namely PF3 (Ubiquitous Trustworthy Learning Environments), PF5 (Commitment to Inclusion and Equity in Education), and CF2 (Responsible Digital Technology in Education), also show a significant moderate correlation with the Quality of Education. The correlation coefficients are about or higher than 0.4 with the significance test at the 0.01 level, indicating that their relationship with the quality of education is statistically significant.

The strong correlation suggests that CF4 (National-level Policy Sustainability of Educational Digital Transformation) and CF5 (Effective Collaboration among Multi-sector Stakeholders in Education) may be key factors affecting the quality of education, while the moderate correlation of the other variables, although less influential, still plays an important role in promoting the quality of education. The potential impact of these features should be considered and explore their specific mechanisms of action with the quality of education be further explored.

The matrix also displays the interrelations between subdimensions of the constructive features of smart education (CF1 to CF5) and how they relate to specific subdimensions of performative features of smart education (PF1 to PF5) and vice versa. The interrelations have specific correlation values to indicate the strength and direction of the relationship. For example, strong positive relationships include PF1 (Beneficial Approach to Student-centered Learning) with PF2 (Evidence-based Assessment for Comprehensive Student Development) and PF2 (Evidence-based Assessment for Comprehensive Student Development) with PF4 (Sustainability of School Improvement with Digital Technology). Strong Negative Correlations include PF4 (Sustainability of School Improvement with Digital Technology) with CF2 (Responsible Digital Technology in Education). This implies that a beneficial approach to student-centered teaching and learning results in effective data-driven learning assessments for comprehensive student development and this ultimately results in sustainable school improvement. A culture of continuous school improvement with digital technology allows principals and school management team members to engage in educational leadership by ensuring they take responsibility for teaching skills and student outcomes, informing parents or guardians about school and student performance, and developing a professional development plan for the school.

The sustainability of school improvement with digital technology is shown to negatively affect the responsible use of digital technology in education. A strong culture which prioritises results over responsible and equitable technology integration may overlook the responsible or ethical adoption of digital technology in education. Upon a detailed analysis of the correlational patterns between the sub-indicators of performative feature and those within the dimension of constructive feature, it is obvious that inclusion, equity and quality of education, seamless and qualified connectivity have become the common considering.

3.5 Relationships among Sub-indicators of Performative and Constructive Features

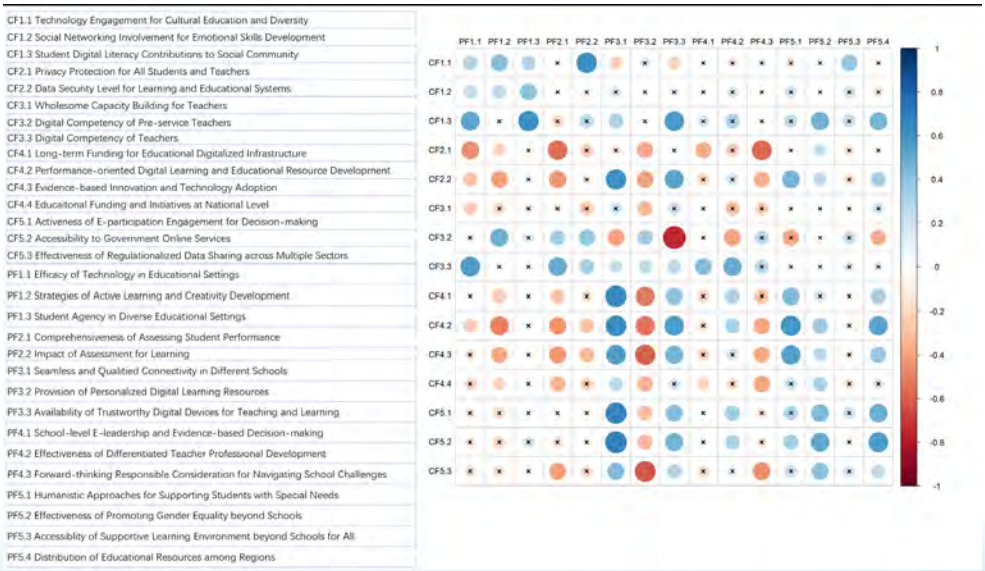


Figure 3-5 Relationships among sub-indicators of performative and constructive features

Specifically, looking at key sub-indicators from the same category (performative features) that are interconnected, it can be observed that CF4.1 (Long-Term Funding for Educational Digitalized Infrastructure) is strongly and positively related to CF4.2 (Performance-oriented Digital Learning and Educational Resource Development) and CF4.3 (Evidence-based Innovation and Technology Adoption). This implies that adequate continuous financial investment in digital infrastructure in education tends to enhance the development of educational resources for higher performance and promote effective and novel ways of infusing technology into education. And CF5.2 (Accessibility to Government Online Services) is positively related to CF1.3 (Student Digital Literacy Contributions to Social Community). That is, when governments make digital resources available and accessible to the general public, especially students, it increases their digital competencies to bring about social development in their respective communities.

A look at the relationships between sub-indicators of performative features also shows that PF1.1 (Efficacy of Technology in Educational Settings) is positively related to PF2.1 (Comprehensiveness of Assessing Student Performance) and PF2.2 (Impact of Assessment for Learning). This means that appropriate technologies in the school learning environment foster authentic assessment strategies for effective learning to be achieved. Diverse countries and regions should prioritize procuring the right technologies that can lead to the enhancement of learning. This also calls for educators/teachers to possess the technical abilities to integrate technology into the classroom and develop comprehensive assessment strategies that enhance learning experiences and lead to quality education.

An inspection of the interrelationships between specific sub-indicators of performative and constructive features of smart education demonstrates that CF1.1 (Technology Engagement for Cultural Education and Diversity) has a significant correlation with PF2.2 (Impact of Assessment for Learning) and PF5.3 (Accessibility of Supportive Learning Environment beyond Schools for All). It can be deduced that technology use in multicultural classrooms to promote diversity improves overall learning assessment and encourages easy access to supportive systems/mechanisms in and out of the confines of school for all people regardless of their background. A holistic approach to technology integration for the digital transformation of education suggests that it is crucial to also consider cultural elements and the creation of supportive learning environments that extend beyond traditional classroom settings to reach diverse learners. This coincides with the call for providing lifelong learning opportunities for all people in different countries and regions of the world. In the same light, it can be seen that PF3.3 (Availability of Trustworthy Digital Devices for Teaching and Learning) has a positive relationship with CF2.2 (Data Security Level for Learning and Educational Systems). This suggests that trustworthy digital devices safeguard the privacy and digital information of participants from unauthorized access and use by third parties. Trustworthy digital devices foster transparency regarding how data is collected, stored, and used.

The correlation matrix highlights strong positive relationships among sub-indicators within the same category of performative and constructive features in smart education, indicating that investments in digital infrastructure enhance educational resource development and performance. Additionally, the availability of government online services boosts student digital literacy, fostering social development. The effective use of technology in educational settings supports comprehensive assessment strategies, emphasizing the need for educators to integrate technology effectively. However, a negative correlation between the availability of trustworthy digital devices and the digital competency of pre-service teachers suggests that simply having access to devices does not guarantee the development of essential skills.

