Report on National Smart Education Framework
CONTENT

Content
Acknowledgements
List of Figures
Abbreviations and Acronyms
Executive summary

Preface ................................................................. 1

Chapter 1. The Development and Trends of Smart Education ............................................. 3
1.1 The Derivation of Smart Education .............................................................. 3
1.2 The Concept of Smart Education ................................................................... 4
1.3 The Models of Smart Education ................................................................. 5

Chapter 2. National Smart Education Framework .......................................................... 8
2.1 Leverage point 1: Transformative Teaching and Learning Enabled through Technology ........ 8
2.2 Leverage point 2: Digital Learning Environments Conducive to Smart Education ................. 9
2.3 Leverage point 3: Forward-Thinking Governance and Policy Initiatives ......................... 11
2.4 Overarching Considerations Across All Leverage Points ........................................ 12

Chapter 3. National Cases of Smart Education ............................................................ 13
3.1 China’s Centralized Governance Model of Smart Education ...................................... 13
3.2 United States’ Decentralized Governance Model of Smart Education ......................... 21
3.3 Uruguay’s Three Institution Governance Model of Smart Education ......................... 33
3.4 Russia’s Centralized and Decentralized Governance Model of Smart Education ................ 38

Conclusion .................................................................. 44
Glossary ..................................................................... 48
Reference .................................................................... 50
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LIST OF FIGURES

Figure 1: Three Realms of Smart Education ................................................................. 5
Figure 2: A Framework of Smart Learning ................................................................. 7
Figure 3: National Smart Education Framework ......................................................... 8
## Abbreviations and Acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AI</td>
<td>Artificial Intelligence</td>
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<tr>
<td>ANEP</td>
<td>National Administration of Public Education</td>
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<td>AR</td>
<td>Augmented Reality</td>
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<tr>
<td>CETV4</td>
<td>Channel 4 of China Educational Television</td>
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<tr>
<td>CLE</td>
<td>Comprehensive Literacy Evaluation</td>
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<td>FERPA</td>
<td>Family Educational Rights and Privacy Act</td>
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<tr>
<td>GTCD</td>
<td>Digital Citizenship Working Group</td>
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<tr>
<td>ICT</td>
<td>Information and Communication Technology</td>
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<td>IoT</td>
<td>Internet of Things</td>
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<td>IT</td>
<td>Information Technologies</td>
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<td>MEC</td>
<td>Ministry of Education and Culture</td>
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<td>MOE</td>
<td>Ministry of Education</td>
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<td>N2E</td>
<td>Nation Network for Education</td>
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<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
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<td>NETP</td>
<td>National Education Technology Plan</td>
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<td>OER</td>
<td>Open Educational Resources</td>
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<td>OET</td>
<td>Office of Educational Technology</td>
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<td>PACE</td>
<td>Performance Assessment of Competency Education</td>
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<td>PAM</td>
<td>Adaptive Mathematics Platform</td>
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<tr>
<td>rSEM</td>
<td>remote Scanning Electron Microscopy project</td>
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<tr>
<td>SDGs</td>
<td>Sustainable Development Goal</td>
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<tr>
<td>SmartEDU</td>
<td>Rethinking and Redesigning National Smart Education Strategy</td>
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<tr>
<td>SVE</td>
<td>Secondary Vocational Education</td>
</tr>
<tr>
<td>UGBS</td>
<td>Universities, Government, Business, Primary and Secondary Schools</td>
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<tr>
<td>VR</td>
<td>Virtual Reality</td>
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Although schools have gradually opened as the pandemic has been brought under control, the importance of smart education as strategy for building a smart society still remains paramount. However, how to build smart education at the national level requires deliberate, collaborative leadership and ICT planning in education.

This report aims to build a technological framework for smart learning and education that recognizes the characteristics of smart education. Furthermore, this report proposes a framework for smart education and explores the best route to realize smart education.

First, this report will describe the development of smart education and its trends. In order to do so, a review of the derivations, concepts and models proposed by scholars of smart education will be detailed in the first chapter. In the second chapter, the above stated development of smart education and its trends will be presented by discussing its origins, concepts and related models proposed by scholars in the field. In the third part, we will propose a framework for smart education for various countries in terms of policy formulation. This framework will consist of three leverage points: 1). transformative teaching and learning enabled through technology, 2). digital learning environments conducive to smart education and 3). forward-thinking governance and policy initiatives. Such points will entail three overarching considerations: 1). inclusion and equity, 2). Continuous improvement culture and 3). multi-sector cooperation and partnerships. Also, this chapter will articulate the characteristics of each leverage point. Chapter three will provide several cases to help elucidate the current status of smart education. These case studies will include China, the U.S.A., Uruguay and Russia. This will ultimately be followed by six conclusions: creating a national plan, establishing a foundational infrastructure, building a learning community, expanding educator capacity, focusing on transformational learning environments and finally engaging in multi-sector partnerships.
The COVID-19 pandemic is still affecting the world, and that means in some parts of the world that education cannot continue as normal. With such effects still looming, international organizations are particularly concerned about how to respond to the crises and emergencies brought on by COVID-19. At the peak of COVID-19 on March 25, 2020, there were 165 countries with school closures and 1,524,648,768 affected learners. With the pandemic brought under control, schools have gradually opened up. However, as of December 1, 2021, there were still seven countries with school closures and 37,866,207 affected learners (UNESCO, 2021a). The “Education 2030 Framework for Action” states that it is critical to develop education systems that are more resilient and responsive in the face of conflict, social unrest and natural hazards, and that education is continued during emergencies, conflicts and post-conflict situations (UNESCO, 2015a). Since the beginning of the COVID-19 pandemic in early 2020, in order to minimize the negative impact of school closures countries have adopted Information Technologies (IT) as the main way to respond to the crisis, as well as developing smart education and providing flexible teaching for students to learn from home (Huang et al., 2021a).