4 Fostering Inclusiveness and Equity within Smart Education

Emergencies such as the COVID-19 pandemic, and the disruptive impact of rapidly evolving technologies like Artificial Intelligence, makes it imperative to construct an education system geared towards achieving inclusive and equitable quality education and promote lifelong learning opportunities for all (SDG 4).

The concept of "inclusiveness" involves creating an education system that is open to all individuals, adapts to diverse needs, and promotes sustainable development. This section highlights the concept, key features, strategies and practices of inclusivity that promote smart education that caters to the needs of special groups and marginalized communities.

4.1 The Philosophy of Promoting Inclusiveness in Smart Education

4.1.1 The Concept of Inclusiveness in the Age of AI

While different disciplines approach the study of "inclusiveness" from varied backgrounds and themes, the concept of "inclusiveness" emphasizes compatibility, equality, participation, and sharing. The core concerns across different fields regarding "inclusiveness" primarily converge on three aspects: focusing on marginalized groups to promote equal opportunities; addressing complex socio-ecological issues to build a resilient ecosystem; and delving into the deep integration of technological, economic, and social issues to foster sustainable development. Inclusiveness involves ensuring equitable access to resources, services and opportunities regardless of geographical location or social status.

Firstly, learner-centric inclusiveness implies that education systems should provide equitable educational opportunities for everyone. Digital educational resources should be accessible to learners regardless of their gender, age, ethnicity, economic status, abilities, or any other characteristics. An inclusive smart education system aims to eliminate exclusion and discrimination, ensuring that everyone can engage and benefit from education.

Secondly, the resilience of smart education systems in response to crises specifically refers to their capacity to handle crises and other external shocks. Global crises have had disruptive impacts on education systems, offering new tools for teaching and learning, yet also presenting challenges that need to be addressed. A resilient smart education system can effectively leverage these crises, maintaining its core services unaffected when faced with challenges such as wars or pandemics, and even growing and advancing from them.

Finally, the sustainability of education for the future involves not only the structure and implementation methods of smart education systems but also the inclusive growth and development of education itself. Inclusive growth suggests that smart education systems can expand their reach in line with societal changes, while inclusive development refers to the ongoing evolution of smart education systems in practice, encompassing curriculum design, pedagogical approaches, assessment methods, and more, to cater to the needs of diverse learners.

4.1.2 Identifying the Key Features of AI Technology-Driven Inclusiveness

The key features highlight how AI can serve as a catalyst for inclusiveness, ensuring that technological progress does not exacerbate existing inequalities but instead works to level the playing field for all.

Diversity. The concept of diversity encompasses acceptance and respect. The issue of diversity should be examined within the framework of fundamental educational questions.

Inclusion and digital inclusion. In education, inclusion means real learning opportunities for groups who have traditionally been excluded. Inclusive education allows students of all backgrounds to learn and grow side by side, to the benefit of all. Digital inclusion refers to the active engagement of individuals and communities in the digital world, ensuring that everyone has the access, resources, skills, and support needed to fully participate in a society that is increasingly dependent on digital technologies.

Equity. To promote equity in education, UNICEF is calling on governments to provide children with disabilities with equal opportunities, persons with disabilities, and consider the full range of disabilities (UNICEF, 2021).

Access. Distance modalities have been used to expand access across the education system. The youth bulge and the growing number of NEETs signal the urgency to expand opportunities, especially for women, persons with disabilities, and those who geographically and economically are unable to participate in education.

Efficiency. Efficiency can be measured in terms of costs and human capacity building for marginalized and hard to reach communities. For example, distance programmes are more efficient in terms of cost but need to improve retention and throughput.

Quality. Depending on the development of digital and textual resources, as well as the training of facilitators, the success of educational programs or initiatives hinges on having well-prepared materials and competent individuals who can guide the learning process effectively.

4.2 Trustworthy Technology Assisting Learners with Special Needs

4.2.1 Demands on Technical Support for Learners with Special Needs

As mentioned in the Convention on the Rights of the Child, Convention on the Rights of Persons with Disabilities and the clear mandate set by the Sustainable Development Goals, all children have a right to education and as a consequence the right to make progress. The Pledge of the 2030 Agenda for Sustainable Development, to leave no one behind, emphasizes reaching those furthest behind first, which inevitably includes children with disabilities and their families.

Learners with special needs include those who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis (United Nations, 2016). The number of children with disabilities globally is estimated at almost 240 million (UNICEF, 2021). Due to the varied spectrum of risks and outcomes based on the type of disability, where the child lives and what services they can access, targeted solutions are needed to the issues of address diversity, inclusivity and equity.

4.2.2 Technology-Integrated Strategies to Assist Learners with Special Needs

Assistive Technologies, Collaborative Tools and Accessible Online Resources. Incorporate a range of assistive devices and software tailored to individual needs. This includes text-to-speech software, speech recognition tools, screen readers, and adaptive keyboards to support students with

visual, auditory, or motor impairments. Use online collaboration tools that facilitate group work and peer-to-peer interactions, ensuring that students with special needs can participate equally in collaborative learning activities. Ensure that all digital educational resources are designed with accessibility in mind. This includes captioning videos, providing transcripts for audio content, and creating user-friendly interfaces that are navigable by assistive technologies.

Universal Design for Learning (UDL), Personalized Learning Platforms and Inclusive Assessment Methods. Apply UDL principles to design educational content and environments that are accessible to all learners, regardless of their abilities. This involves offering multiple means of representation, expression, and engagement to cater to diverse learning styles. Implement adaptive learning technologies that adjust to the pace and style of each student, providing customized feedback and learning paths that accommodate different levels of ability and prior knowledge. Develop assessment strategies that are fair and inclusive, allowing students with special needs to demonstrate their knowledge and skills without being disadvantaged by their disabilities.

Capacity Building and Professional Development for Educators. Provide ongoing professional development for teachers to enhance their skills in using technology effectively to support inclusive education. This includes training in assistive technologies, UDL, and the latest educational software.

Stakeholder Engagement and Policy and Infrastructure Support. Involve all stakeholders, including students, parents, and specialists, in the planning and evaluation of technology use in education. This ensures that the needs and perspectives of learners with special needs are considered and addressed. Advocate for policies that support technology integration for inclusive education and invest in robust technological infrastructure to ensure reliable access for all students, including those in rural or under-resourced areas.

Monitoring and Evaluation. Regularly assess the effectiveness of technology integration in promoting inclusiveness. This involves collecting data on student outcomes and teacher practices to refine and improve strategies over time.

4.2.3 Cases on Promoting Inclusiveness for Learners with Special Needs

- **Asia Pacific University of Technology & Innovation: Supporting Learning Experience through Extended Reality via Gamification**

Asia Pacific University of Technology and Innovation supports learning experiences for kids with autism spectrum disorder and supports deaf and mute learning experiences through extended reality.

Kids with Autism Spectrum Disorder (ASD) experience difficulties in social skills. They also display repetitive behaviors and sensory processing disorders. Research indicates that game-based interventions with autistic children have proven to accelerate the learning process, and digital games have the capacity to raise motivation and engagement. Use XR can assist deaf and mute students in the classroom to diversity the students' learning experiences.

- **Malaysian Federal Government: Inter-Sector Cooperation to Protect Disable Children**

Malaysian Federal Government provides more options for flexibility, disabled-friendly facilities and teacher training in special education.

Ministry of Women, Family and Community Development introduced six subcategories of Learning Disabilities, including autism, down syndrome, intellectual learning disability, specific learning disability, global development delay and ADHD.

The Special Education Programmes from the Ministry of Education cater to 97,220 students:

- Special Education Schools: 34 schools, 2686 students
- Special Education Integration Programme :2586 schools, 78,030 students
- Inclusive Education Programme: 3774 schools, 16,504 students

The Malaysian Government introduced the Zero Reject Policy, providing disabled-friendly facilities in schools, making more inclusive schools available and offering more special education teachers.

4.3 Enhancing Internet Accessibility for Remote Community

4.3.1 Limited Access to Digital Resources and Support for Remote Communities

There is a need for providing education that reaches the unreached-those in remote regions, resource-poor communities and those who are disadvantaged on the basis of race, religion, gender and cultural differences (UNESCO, 2021). Inclusiveness for remote communities involves ensuring equitable access to resources, services and opportunities regardless of geographical location or social status.

Each marginalized group faces distinct challenges that require tailored solutions. For instance, addressing the needs of nomadic populations might involve mobile schools and clinics, while supporting indigenous communities could require land rights advocacy and preservation of traditional practices. Understanding and responding to these nuances is essential for effective intervention.

4.3.2 Accessible and Affordable Digital Solution for Remote Communities

Learning for inclusiveness in remote communities, especially with low literacy rates and with school-aged learners, requires strategies to address issues of both access and quality.

Appropriate Media and Technology Integration, which includes utilizing media and technology for remote learning, including radio and television, online platforms, educational apps, and assistive devices, to bridge gaps and provide equal access to education.

Accessible and Affordable Resources, including Mobile Education Units and Pre-developed printed study guides and workbooks. Ensure the availability of accessible learning materials, such as in braille, audiobooks, and digital resources, to accommodate diverse learning styles and abilities.

Community Engagement and Collaborative Partnerships. Involve local communities in decision-making processes to ensure inclusiveness and cultural relevance. Foster partnerships with local organizations, NGOs, and government agencies to enhance access to resources, expertise, and funding.

Flexible Curriculum and Individualized Support. Design a curriculum that accommodates diverse learning needs, abilities, and cultural backgrounds. Implement individualized education plans (IEPs) and support systems tailored to the unique needs of students with disabilities or special needs (NCSE, 2006). Especially for remote communities, a culture of care is vitally important.

4.3.3 Cases on Promoting Inclusiveness for Remote Areas

- **South Africa: The South African Literacy Campaign for capacity building**

The South African Literacy Campaign trained local residents to act as teachers and facilitators. This not only provides employment opportunities but also helps ensure that the education is relevant and culturally appropriate. This coupled with mobile learning and text-based learning opens access In remote communities.

Assistance can be obtained from NGOs, religious groups, and community organizations.

- **Universitas Terbuka, Indonesia: Open Policies**

Openness policies at Universitas Terbuka (UT), Indonesia, are designed to promote inclusiveness, flexibility, and accessibility in higher education. UT, as the country's national open university, has been at the forefront of providing distance education opportunities to a wide spectrum of the population. UT implements its openness policies through:

- Flexible Admissions
- Distance Learning Model
- Multimedia Course Materials
- Student Support Services
- Examination Flexibility
- Community and Corporate Partnerships
- Research and Innovation, International Collaborations

Implementing open policies helps UT democratize access to higher education in Indonesia, by enabling a greater number of people to pursue academic and professional goals regardless of their circumstances.

- **Nisai Group, UK: Equitable, Inclusive, Outcome-Based When "All Means All" in Education and Training**

Nisai Group, based in the United Kingdom, is a pioneering organization dedicated to transforming education and training by championing principles of equity, inclusivity, and outcome-focused practices, where "all means all" is not just a slogan but a guiding ethos.

"All means all" in the context of Nisai's work signifies a relentless pursuit of educational excellence for every single learner. This commitment extends to tailoring educational pathways, resources, and support mechanisms to meet the unique needs of each student, ensuring that no one is left behind. Through innovative strategies, partnerships with schools, colleges, and local authorities, and a deep understanding of the challenges faced by marginalized learners, Nisai Group strives to make this vision of equitable, inclusive, and outcome-driven education a reality for all.

4.4 Reliable and Unbiased Social Mechanism for Gender Equity

4.4.1 Emerging Gender Equity Issues During Digital Transformation

Digital technologies create far more opportunities for women's leadership through flexible and equitable access to education and competency building. Efforts to bridge the digital skills gap and provide training in digital and technical skills can empower more women to pursue leadership roles in digital and related sectors. Remote work and flexible work arrangements are more suited to women with multiple role expectations. While access to educational opportunities can be facilitated through digital platforms, biases and discrimination can also be perpetuated.

Technology developments have always had an impact on women's lives at the personal professional and academic levels. Washing machines, computers and online learning are just a few examples. During the pandemic, 45% of women participating in Coursera courses said they would not have been able to learn if it was not for online provision (Coursera, 2021). AI is an exciting new development—can this be an opportunity for promoting gender equality? However, a mixed picture has emerged—violence against women has increased through the use of technology; gender stereotypes are reinforced through the creation of female bots such as Siri and Alexa; there are gender biases in algorithms and large language models—suggesting that instead of promoting equity and inclusion, there seems to be every likelihood that the gender gap can be further exacerbated.

For example, women are 15% less likely to own mobiles and 33% less likely to be connected to mobile internet services. To address these issues, comprehensive strategies are needed. These include increasing access to early education in STEM subjects, providing mentorship and networking opportunities for women in tech, and implementing policies that promote work-life balance and equal opportunities in the workplace.

4.4.2 Gender-Sensitive-Responsive Approach for Equity and Justice

Internet Access, Affordability and Women's Empowerment. The relationship between internet access and women's empowerment is multifaceted, influenced by various factors that either facilitate or hinder women's ability to utilize the internet effectively. Affordability is a critical factor in determining whether individuals can access and utilize the Internet effectively. Several aspects contribute to the affordability challenge, particularly impacting women and underserved communities. Key aspects include limited sex-disaggregated information, ownership of mobile phone, Internet affordability, and use of the Internet for empowerment. Addressing these issues requires concerted efforts from governments, private sector actors, and civil society to improve internet access and affordability, challenge gender stereotypes, and ensure that women have the skills and confidence to use the internet to their full advantage.

Digital Skills and Education. Digital Skills and Education play a vital role in empowering women and closing the gender gap in technology sectors. Specific interventions include ICT training for women in the workforce, promoting representation of women in ICT and engineering fields.