The Development of a New Generation of Information Technology

With the development of IT, educational intelligence technology integrates 5G, IoT, big data, cloud computing, artificial intelligence, blockchain and other technologies to promote the research and iteration of educational intelligence technology. The basic support for smart education is provided by environment perception, data acquisition and data security. The generation of smart education is reliant on intelligent technologies such as cloud computing, artificial intelligence and machine learning. Further to optimize the presentation of the teaching content to create a learning space that integrates virtual and reality and helps the development of smart education, virtual reality, holographic projection and other technologies are used (Yang et al., 2021).

The Transformative Role of Technology in the Development of Education

The application of technology in teaching and learning improves the quality of education and promotes educational equity. The Sustainable Development Goal 4 (SDG4) aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all, which emphasizes transforming education through technology to achieve inclusive and equitable quality education (Huang et al., 2021b). Technological breakthroughs provide an opportunity to improve access to education for marginalized people and communities, people with disabilities, refugees, those out of schools and those living in isolated communities. Furthermore, as the “National Plan for Education Reform and Development (2010-2020)” from the MOE of China states, IT has a revolutionary impact on the development of education which must be highly valued (MOE, 2010).

Large-scale digitization and the application of intelligence technology will bring new opportunities for education as it is integrated into school education (Liu et al., 2018). For instance, information at the advanced stage facilitates supply-side structural reform in the field of education,
transforms evidence-based policy planning processes by the use of data, reshapes instructional environments and models and so on.

**The Necessity for a National Smart Education Framework**

Along with these opportunities, there are some challenges for integrating emerging intelligence technologies into teaching and learning (UNESCO, 2019). Such challenges include inclusion and equality problems, technology governance, ethics, accountability, transparency and security of smart technologies and so on. With the challenges above, the key to infusing technology into schooling is an effective collaboration among governments, private sectors and academia. To adapt to an uncertain, complex and diverse world, a global community belief in a shared future for all humankind should be created with education as the cornerstone of human well-being (Xi, 2017). Thus, smarter education should be constructed for the benefit of all humankind.

In many countries, smart education has already begun to be implemented. For example, China has intensively issued relevant policy documents and elevated the smart education demonstration zone to the level of national strategy. The United States also has developed relevant policies and increased educational funding. Consequently, smart education has become an important infrastructure when building a smart society.

**The Project of National Smart Education Framework**

Rethinking and Redesigning National Smart Education Strategy (SmartEDU), initiated by UNESCO IITE, COL, ISTE, HSE and BNU in August 2020, is designed to identify the major issues and trends in education and to explore the solutions for infusing technology into education to ensure inclusive and equitable education and promote lifelong learning opportunities for all. There are five projects in total, of which project two is focused on building the technological framework for smart learning and education to recognize the characteristics of smart education, propose a framework for smart education and explore the route to realize smart education.

The International Society for Technology in Education (ISTE), Beijing Normal University (BNU) and Hangzhou Normal University (HZNU) worked together to complete this project. Project 2 began a joint initial study in August 2020 and completed this report in January 2022, lasting a total of 17 months. The aim of this project is 1) to foster human and social development worldwide through rethinking and redesigning national smart education strategies and to elaborate on the most up-to-date policy agendas to expand access to quality education and relevant lifelong learning opportunities for all, which will be achieved through pursuing the main project outcomes and primary objectives, and 2) to help educational communities promote the transformative role of ICT in education, develop transferable skills like critical thinking, creativity, communication and collaboration, and evaluate progress in light of the SDGs and the associated targets of the 2030 Agenda for Sustainable Development.
CHAPTER 1.

THE DEVELOPMENT AND TRENDS OF SMART EDUCATION

1.1. The Derivation of Smart Education

The concept of smart education was introduced with the belief that realizing the objectives of smart education requires information resources to play a key role, as well as “qualified knowledgeable educators” and “well-informed and well-supported individuals” (Edzan & Abdullah, 2000). In 2003, smart education was discussed in the field of earth and space science, namely, as Thomas V. believed that Smart was an acronym for Science, Mathematics, Aerospace, Research, and Technology (S.M.A.R.T.) (Thomas & Carruthers, 2003). Since then, with the development and progress of intelligent technology, smart education systems have been widely developed and have expanded in their definition. For example, Rothman (2007) talked about how districts and communities could create smart education systems in city schools. However, not much attention was paid to smart education till 2008.