Relevant Content and Services. Access to relevant content and services online is crucial for empowering individuals and communities, especially for women and vulnerable groups. Specific details regarding the availability and impact of such content and services, including the use of mobile financial systems, healthcare services and information limitations, helplines for domestic and sexual violence and information availability via social media.

Online Safety. Online safety is a critical component of digital citizenship, encompassing measures to protect individuals from various forms of harm in the digital realm. Together, these components of online safety—cybercrime legislation, measures against online Gender Based Violence, and data protection guidelines—work to create a safer digital environment. They empower users to engage online with greater confidence, knowing that their rights and privacy are protected by law and that there are consequences for those who violate these protections. Ensuring online safety is an ongoing process that requires collaboration between governments, technology companies, civil society, and individuals themselves.

4.4.3 Cases on Promoting Inclusiveness for Gender Equity

- **South Pacific Region: Alliance for Affordable Internet and Pacific Digital Gender Scorecards**

The Pacific Private Sector Development Initiative (PSDI) has supported the the Alliance for Affordable Internet (A4AI), to audit the digital gender gap in the Pacific, and the ways in which Pacific women are prevented from obtaining meaningful internet connectivity.

The Pacific Digital Gender Scorecards audit includes a regional synthesis report and digital "scorecards" for Papua New Guinea, Samoa, and Tonga. The scorecards measured the state of women's digital inclusion and empowerment across five key themes—internet access and women's empowerment, affordability, digital skills and education, relevant content and services for women, and online safety.

- **China: Digital Technology Promotes Equity of Girls' Education**

Girls' education has always been the focus of extensive attention of the international community, and the use of information technology to empower girls and girls' education is of great significance in promoting the comprehensive development of girls. The case analyzes the current situation of girls' education in the era after the popularization of education in China and finds that Chinese girls are receiving digital education on an equal footing with boys. Commitment to inclusion and equity in education takes the construction of the "Internet+Education" demonstration area in Yuanzhou District, Ningxia, as an example, and describes the typical cases of digital teaching practice of female teachers in Yuanzhou District and analyzes in detail the process of girls' digital education. It also puts forward targeted suggestions to promote the cultivation of digital girls in line with the requirements of the times, with a view to providing a reference for the study of girls' education and digital girls.

This was an area where girls' education was a challenge. Yuanzhou District, located in Guyuan City, a mountainous area in southern Ningxia, was once a key area in China where girls' education faced great difficulties. However, by 2020, Yuanzhou District has achieved full coverage of school-age girls' education. However, from a nationwide perspective, Yuanzhou is still a relatively weak area in China's education quality development.

Generally speaking, girls' education in ethnic minority areas lags behind seriously, and problems such as low enrolment rates, high dropout rate are very prominent. Teachers are one of the most important factors influencing student learning and need opportunities for professional development, and support to work with a diverse group of people who are ethnically, culturally and linguistically diverse in order to be able to accommodate and adequately assist those with special needs.

With the deepening of information technology applications in Yuanzhou District, the internal and external factors that affect girls' enrolment and access to high-quality education have been fundamentally improved.

4.5 Recommendation on Promoting Inclusiveness in Smart Education

Providing Reliable Internet Access. Recognizing that connectivity is a cornerstone of modern education, health services, and economic opportunities, governments and NGOs should prioritize expanding high-speed internet coverage to underserved regions. This may involve building new infrastructure, subsidizing access costs, or deploying mobile broadband solutions to bridge the digital divide.

Harnessing Appropriate and Accessible Technology According to the Context. Utilize cutting-edge technologies such as artificial intelligence, machine learning, and assistive devices tailored for learners with special needs. Technology should facilitate personalized learning experiences and provide alternative modes of interaction and communication and recognize the unique social contexts in which learners with special needs operate. Educational strategies should be culturally sensitive and responsive to local conditions, ensuring that all students feel valued and included within their community.

Combating Gender Bias in Technology. Ensuring that the design and development processes include diverse teams and perspectives, particularly those of women, to avoid overlooking gender-specific needs. Actively identifying and correcting biases in algorithms, which can perpetuate existing inequalities if not addressed. This requires regular audits and the use of diverse and representative datasets. There is a need to fostering innovation that considers the needs of all genders, leads to products and services that are more universally applicable and fair.

Investing in Digital Competence Building and Continuing Professional Development for Teachers. Access to ICTs and meaningful internet connectivity is not just about technological access; it's a fundamental aspect of promoting gender equality, women's empowerment, and building sustainable economies. Recognizing this, the Sustainable Development Goals (SDGs) have emphasized empowering women through technology and ensuring universal, affordable internet access, alongside quality education that includes digital skills training. Educators need to be equipped with comprehensive knowledge of universal design principles and specialized skills relevant to teaching students with special needs. Professional development should include best practices for creating accessible environments and instructional techniques that cater to diverse learning styles.

Advancing Gender Responsive Digital Policies. Governments must urgently fulfill their commitments to bridge the gender digital divide. This involves setting policy targets and investing in infrastructure and education to provide women and girls with the necessary digital skills. Equal access to the internet and digital technologies is vital for achieving universal quality education, ensuring access to healthcare, promoting financial inclusion, and enhancing public service delivery.

Engaging a Wider Range of Stakeholders. Involve parents, caregivers, community leaders, and students themselves in the decision-making process. Collaboration among stakeholders fosters a supportive network that can advocate for and implement inclusive practices effectively.

Context-Specific Innovations. Encourage the development of context-specific innovations that address the particular challenges faced by learners with special needs within a given country or community. Tailored solutions are more likely to be sustainable and impactful.

5 Conclusion

- **By investigating the adoption of smart education from different regions and countries, the concept of smart education with a shared vision of quality education in the age of AI is being understood by different countries through diverse cultural, technological, and pedagogical lenses.**

The investigation encompassed 92 participants from 41 countries, covering the Asia & Pacific, Western Europe and North America, Eastern Europe, Africa, and the Latin America and Caribbean regions, aiming to consolidate the diverse perspectives on smart education across the globe.

The participants were categorized into stakeholder groups based on their institutions and affiliations, including prominent academics, renowned researchers, influential non-profit leaders, key policymakers, and officials from regional and international organizations.

Smart education is perceived by participants as an enhancement of current educational practices and regarded as synonymous with good education. Smart education reflects and responds to the core concerns of the future of education which relate to promoting a human-centered integration of technology within the educational process.

- **The features of smart education can be categorized into two types: a) performative features which focus on learning, assessment, infrastructure, sustainability, and equity, and b) constructive features, which relate to students, teachers, digital technology, policy, and partnerships.**

The performative features of smart education depict the ideal educational blueprint, where student-centered learning, comprehensive learning assessment, a smart and ubiquitous learning environment, a culture of continuous improvement, and commitment to inclusion and equity in education are the norm rather than exceptions.

The constructive features of smart education outline the actionable pathways to achieve smart education, by creating social learning communities, promoting the ethical adoption of ICT in education, prioritizing teacher professional development, developing sustainable plans for educational reform, and facilitating multi-sectoral collaboration.

Based on Kendall's W coefficient (a measure of inter-rater reliability/level of consensus) derived from the participants' evaluation data on the importance of each feature of smart education, the level of consensus among participants is remarkably high, particularly in the areas of sustainable educational reform plans and effective multi-sectoral collaboration.

- **Within the context of uncertainty, change and cultural diversity, smart education can be achieved through four critical leverage points: transformative teaching and learning enabled through technology, smart learning environments conducive to smart education, forward-thinking governance and policy initiatives, and overarching considerations that connect these three leverage points.**

The Asia-Pacific region places great emphasis on building technological infrastructure and fostering partnerships between educational institutions and technology companies but faces challenges in providing teacher professional development and building capacity in technology adoption. The

region is committed to creating interactive, technology-enriched learning environments to meet the diverse needs of students while relying on comprehensive policy support and sustainable development.

Western European and North American regions prioritize gender and cultural equity, enhancing professional development through global practices and cross-cultural exchanges. The regions focus on creating dynamic, personalized learning environments and improving teaching capacity. Key challenges include technology dependency, the digital divide, resource limitations, and addressing ethical issues.

The Eastern Europe region prioritizes the alignment of policy and practice in smart education, supporting its development through meaningful integration, as well as continuous professional development. However, some countries face challenges such as inadequate infrastructure, deeply ingrained traditional teaching methods, and the high costs associated with educational technology. Convincing educators, administrators, and parents to embrace educational reform remains a significant challenge, requiring further consensus and support for long-term sustainability.

African regions face significant challenges in implementing smart education due to complex factors. Limited funding and resource allocation hinder investments in technology and infrastructure, while teacher training is crucial to bridging the skills gap. However, the digital divide, high infrastructure costs, data privacy and cybersecurity concerns, and resistance to change within the system, further complicate the adoption of smart education.

The Latin America and Caribbean region are reshaping education by aligning curricula with societal needs. However, challenges include high technology costs, inadequate infrastructure, and resistance to digital literacy. Traditional teaching methods also pose obstacles. Overcoming these challenges requires continuous professional development and strong technical support to foster mindset shifts and build essential skills.

- **The analysis of digital education policies in selected countries indicates different stages of educational transformation, relating to digitization, cyberization, and intelligentization. The implementation of the smart education framework could provide an effective roadmap for transforming education.**

Digitization is marked by the foundational setup of informational technologies and the initial application of such technologies, which focuses on acquiring smart devices, developing digital resources, constructing informational platforms, and experimenting with the use of various media. **Cyberization** centers on leveraging data to empower educational reform, through fully integrated information platforms that support teaching, learning, administration, assessment, and evaluation. **Intelligentization** involves the comprehensive reshaping of educational structures and processes using artificial intelligence. **Six aspects of the smart education framework**, include: “Develop a National Vision and Plan”, “Build Infrastructure Capacity,” “Invest in Human Capacity,” “Inclusion and Equity,” “Continuous Improvement Culture,” and “Multi-Sector Cooperation and Partnerships”.

- **Creating a high-quality, inclusive, and sustainable digital education ecosystem is the main concern in digital education policy vision and plan. Infrastructure development and human capacity are integral to digital education policies.**

Although most countries have integrated digital technologies in education, the realization of digital education is still constrained by technology and resources. Strongly enhancing infrastructure construction and investing in human resources is crucial for achieving high-quality digital education. Digital education emphasizes the use of digital technology to establish an educational ecosystem where anyone can learn anytime and anywhere. The vision and plan aim to optimize educational data to support all students with digital resources and achieve learner-centered educational reform.

Additionally, digital education is advancing towards an equitable and inclusive learning environment by narrowing the digital access divide, the digital design divide, and the digital use divide. Furthermore, countries need to establish specialized agencies to oversee, monitor and assess the implementation of digital education, regularly updating digital education policies to promote the sustainable development of smart education.

- **A global framework for tracking smart education encompassing 10 indicators and 30 sub-indicators was identified which coincides well with the GSE dataset covering 58 observing data points, compiled from six reliable public data sources.**

This framework comprises 10 primary dimensions, each meticulously aligned with one of the ten key features that define smart education. To ensure a thorough and nuanced analysis, these primary dimensions are further subdivided into 30 sub-indicators, providing a more granular perspective on specific aspects of smart education.

Data collection for this framework is both rigorous and methodical, drawing on publicly available and reliable sources. The data is aggregated from internationally recognized surveys and databases, ensuring that the indicators are grounded in widely accepted and credible information. As a result, the framework encompasses a total of 58 data observing points. These observing points serve as critical reference metrics, enabling stakeholders to assess the progress, challenges, and overall impact of smart education initiatives across different contexts and regions. The data is drawn from multiple reports or webpages related to the digital transformation of education from the OECD, UNESCO, Portulans Institute, The International Telecommunications Union, and the World Bank.

- **The GSE dataset revealed that sustainable national policies sustainability and effective partnerships in educational digital transformation significantly impact the overall quality of education. In addition, ubiquitous learning environments, responsible digital technology, and commitment to inclusion have a positive impact on educational quality.**

The analysis of the data revealed a significant positive correlation between the two performative features such as “National-level Policy Sustainability of Educational Digital Transformation” and “Effective Collaboration among Multi-sector Stakeholders in Education” with the quality of education.

In addition, the other three variables, namely “Ubiquitous Trustworthy Learning Environments”, “Commitment to Inclusion and Equity in Education”, and “Responsible Digital Technology in Education”, also show a significant moderate correlation with the quality of education.

The strong correlation suggests that “National-level Policy Sustainability of Educational Digital Transformation” and “Effective Collaboration among Multi-sector Stakeholders in Education” may be key factors affecting the quality of education, while the moderate correlation of the other variables, although less influential, still play an important role in promoting the quality of education. The potential impact of these features and their specific mechanisms of action on the quality of education need to be explored further.

- **The GSE dataset indicates that most countries recognize the importance of inclusion, equity, and quality access to the Internet in schools. However, issues of access to digital technology beyond schools, E-leadership training in schools, adaptive learning resources and forward-responsible thinking have not been fully emphasized in the process.**

In an analysis of the correlation between sub-indicators within the performative and constructive

features, each consisting of 15 sub-indicators, it can be observed that “Humanistic Approaches for Supporting Students with Special Needs” and “Effectiveness of Promoting Gender Equality beyond Schools”, which belong to the performative feature, exhibit significant positive correlations with multiple sub-indicators within the constructive feature. Notably, there were no instances of negative correlation. Specifically, “Effectiveness of Promoting Gender Equality beyond Schools” stands out with significant positive correlations with nine sub-indicators from the constructive features.

These findings suggest that “Humanistic Approaches for Supporting Students with Special Needs” and “Effectiveness of Promoting Gender Equality beyond Schools” are influenced by a variety of factors within the performative feature, making them a common consideration in digital education.

Our findings also suggest that the attention given to some sub-indicators within the constructive features may not have matched their impact on the performative dimension variables. It could also indicate that these indicators warrant greater consideration in the study.