This changed when Palmisano (2008), the CEO and President of IBM, brought up the “Smarter Planet” initiative. Likewise, in 2009, Jim Rudd et al. pointed out the role of cloud computing and other intelligent technologies in future education in the IBM RedGuide publication. Since then, smart education has gradually become popular as has the technology to support it. For example, around 2010, the software and hardware in personal notebooks matured enough to support learners to learn through PCs. In 2011, Vlad et al. mentioned smart education and used notebooks to build a platform. With information technology to help learners understand electronic components, simple circuits and other experimental equipment, learners could even learn how to use electronics better. Thus, as smart education was developed in ICT technology, it caught the attention of national governments.

Singapore was the first country to issue policies at the national level with its iN2015 plan (Intelligent Nation 2015) in June 2006, led by the Information and Communications Management Development Agency (IMDA) of Singapore. The plan called for an investment of tens of billions of Singapore dollars in such technology in the decade from 2006 to 2015. Such policies in advancing information and communication ecosystems has built Singapore into a smart country and a global city supported by the information and communication industry and ubiquitous information technology. Which has ultimately enhanced the country’s economic competitiveness and innovation capabilities.

South Korea quickly followed suit by issuing the "Advancing Smart Education Strategy" in October 2011 to carry out smart education reforms, transform the classroom, improve the learning effect of technical support and cultivate innovative international talents who were suitable for the future information society (Keris, 2011). In the strategic proposal, MEST decomposes the word SMART in smart education into five acronyms. These five letters represent the five characteristics of smart education - self-directed, motivated, adaptive, resource-enriched and technology-embedded.
With the maturity of information and communication technology (ICT), a new generation of information technology innovation with artificial intelligence (AI) as the core has started being promoted in education. For example, the Ministry of Education of the People’s Republic of China issued an action plan for educational informatization 2.0 in 2018. Further, smart education appeared in national-level planning documents as a way to promote educational equity and improve educational quality.

Since 2012, research on smart education in China has become more abundant, and the policies and practices of smart education have gradually intensified. Starting with the demand for social informatization for the learning environment reform, researchers have explored the smart learning environment and proposed a conceptual model for learning scenario recognition (Zhang et al., 2012). In January 2018, the MOE of China (2018c) issued the “Key Points of Work of MOE for 2018”, which for the first time proposed the idea of “Promoting the Innovative pilot of Smart Education”. In 2019, China’s MOE issued a policy on the construction project of “Smart Education Pilot Zones”, to promote the integration and innovative development of education informatization. While at the same time also realizing the reform and innovation in education ideas, models, teaching contents and methods, improving education standards, exploring and accumulating advanced experiences and excellent cases that can be promoted and finally forming new ways and new models to support and lead education modernization. Furthermore, all regions of China are expected to actively carry out the construction of "smart education demonstration areas" according to policies.

1.2. The Concept of Smart Education

As for “smart pedagogy”, Gillies et al. (2007) believes that cooperative learning is a kind of smart pedagogy. This view focuses on the understanding of pedagogy. As defined in the Cambridge Dictionary, pedagogy is “the study of the methods and activities of teaching”. Based on this, Uskov et al. (2018) has studied smart pedagogies, such as learning-by-doing, flipped classroom, game-based learning, adaptive teaching, etc. In addition, Meng (2020) believes that smart pedagogy includes the following key elements: SMART (situated learning, mastery learning, adaptive learning, reflective learning and thinking tools), curriculum design and teaching strategy. Obviously, smart pedagogy focuses on instruction and learning, but it is significantly different from education.

Intelligent education emphasizes the support of intelligent technology which can be seen in the following studies. Wang (2019) regards educa-
tional data mining algorithms as intelligent education, and has built a smart education platform with this algorithm; Ever & Dimililer (2018) have developed a distance learning intelligent education platform that integrates virtual learning environments (VLEs) into their traditional teaching mechanisms; and Dimililer (2018) has used facial recognition and machine learning to build an intelligent education system. Each example mentioned above applies platforms or systems based on intelligent technology to support teaching & learning and hence must be considered as intelligent education.

The third understanding of wisdom education is derived from Socrates’ reference to "wisdom". To expand, Levanon (2011) regards “wisdom education” as an approach to education that emphasizes the development of better thinking skills as well as socialization and the development of students’ sense-of-self.

From the above literature, it can be found that the interpretation and understanding of these terms are different as each has different emphases: pedagogy, intelligent technology and learners’ competencies. Based on the above elements, smart education can be said to be based on intelligent technology to create a smart learning environment, support teaching and promote smart pedagogy, so as to cultivate learners who adapt to global change and development (Zhu et al., 2016). Therefore, the following definitions are adopted in this study: smart education (system) is considered as the educational behaviors (system) provided by schools, regions or governments with the characteristics of a high learning experience, learning content adaptation and teaching efficiency. Furthermore, in smart education modern science and technologies are used to provide diversified supports and on-demand services for students, teachers and parents, etc., record the data of participants and learning and teaching processes and lastly, promote the quality and equity of education (Huang, 2014).