- **Based on a survey from 10+ countries and regions, it was found that assistive technologies for learners with special needs, internet access for remote areas, and reliable social mechanisms for gender equity, play a crucial role in promoting inclusiveness and equity, essential components of smart education.**

Adaptive technologies and specialized software can significantly enhance the learning experience for students with disabilities, allowing them to access educational materials and participate in classroom activities on an equal footing with their peers. Bridging the digital divide by providing internet connectivity to underserved and remote regions ensures that students in these areas have the same opportunities to learn and engage with digital resources as their peers in urban centers. Establishing robust mechanisms to promote gender equality in education is essential. This includes ensuring that both boys and girls have equal access to education and that gender stereotypes do not hinder educational opportunities.

These findings align closely with the core principles of smart education, which seek to integrate technology into educational policies and practices in a way that promotes inclusiveness in the era of artificial intelligence (AI). Smart education aims to leverage technological advancements to improve educational outcomes while ensuring that they are accessible to all learners regardless of their background or abilities.

By working collaboratively, stakeholders can establish guidelines, standards, and frameworks that prioritize equity, accessibility, and quality in education. This ensures that the digital transformation of education benefits every learner, contributing to a more equitable and inclusive society.

- **From the perspective of digital transformation, it is confirmed from case studies that “girls if given the opportunity to do, they can perform better” and it is crucial to address the structural barriers to reaching girls’ full potential. The cases include girls’ digital education on an equal footing with boys in the Chinese mountainous area, Ningxia, and the alleviation of digital resource scarcity in small islands conducted by the Pacific Private Sector Development Initiative (PSDI).**

In the mountainous region of Ningxia, China, girls are provided digital education on an equal footing with boys. This addresses the challenges of low enrollment rates, high dropout rates, and lower educational outcomes compared to other regions. The use of digital technology can play a transformative role in empowering girls and improving their access to education. For instance, online platforms can offer flexible learning opportunities that might not be available due to geographical or social barriers.

Regional partnerships and collaborations are

essential in addressing resource scarcity and enhancing the impact of development initiatives, especially in regions like the South Pacific where there might be a significant gender gap in accessing digital technologies. This disparity can limit women's ability to benefit from advancements in areas such as information sharing, education, healthcare, and economic opportunities. By fostering collaboration among countries and organizations within the region, resources can be pooled together to create more effective programs and services that cater to the specific needs of women and girls.

To further these goals, regional partnerships can facilitate the exchange of best practices, technology, and funding, which are critical for sustainable development. Collaborative efforts can also lead to the creation of regional standards and policies that ensure equitable access to digital technologies and education across different communities.

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Appendix

Appendix A The country list of participants from different regions

Regions	Countries	Regions	Countries
Asia-Pacific	Australia	Eastern Europe	Albania
	Cambodia		Bulgaria
	China		Croatia
	India		Cyprus
	Maldives		Czech
	Philippines		Greece
	Vietnam		Hungry
Western Europe and North America	Canada		Moldova
	Germany		North Macedonia
	Ireland		Russia Federation
	Malta		Romania
	Netherlands		Turkey
	Norway	Africa	Botswana
	Spain		Côte d'Ivoire
	Sweden		Egypt
	Switzerland		Ghana
	UK		South Africa
	USA		Tunisia
Latin America and the Caribbean	Brazil		Uganda
	Ecuador		
	Uruguay		
	Saint Lucia		

Appendix B Indicators list of smart education

	Primary Indicator		Sub-Indicator
PF1	Beneficial Approach to Student-centered Learning	PF1.1	Efficacy of Technology in Educational Settings
		PF1.2	Strategies of Active Learning and Creativity Development
		PF1.3	Student Agency in Diverse Educational Settings
PF2	Evidence-based Assessment for Comprehensive Student Development	PF2.1	Comprehensiveness of Assessing Student Performance
		PF2.2	Impact of Assessment for Learning
PF3	Ubiquitous Trustworthy Learning Environments	PF3.1	Seamless and Quality Connectivity in different schools
		PF3.2	Provision of Personalized Digital Learning Resources
		PF3.3	Availability of Trustworthy Digital Devices for teaching and learning
PF4	Sustainability of School Improvement with Digital Technology	PF4.1	School-Level E-Leadership and Evidence-based Decision-making
		PF4.2	Effectiveness of Differentiated Teacher Professional Development
		PF4.3	Forward-thinking Responsible Consideration for Navigating School Challenges
PF5	Commitment to Inclusion and Equity in Education	PF5.1	Humanistic Approaches for Supporting Students with Special Needs
		PF5.2	Effectiveness of Promoting Gender Equality beyond Schools
		PF5.3	Accessibility of Supportive Learning Environment beyond Schools for All
		PF5.4	Distribution of Educational Resources among Regions
CF1	Social Learning and Emotional Development for Students	CF1.1	Technology Engagement for Cultural Education and Diversity
		CF1.2	Social Networking Involvement for Emotional Skills Development
		CF1.3	Student Digital Literacy Contributions to Social Community
CF2	Responsible Digital Technology in Education	CF2.1	Privacy Protection for All Students and Teachers
		CF2.2	Data Security Level for Learning and Educational Systems
CF3	Prioritization of Teacher Professional Development	CF3.1	Wholesome Capacity Building for Teachers
		CF3.2	Digital Competency of pre-service teachers
		CF3.3	Digital Competency of teachers

CF4	National-level Policy Sustainability of Educational Digital Transformation	CF4.1	Long-term Funding for Educational Digitalized Infrastructure
		CF4.2	Performance-oriented Digital Learning and Educational Resource Development
		CF4.3	Evidence-based Innovation and Technology Adoption
		CF4.4	Educational Funding and Initiatives at National Level
CF5	Effective Collaboration among Multi-sector Stakeholders in Education	CF5.1	Activeness of E-Participation Engagement for Decision-making
		CF5.2	Accessibility to Government Online Services
		CF5.3	Effectiveness of Regulated data sharing across multiple sectors

Appendix C Observing points with data source for smart education indicators

	Sub-indicator	Observing Point	Data source
PF1.1	Efficacy of Technology in Educational Settings	a. Teacher competency in digital pedagogy	PISA 2022
		b. Application of digital resources across subjects	PISA 2022
PF1.2	Strategies of Active Learning and Creativity Development	a. Student curiosity	PISA 2022
		b. Flexible and adaptive teaching strategies	TALIS 2018
		c. Cognitive ability development through multiple strategies	TALIS 2018
		d. Responsive instruction and support	PISA 2022
PF1.3	Student Agency in Diverse Educational Settings	a. Student confidence for self-directed learning	PISA 2022
PF2.1	Comprehensiveness of Assessing Student Performance	a. Student performance and outcomes	PISA 2022
		b. Standardized and teacher-developed assessments	PISA 2022
		c. National learning assessments implementation	UIS
PF2.2	Impact of Assessment for Learning	a. Diverse assessment and teacher feedback	TALIS 2018
		b. Multi-source feedback for students	PISA 2022
PF3.1	Seamless and Quality Connectivity in different schools	a. Internet bandwidth and subscriptions	ITU, World Bank
		b. Comprehensive internet access and cybersecurity	ITU, World Bank, NRI, UIS
PF3.2	Provision of Personalized Digital Learning Resources	a. Utilization of digital learning resources	PISA2022
PF3.3	Availability of Trustworthy Digital Devices for teaching and learning	a. Digital device availability for education	PISA2022
PF4.1	School-Level E-Leadership and Evidence-based Decision-making	a. School autonomy	PISA2022
		b. Curriculum and resource decision-making	PISA2022
		c. Teacher involvement in school governance	TALIS2018
PF4.1	School-Level E-Leadership and Evidence-based Decision-making	d. Educational leadership and accountability	PISA2022
		e. Quality assurance and improvement measures	PISA2022
		f. Impact of Teacher Evaluations	PISA2022
PF4.2	Effectiveness of Differentiated Teacher Professional Development	a. Collaborative teaching and professional learning	TALIS2018
		b. Teacher exchange and coordination	TALIS2018

PF4.3	Forward-thinking Responsible Consideration for Navigating School Challenges	a. School flexibility and responsiveness	PISA2022
		b. Innovative school culture	TALIS2018
PF5.1	Humanistic Approaches for Supporting Students with Special Needs	a. Accessible resources and infrastructure	UIS
PF5.2	Effectiveness of Promoting Gender Equality beyond Schools	a. Gender equality in schooling	UIS
PF5.3	Accessibility of Supportive Learning Environment beyond Schools for All	a. Cultural diversity accommodation	TALIS2018
		b. Inclusive and supportive school policies	TALIS2018
		c. Diversity, equity, and inclusivity practices	TALIS2018
PF5.4	Distribution of Educational Resources among Regions	a. Educational resource equality	Gini Coefficients of Education
CF1.1	Technology Engagement for Cultural Education and Diversity	a. School staff's behaviors to promote a diversity-oriented culture	PISA2022
		b. Self-related efficacy of teachers in multicultural classrooms	TALIS2018
CF1.2	Social Networking Involvement for Emotional Skills Development	a. Students' teamwork, emotional control, and stress management	PISA2022
		b. Students' empathy and perspective-taking	PISA2022
CF1.3	Student Digital Literacy Contributions to Social Community	a. Students use digital resources for various school-related activities	PISA2022
		b. Students self-efficacy in digital competencies	PISA2022
CF2.1	Privacy Protection for All Students and Teachers	a. Legal framework stipulates measures to protect internet users' privacy and data	NRI2023
CF2.2	Data Security Level for Learning and Educational Systems	a. ICT regulatory tracker composite index	NRI2023
		b. Adaptability of legal frameworks to emerging technologies	NRI2023
CF3.1	Wholesome Capacity Building for Teachers	a. Number of certified teachers	PISA2022
CF3.2	Digital Competency of pre-service teachers	a. ICT skills training in initial education and in professional development	TALIS2018
CF3.3	Digital Competency of teachers	a. Availability of professional resources and online platforms for teachers	PISA2022
		b. School policies on promoting teachers to use digital devices	PISA2022
CF4.1	Long-term Funding for Educational Digitalized Infrastructure	a. Investment in emerging educational technologies	NRI2023
		b. Government support for technology investment	NRI2023
		c. Spending on educational software	NRI2023
		d. Investment in IT services for education	NRI2023

CF4.2	Performance-oriented Digital Learning and Educational Resource Development	a. Open source contribution and content availability	NRI2023
		b. Opportunities of degree program offerings	Study Portal
CF4.3	Evidence-based Innovation and Technology Adoption	a. Adoption of emerging educational technologies	NRI2023
		b. R&D investment relative to GDP	World bank
CF4.4	Educational Funding and Initiatives at National Level	a. Government expenditure on education as a percentage of GDP (%)	UIS
		b. Per-Pupil funding in secondary education	World bank
CF5.1	Activeness of E-Participation Engagement for Decision-making	a. E-Participation in educational decision-Making	NRI2023
CF5.2	Accessibility to Government Online Services	a. Accessibility to government online services	UIS
CF5.3	Effectiveness of Regulated Data Sharing across Multiple Sectors	a. Management data flow for collaborative planning	UIS

Appendix D Notes for observing points of smart education indicators

PF1.1 Efficacy of Technology in Educational Settings	
a.	**Teacher competency in digital pedagogy** teachers have the necessary technical and pedagogical skills to integrate digital devices in instruction and have sufficient time to prepare lessons integrating digital devices.
b.	**Application of digital resources across subjects** digital resources are used in various subject lessons.
PF1.2 Strategies of Active Learning and Creativity Development	
a.	**Student curiosity** students' curiosity of learning
b.	**Flexible and adaptive teaching strategies** teachers' flexible instruction strategies including craft good questions for students and use a variety of assessments strategies.
c.	**Cognitive ability development through multiple strategies** teachers assign tasks that require critical thinking and present challenges without obvious solutions.
d.	**Responsive instruction and support** teachers give help when students need it and continues teaching until the students understand.
PF1.3 Student Agency in Diverse Educational Settings	
a.	**Student confidence for self-directed learning** students have confidence to do a range of self-directed learning tasks.
PF2.1 Comprehensiveness of Assessing Student Performance	
a.	**Student performance and outcomes** specification of student performance standard and student test results and graduation rates.
b.	**Standardized and teacher-developed assessments** standardized tests for students and teacher-developed tests for students
c.	**National learning assessments implementation** implementation of nationally representative learning assessments at key stages to ensure students acquire.
PF2.2 Impact of Assessment for Learning	
a.	**Diverse assessment and teacher feedback** teachers use various assessment and provide feedback.
b.	**Multi-source feedback for students** students get feedback from teachers, other students and educational software.
PF3.1 Seamless and Quality Connectivity in different schools	
a.	**Internet bandwidth and subscriptions** International Internet bandwidth, building internet subscriptions, fixed broadband subscriptions, and active mobile-broadband subscriptions
b.	**Comprehensive internet access and cybersecurity** Global Cybersecurity Index (GCI) measures the level of cybersecurity commitments.
PF3.2 Provision of Personalized Digital Learning Resources	
a.	**Utilization of digital learning resources** students use specific learning resources
PF3.3 Availability of Trustworthy Digital Devices for teaching and learning	
a.	**Digital device availability for education** primary schools with access to computers for pedagogical purposes, the number of digital devices available for students in school, desktop or laptop computers in school that are connected to the Internet, and tablet devices or e-book readers available for students in school for educational purposes