1.3. The Models of Smart Education

1.3.1. Three Realms of Smart Education

From a more macro perspective, the smart education system can be transformed into three levels (See Fig.1): a smart learning environment, a new model of instruction and a modern education system. Moreover, the smart education system continuously improves the knowledge production capacity from the three aspects of effect, efficiency and benefit by promoting educational equity and improving educational quality through the adaptation of the education system and education objectives. Finally, the educational goal of cultivating excellent national talents is realized (Huang, 2014).

![Fig.1. Three Realms of Smart Education](image-url)
The essential features of smart education are sensibility towards the learning environment, the adaptability of the learning content to all learners, respect and care from educators towards students, equal learning opportunities among all learning groups and the orchestration of different elements within the education system. Each will be discussed below.

Firstly, sensibility toward the learning environment and the adaptability of the learning content to all learners are the key features of smart learning environments, with which the education system makes people experience the ‘smartness’.

Secondly, the personality and diversity of students will be respected under the innovative learning modes, which will help students to learn in an easy, engaged and effective way. The core objective is to help enlighten students' wisdom. Finally, with the support of big data, we can in advance analyze and simulate the schools’ setting in areas like education finance, employment channels, students’ selection and other subsystems of the education system and lastly, the development of their relationships among those subsystems. This kind of information provides evidence for reformation and decision-making in the teaching system, school administration system and even the education system at the provincial and national levels. The analysis and simulation with big data can help to innovate the talent cultivation system and promote educational equity across urban and rural and regions and schools. The aim of this is to develop a modern education system that supports the development of human wisdom.

1.3.2. Three Realms of Smart Education

5G technology use cases depict the prospects of the 5G network model to revolutionize Industry and education is not an exception. The 5G model, in general, is made up of three main blocks: Enhanced Mobile Broadband (eMBB), Massive Machine Type Communication (mMTC) and Ultra Reliable and Low Latency Communication (uRLLC). Within these blocks are the services 5G offers to users. 5G technology integrates with the Internet of things, big data, AI, machine learning, etc. to serve the field of education and promote the development of smart education. Considering the expected services of 5G, an ecosystem model has already been adopted and applied to smart education as shown in Fig. 2 (Dake & Adjei, 2019).

1.3.3. Research Framework of Smart Education

Smart education has created intelligent environments by using smart technologies, so that smart pedagogies can be facilitated to provide personalized learning services and empower learners. And thus talents of wisdom who have better value orientation, higher thinking quality and stronger conductibility could be fostered (See Fig.3). Smart education addresses the need for smart pedagogies as a methodological issue and smart learning environments as a technological issue and advances the educational goals to cultivate smart learners as a result. Smart environments could be significantly influenced by smart pedagogy as smart pedagogies and smart environments support the development of smart learners (Zhu et al., 2016).

1.3.4. Smart Education System

Smart education entails the application of the latest or smartest technologies in collaboration with advanced pedagogical practices, tools and techniques for the effective delivery of education services. Smart education is related to the rapidly evolving domains, including 11 major themes (See Fig.4). From the perspective of intelligent technology, smart education effectively connects digital resources, social media and intelligent devices through communication technology, cloud computing and other technologies, in order to provide new knowledge to improve methodologies for learning (Singh & Miah, 2020).
1.3.5. Smart Learning

A complete smart learning system, by positioning the learner at the center, can be categorized into four levels from inside out: learner’s experience, digital learning support technology, key elements of learning scenario and teaching and learning logic (See Fig.2). Teaching and learning logic should be followed by four basic principles: matching learning resources, following instructional principles, abundant learning experience and timely learning feedback (Smart Learning Institute of Beijing Normal University, 2015).

There are four types of digital learning support technologies: 1). the technique of environmental perception, context sensibility and learning adaptability, oriented towards learning time and space, 2). the technique of teaching assessment and learning support oriented towards teaching activities, 3). the technique of dynamic tracking and learning analysis oriented towards learning activities and 4). the technique of knowledge organizing and reconstructing oriented towards learning contents.

Fig.2. A Framework of Smart Learning
CHAPTER 2.

NATIONAL SMART EDUCATION FRAMEWORK

The United Nations’ Sustainable Development Goal 4 states that all nations should ensure inclusive and equitable quality education and promote life-long learning opportunities for all (United Nations, n.d.). Due to the COVID-19 pandemic and the consequent, unprecedented expansion of remote and online learning models (World Economic Forum, 2020), education leaders have recognized the urgency to modernize the digital learning ecosystem so as to truly provide inclusive and equitable educational opportunities to all students in this new era of learning.

In envisioning such modernized digital learning ecosystems, national government leaders must engage in a multipronged approach with three major leverage points: 1). a renewed focus on transformative teaching and learning enabled through technology, 2). building a digital learning infrastructure conducive to smart education and 3). ensuring forward-thinking governance and policy initiatives. The below framework describes the core elements of each leverage point.