PF4.1 School-Level E-Leadership and Evidence-based Decision-making	
a.	**School autonomy** the school provides staff, parents or guardians, and students with opportunities to actively participate in school decisions, fostering a collaborative culture of shared responsibility for school issues and mutual support.
b.	**Curriculum and resource decision-making** school staff's responsibility in deciding issues related to curriculum and assessment and school staff's responsibility in deciding issues related to allocating resources
c.	**Teacher involvement in school governance** teachers' participation in various decisions or activities in school
d.	**Educational leadership and accountability** Principals and school management team members engage in educational leadership by ensuring teachers take responsibility for teaching skills and student outcomes, informing parents or guardians about school and student performance, and developing a professional development plan for the school.
e.	**Quality assurance and improvement measures** school's arrangements in quality assurance and improvement measures
f.	**Impact of Teacher Evaluations** teacher evaluations impact opportunities for professional development, career advancement, public recognition, job responsibilities, and involvement in school development initiatives.
PF4.2 Effectiveness of Differentiated Teacher Professional Development	
a.	**Collaborative teaching and professional learning** teachers' professional collaboration in lessons including teach jointly as a team, provide feedback to other teachers and participate in collaborative professional learning.
b.	**Teacher exchange and coordination** exchange and coordination among teachers
PF4.3 Forward-thinking Responsible Consideration for Navigating School Challenges	
a.	**School flexibility and responsiveness** school flexibility including quickly identifying the need for change, responding promptly, accepting new ideas, and providing assistance for their development.
b.	**Innovative school culture** school team innovativeness including teachers strive to develop new ideas, are open to change, seek new problem-solving methods, and support each other's application of new ideas.
PF5.1 Humanistic Approaches for Supporting Students with Special Needs	
a.	**Accessible resources and infrastructure** schools adapted infrastructure and materials for students with disabilities
PF5.2 Effectiveness of Promoting Gender Equality beyond Schools	
a.	**Gender equality in schooling** ratio of gender on average years of schooling
PF5.3 Accessibility of Supportive Learning Environment beyond Schools for All	
a.	**Cultural diversity accommodation** accommodate student diversity including cultural backgrounds, different values and respect other cultures
b.	**Inclusive and supportive school policies** school policies and practices including teaching students to be inclusive, opposing gender and socio-economic discrimination, and providing additional support for disadvantaged students
c.	**Diversity, equity, and inclusivity practices** teacher's practices in relation to diversity, school's practices in relation to diversity, school's practices in relation to equity and inclusivity
PF5.4 Distribution of Educational Resources among Regions	
a.	**Educational resource equality** degree of inequality in the distribution of educational resources within a country or region.

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CF1.1 Technology Engagement for Cultural Education and Diversity	
a.	**School staff's behaviors to promote a diversity-oriented culture** school staff's efforts to promote a diversity-oriented culture and climate
b.	**Self-related efficacy of teachers in multicultural classrooms** multicultural classrooms
CF1.2 Social Networking Involvement for Emotional Skills Development	
a.	**Students' teamwork, emotional control, and stress management** students' awareness and behaviors indicative of cooperation, students' ability of controlling emotion, students enjoy cooperating with classmate, and students can remain calm under stress
b.	**Students' empathy and perspective-taking** students' empathy and students' perspective-taking
CF1.3 Student Digital Literacy Contributions to Social Community	
a.	**Students use digital resources for various school-related activities** students use digital resources for various school-related activities
b.	**Students' self-efficacy in digital competencies** students' self-efficacy in digital competencies
CF2.1 Privacy Protection for All Students and Teachers	
a.	**Legal framework stipulates measures to protect internet users' privacy and data** legal framework to protect internet users' privacy and data stipulate
CF2.2 Data Security Level for Learning and Educational Systems	
a.	**ICT regulatory tracker composite index** ICT regulatory environment indicator including regulatory authority, mandate, regime and competition framework
b.	**Adaptability of legal frameworks to emerging technologies** legal framework of adapting to emerging technology in countries (Artificial intelligence, Robotics, App- and web-enabled markets, big data analytics, and Cloud computing)
CF3.1 Wholesome Capacity Building for Teachers	
a.	**Number of certified teachers** the number of full-time and part-time teachers fully certified by the appropriate authority
CF3.2 Digital Competency of Pre-service teachers	
a.	**ICT skills training in initial education and in professional development** ICT skills for teaching in initial education and professional development
CF3.3 Digital Competency of teachers	
a.	**Availability of professional resources and online platforms for teachers** effective professional resources for teachers to learn how to use digital devices and effective online learning support platform
b.	**School policies on promoting teachers to use digital devices** school has specific policy to promote teachers to use digital devices
CF4.1 Long-term Funding for Educational Digitalized Infrastructure	
a.	**Investment in emerging educational technologies** investment in emerging technologies (Artificial intelligence, Robotics, App- and web-enabled markets, Big data analytics, and Cloud computing)
b.	**Government support for technology investment** government promotion of investment in emerging technologies

c.	**Spending on educational software** **total computer software spending**
d.	**Investment in IT services for education** investments of providing telecommunication networks and/or services (including fixed mobile and Internet services and the transmission of TV signals).
CF4.2 Performance-oriented Digital Learning and Educational Resource Development	
a.	**Open-source contribution and content availability** online content creation (GitHub) and internet content and services tailored to the local population
b.	**Opportunities of degree program offerings** the total number of online, offline, and hybrid degree programs offered by various countries
CF4.3 Evidence-based Innovation and Technology Adoption	
a.	**Adoption of emerging educational technologies** adoption of emerging technologies (Artificial intelligence, Robotics, App- and web-enabled markets, big data analytics, and Cloud computing)
b.	**R&D investment relative to GDP** research and development expenditure
CF4.4 Educational Funding and Initiatives at National Level	
a.	**Government expenditure on education as a percentage of GDP (%)** government total expenditure on education
b.	**Per-Pupil funding in secondary education** government expenditure per secondary student
CF5.1 Activeness of E-Participation Engagement for Decision-making	
a.	**E-Participation in educational decision-Making:** the capacity and willingness of the state to promote citizen participation in public policy decision-making.
CF5.2 Accessibility to Government Online Services	
a.	**Accessibility to government online services** government's online service capability
CF5.3 Effectiveness of Regulated data sharing across multiple sectors	
a.	**Management data flow for collaborative planning** government's situation regarding the release and use of open data

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Global Smart Education Network (GSENet)

The Global Smart Education Network (GSENet) was initiated in 2022 by the Smart Learning Institute of Beijing Normal University (SLIBNU) with five partners: UNESCO Institute for Information Technologies in Education (UNESCO IITE), Commonwealth of Learning (COL), International Society for Technology in Education (ISTE), Southeast Asian Ministers of Education Organization (SEAMEO) and Arab League Educational, Cultural and Scientific Organization (ALECSO).

Vision To network with leading partners and diverse experts to promote better education for all.

Mission To create a shared platform that connects organizations and institutions for intercultural dialogue, leveraging smart learning technologies to enhance educational excellence and innovation for all through research, policy development, and capacity building.

Key Takeaways

1. The concept of smart education is gradually being demystified across several countries and regions in the perspective of diverse culture, technological adoption, and pedagogical context.

2. Performative features (learning, assessment, infrastructure, sustainability, equity) and constructive features (students, teachers, digital technology, policy, partnership) of smart education depict the ideal blueprint for quality education.

3. Digital education policies to attain smart education should emphasize robust infrastructure, prioritize capacity building, and create a high-quality, inclusive, sustainable digital education ecosystem.

4. National policy sustainability, effective partnerships, ubiquitous learning environments, and commitment to inclusion significantly impact the overall quality of education according to current public datasets worldwide.

5. Across different countries and regions, access to digital technology beyond schools, E-leadership training in schools, adaptive learning resources and forward-responsible thinking should be fully emphasized to achieve Education Agenda 2030.