2.1.
Leverage point 1:
Transformative Teaching and Learning Enabled through Technology

A modernized digital learning ecosystem requires a renewed, shared understanding among leaders and stakeholders around what an effective educational experience transformed through technology should look like (Tri, 2021). For example, how does technology empower educators and students to co-develop experiences that move from traditional, drill-and-skill instruction to models where a learner is no longer a passive recipient of information? This fundamental shift necessitates an in-depth look into improving pedagogy, assessments and learner communities.

Fig.3. National Smart Education Framework

Through the active developmentally appropriate use of technology grounded in the learning sciences, educators should design and deliver educational experiences for students to become empowered learners and digital creators, who construct knowledge and develop metacognitive skills from early childhood to higher education and beyond. This may be achieved through implementing learning models that center student agency and provide students with multiple pathways for authentic learning beyond the physical classroom (Darling-Hammond et al., 2020), including, but not limited to:

- Personalized learning which differentiates and tailors’ objectives, approaches, content, the pace of learning and support based on the unique needs, interests and background of each student (Netcoh, 2017).
- Collaborative learning that expands the educational experience beyond individual endeavors to cooperative efforts between students, peers, educators, experts and local or global communities (Darling-Hammond, 2020a).
- Design-based learning that integrates design thinking principles empathy, investigation, prototyping, evaluation and revision into the educational experience to inspire creativity and innovation (Yang et al., 2021).
- Project- or problem-based learning that engages students in deepening their knowledge of realworld issues and proposing practical, evidence-based solutions (Lewinsohn et al., 2015).

2.1.2. Reimagined Assessments (Sacramento County Office of Education, 2021)

Students co-establish their learning goals with educators and choose, with appropriate guidance, how to demonstrate their mastery. Educators coach, support and use adaptive measures and learning analytics to provide timely and individualized feedback. Assessments are embedded as part of the learning process and encompass the full range of their purpose and function, including, but not limited to:

- Assessment of learning, where educators analyze information about the students’ progress to make judgments about their performance and achievement.
- Assessment for learning, where educators collect appropriately automated, realtime data aligned with learning goals to continuously improve the educational experience and inform instructional strategies.
- Assessment as learning, where educators leverage opportunities for students to develop and reinforce discrete competencies by providing multiple ways of demonstrating their learning.

2.1.3. Learner Community-Building

Technology is leveraged as a critical tool to facilitate culturally responsive instruction, thereby instilling a sense of belonging, and helping students grow to be civic-minded members of the local and global community. Skills and competencies that can be developed and reinforced include, but are not limited to:
Social-emotional skills (CASEL, 2021) such as self-awareness, self-management, social awareness, relationship skills (student-peer, student-educator and student-community) and responsible decision-making skills (Wang & Chen, 2017).

Digital citizenship competencies (DigCitCommit Coalition, 2021) such as creating inclusive communities, information and media literacy, informed engagement with local and global issues and balanced, safe, and ethical usage of technology (Liu et al., 2020).

When implementing concepts from “Transformative Teaching & Learning Enabled through Technology” into instructional tools and resources at the school level, several considerations must be noted, including, but not limited to, the extent to which a given tool or resource meets the following criteria (ISTE, 2019a; UNESCO, 2015b):

- Accessibility: Is it developed to be accessible by and universally-designed for various learners, including those with disabilities?
- Digital Pedagogy: Does it integrate best practices in digital pedagogy and learning science principles?
- Evidence-Based (Huang et al., 2020): Can it be validated by ongoing evaluation and evidence of effectiveness?
- Interoperability: Does it allow for the seamless, secure and controlled transfer of learner data between systems?
- Data Privacy: Does it support the safe and controlled sharing of learners’ private data?

2.2.
Leverage point 2:
Digital Learning Environments Conducive to Smart Education

A modernized digital learning ecosystem requires an environment where both formal and non-formal education opportunities (UNESCO, 2020b) are enabled and accelerated by access to the necessary technology. These digital learning environments must allow for learning to occur anytime and anywhere, whether the learner is on campus (Matthew & Hargali, 2019) or otherwise. In addition, the use of various technologies by leaders, educators and students must be guided by a shared set of standards, rules and guidelines around the ethical use of digital information.

2.2.1. Learning Devices and Support

All students and educators are provided with access to a digital learning device conducive to smart education and capable of connecting to advanced telecommunications and information services. Support should be readily available to help both students and educators troubleshoot technical issues with said devices (ISTE, 2021b).

2.2.2. Seamless Connectivity

All students and educators should be supported in becoming global collaborators through seamless internet connectivity at school, at home or in the community. Thus freeing learners from artificial time-based or geographical constraints.
2.2.3. Ethical Use of Technology

To realize the vision of smart education, personal and performance data must be shared between trusted individuals and entities (Măţă, 2021). Systems must safeguard this data from misuse while ensuring that it is readily available to students, educators and leaders who depend upon it (Wei & He, 2021). Considerations may include, but are not limited to:

- Data Privacy: Student data must be protected and secured at all times. Data also needs to be selectively available for authorized uses for purposes such as personalizing the educational experience or researching improvements to the learning processes.
- Interoperability: For data to be exchanged continuously to inform instruction, it must flow between systems through seamless, secure and controlled protocols and shared standards.
- Ethics of Artificial Intelligence (AI): The design and use of AI tools for instruction or assessment must consider and actively prevent any harm that may occur, including the introduction of algorithmic bias (AI4K12, 2020).

2.3.

Leverage point 3:
Forward-Thinking Governance and Policy Initiatives

A modernized digital learning ecosystem requires a strategic, long-term commitment from government leaders to develop a national vision and plan for the effective use of educational technology, as well as adequate investments to ensure the plan’s effective and sustainable implementation and continuous improvement.

2.3.1. Develop a National Vision and Plan

Government leaders must commit to a shared vision that establishes the essential role that technology plays in ensuring students’ future success and its implications for improving the nation’s equitable social and economic conditions. Stakeholders representing various sectors must support government leaders in crafting a national educational technology plan with established metrics and milestones for measuring progress, as well as associated initial, recurring and hidden costs (Vital Wave Consulting, 2008). All of which must be aligned with this shared vision. Key elements of this vision and plan may include, but are not limited to, a national strategy for:

- Envisioning and implementing competencies that prepare students as lifelong, empowered learners, as well as educator competencies in digital pedagogy that enables them to use technology effectively to achieve student success (Kioupi & Voulvoulis, 2019; International Society for Technology in Education, 2021e).
- Deploying, maintaining and updating the necessary infrastructure (U.S. Department of Education, 2017c) (see 3.2 and 3.3 below).
- Establishing criteria and guidance around creating and/or curating high-quality, digital educational resources (e.g., open, free, and/or proprietary) (U.S. Department of Education, 2017a) and curricula.
- Researching the role of cutting-edge technologies in improving learner experiences.

2.3.2. Build Infrastructure Capacity

Government leaders must deploy, maintain and update advanced telecommunications and information services — including both wired (e.g., fiber) and wireless (e.g., mobile broadband) networks — necessary to ensure that all communities, including those that are rural or otherwise remote, are connected to high-speed internet.
2.3.3. Invest in Human Capacity

Modernizing the digital learning ecosystem must involve modernizing the educator workforce, as large-scale investments to purchase educational technologies without human capacity considerations are less likely to truly transform how those digital tools and resources become used for learning (Darling-Hammond et al., 2017). Such efforts include government leaders funding educators’ preparation, professional development, coaching and mentoring opportunities to build more comprehensive human capacity around digital pedagogy.

2.4. Overarching Considerations across all Leverage Points

In implementing the three key leverage points in this framework, government leaders must place several overarching considerations at the forefront to ensure that the modernized digital learning ecosystem is agile, sustainable and meets the needs of all stakeholders. To do so certain questions must be addressed.

2.4.1. Inclusion and Equity (UNESCO, 2021b)

In implementing a smart education approach to learning are the needs of diverse student and educator groups heard and addressed? Do policies and approaches ensure the full participation and inclusion of people regardless of their ethnicity, origin, cultural and religious identity, gender, age, socioeconomic status, physical ability or other criteria that may lead to the marginalization of certain populations (Ainscow, 2020)? Also, are such groups represented in positions of key decision-making authority?

2.4.2 Continuous Improvement Culture

Are educators and leaders collaborating with stakeholders to continuously collect information on and evaluate educational experiences — including the effectiveness of technology infrastructure, learning content and professional development — to support the broader vision around technology-empowered learning? (Simmers, 2021)

2.4.3 Multi-Sector Cooperation and Partnerships (OECD, 2012)

Are government leaders leveraging the wide, influential reach of the private and social sectors, higher education institutions and other domestic and international non-governmental organizations to provide public services that promote transformative uses of technology for learning? Such cooperative models may be leveraged for a wide range of purposes, including, but not limited to:

- Adaptably overcoming new and ongoing barriers to student learning with technology.
- Experimenting with innovative approaches to learning with technology and accelerating the scaling of evidence-based solutions.
- Strategically incentivizing multi-sector partners to contribute and share their knowledge and resources for the public good.
CHAPTER 3.

NATIONAL CASES OF SMART EDUCATION

3.1.

China’s Centralized Governance Model of Smart Education


Under the top-down national leadership, local governments and the Bureau of Education have responded to the call to actively participate in the construction of Smart Education. For example, the Ministry of Education (MOE) of the People’s Republic of China chose and built a "Smart Education Pilot Zone" each year. The regional examples below are selected from the 20 Smart Education Pilot Zones in 2019 (General Office of MOE, 2019a) and 2020 (General Office of MOE, 2021).

3.1.1. Leverage Point 1: Transformative Teaching and Learning Enabled through Technology

3.1.1.1. Student-Centered Pedagogy

For more than 20 years, since the full implementation of Well-rounded Education (State Council, 1999), the concept of “student-centered” has been widely recognized. However, in fact, it is often difficult to implement and get rid of exam-oriented education (China Education Newspaper, 2016). Thus, it is hard to implement students' overall and individual development. The “National Plan for Education Reform and Development (2010-2020)” states that Information Technology (IT) has had a revolutionary impact on the development of education, which must be highly valued (MOE of China, 2010). With the increasing development of education and technology, educators should utilize technologies to innovate instructional methods, change spoon-feeding pedagogy to inspiring, interactive and inquiry-based teaching while also carrying out research-based, project-based and cooperative learning (State Council, 2019).

Regional

Wuhou District, Chengdu City, Sichuan Province

In order to create a new ecology of smart pedagogy, Wuhou District proposed a change from traditional experience teaching to smart teaching to promote adaptive learning, dual-teacher
classes, deep learning, inquiry-based learning, hybrid learning, experiential learning, project-based learning and so on (China Education Network, 2019a). Wuhou district used IT to reform the process of teaching and learning. Three processes were emphasized: self-learning before class, cooperative inquiry in class and learning feedback after class, which aimed to cultivate students' self-learning habits and skills. What's more, during the COVID-19 pandemic, the Wuhou Three Visits Education Cloud platform (Wuhou District Education Bureau, n.d.) as an online teaching support, provided 9,128 thematic resources with a total of 70 million visitors and 2 million submissions. After the platform was upgraded, a new "project-based learning" section was added to promote online, offline and hybrid courses through initiating the project, managing the project and forming the evaluation reports.

3.1.1.2. Reimagined Assessments

The core of the Comprehensive Literacy Evaluation (CLE) is to cultivate students' competencies in five aspects, including moral, intellectual, physical, aesthetics and labor (State Council, 2019). The "Notice on the Recommendation and Selection of the Smart Education Pilot Zone Construction Project" (General Office of MOE, 2019b) proposed the precise assessment of the students' CLE supported by AI and big data. Here are some of the measures implemented: 1). develop uniform data acquisition standards and usage specifications, 2). take full advantage of big data acquisition technology and 3). relying on CLE index system and assessment model, create an all-round, multi-level and accompanying collection of students' learning process data.

Regional

Guangzhou City, Guangdong Province

Guangzhou City implemented a smart assessment project, which upgraded the "sunshine assessment" based on the big data of students' development. Measures included: 1). establishing a CLE management system for students and 2). relying on the CLE Management Platform for secondary school students in Guangdong Province, they promoted the combination of qualitative and quantitative assessment. By the end of 2022, the goal is to realize the informatization of the secondary school academic level examinations of spoken English and experimental examinations in physics and chemistry (China Education Network, 2019c).

3.1.1.3. Learner Community-Building

The “Core Competencies of Chinese Student Development” (Guangming Education, 2016) divides the Core Competencies into three aspects: cultural foundation, independent development and social participation. Which are further embodied in six competencies: cultural heritage, scientific spirit, learning strategies, healthy life, responsibility, practice and innovation. In 2021, the Cyberspace Administration of China proposed that digital literacy and skills are a series of competencies that all citizens of a digital society need to acquire, produce, use, evaluate, interact with, share, innovate and secure data and ethics in their study, work and life (Cyberspace Administration of China, 2021).
Regional: Qingdao City, Shandong Province

Qingdao City carried out measures to promote student’s information literacy including: 1). strengthening the knowledge, skills, application ability and information awareness, information ethics, and so on, 2). enriching the content of artificial intelligence and programming courses, 3). Promoting the implementation of information technology curriculum and integrating information technology into academic level examination in primary and secondary schools and 4). organizing all kinds of IT application exchanges, promotions and competition activities (Qingdao Municipal Education Bureau, 2020).

3.1.2. Leverage Point 2:
Digital Learning Environment conducive to Smart Education

3.1.2.1. Learning Devices and Support

National

In recent years, the MOE has made solid progress in the construction of ICT infrastructure and achieved remarkable results. For the construction of learning devices, as of the first quarter of 2021, 98.7% of primary and secondary schools in China have built multimedia classrooms. Furthermore, 84.44% of schools have full coverage when it comes to multimedia teaching devices and the total number of multimedia classrooms has reached 4.3 million (China Education Network, 2021a).

Regional

Bishan District, Chongqing City

In terms of policy guarantee, Bishan District issued the “Implementation Plan on ‘Action Plan of ICT in Education (2.0 version)’ in Bishan District”. In terms of economic investment, they invested more than 10 million yuan per year. This investment has led to the purchase of smart devices including more than 600 large-screen whiteboards and more than 8,000 tablets, mobile phones, and so on (Chongqing Municipal Education Bureau, 2020). The objectives were to achieve initiatives like "Connecting Schools through Broad-band Network", "Connecting Classes through High-quality Resources", "Connecting Students, Teachers, Education Managers and Parents through Cyber-Learning Space" and "Equipping teachers with an Office Computer".

3.1.2.2. Seamless Connectivity

National

In August 2019, the State Council proposed "accelerating the construction of National Network for Education (N2E) to realize all schools' access to fast and stable Internet by 2022" (2019a). In 2021, the MOE with other departments proposed to build N2E in order to support the education reform under the conditions of information technology. Measures included: a). improving the quality of network service, b). reducing the overall cost to users, c). ensuring that teachers and students have Internet access and d). ensuring that all school networks change from the period of “full coverage” to the period of “improved quality” (Education INFO, 2021). As of December 2020, the network access rate of primary and secondary schools in China has reached 100%. Furthermore, the proportion of schools with export bandwidth of more than 100M was 99.92% (China Education Network, 2021b).
The smart education environment in Yuncheng City has been initially completed. For example: 1) the core nodes completed IPv6 at the municipal, county and school levels; 2) Smart education private networks in Yuncheng City have cooperated with CERNET (CERNET, n.d.) to build the first N2E, which simultaneously connects CERNET and the National Internet, in the central and western regions. In the face of the COVID-19, Yuncheng City such measures ensured that more than 800,000 teachers and students had access to synchronous online learning. They made joint efforts to ensure that everyone had access to a network, a learning platform, a set of learning resources, a learning account and convenient operation, which covered all families, schools, teachers and students, further ensuring that each student could learn anytime and anywhere (MOE of China, 2019a).

3.1.2.3. Ethical Use of Technology

In 2021, the “Personal Information Protection Law of the People's Republic of China” (People's Government of the People's Republic of China, 2021) provided a legal guarantee for cracking the topical and hard issues in the protection of personal information. The law clearly stipulated that personal information should not be collected excessively, provided for the handling of sensitive personal information and improved the mechanism for protecting complaints and the reporting of personal information (China Daily, 2021).

Bengbu City has proposed plans to improve the management and upgrading of their standard system. Measures include: 1) through the rules, regulations and performance review, all teachers are expected to master using technology in the classroom gradually and all students are expected to use technology with positive intent. and 2) improve technical standards and security management to build a safe and inclusive network (Bengbu Municipal Education Bureau, 2020).

Changsha City put forward the policy of “Integrated planning, hierarchical management, prioritizing prevention, catching the key points, strengthening monitoring and connecting with stakeholders”. This included the following actions: 1) Building, managing and organizing a system for the network and information security, 2) Strengthening the training for team and personnel on information security, 3) establishing mechanisms, 4) improving responsibility systems and accountability mechanisms and 5) carrying out monitoring and early warning on network security to reduce hidden risks and improve the ability to deal with emergencies.
3.1.3. Leverage Point 3: Forward-Thinking Governance and Policy Initiatives

3.1.3.1. Develop a National Vision and Plan

In the past two years, China has attached great importance to smart education and has issued relevant policy documents to vigorously promote the construction of the Smart Education Pilot Zones. In January 2018, the MOE issued the "Key Points of Work of MOE for 2018" (MOE of China, 2018c), which for the first time proposed "Promoting the Innovative pilot of Smart Education". In April, the MOE issued the “Action Plan of ICT in Education (2.0 version)” (MOE of China, 2018a), which put forward the innovative development action for smart education and carried out an exploration and practice of Smart Education. Also, in January 2019, the General Office of the MOE issued the “Notice on the Recommendation and Selection of the "Smart Education Pilot Zone" Construction Project” (MOE of China, 2019b).

Minhang District, Shanghai City

The government of the Minhang District formulated and implemented the implementation “Plan of Creating a National Smart Education Pilot Zone in Minhang District”, which promoted the comprehensive and individual development of teachers and students and promoted the equitable and high-quality development of education. Measures included: 1). focusing on the goal of "data-driven, large-scale and individualized teaching" and adherence to education in five aspects (moral, intellectual, physical, aesthetics and labor), 2). setting up an educational cloud service platform to adapt to the overall promotion of the region, 3). building a smart learning environment that supports personalized teaching and learning, 4). exploring personalized and differentiated teaching and learning and 5). exploring the regional ICT public service system of collaborative innovation in production, learning and research (People’s Government of Yihang District, 2021).

3.1.3.2. Build Infrastructure Capacity

“New Infrastructure Construction” was first proposed at the Central Economic Working Conference in December 2018. Specifically, the educational infrastructure was to be enhanced so to provide the basis for blended learning. The “Guidance on Promoting the Construction of a High-Quality Education Support System for New Infrastructure Construction in Education” (MOE of China, 2021a) issued in July 2021, by the Ministry of Education and other five departments, emphasizing the following six aspects:

- Strengthening the trustworthiness and safety of networks and connection (e.g., creating a sensibility of threads and intrusion of internet and usage and security of information systems in terms of warning and monitoring, while also guaranteeing a “green” network for kids to keep away from harmful information, eyesight damage and internet addiction).
- Upgrading ICT infrastructure for education (e.g., connecting all schools and universities to a specific broadband network and upgrading campus networks with 5G and Wi-Fi 6).
- Upgrading smart campuses with cyber and physical spaces (e.g., redesigning smart classrooms with AI, IoT, VR/AR and HD video Technologies; facilitating the laboratory informatics, collaborations and supervision in terms of data visualization; and deploying security facilities for the campus).
- Harmonizing learning management and administration information systems nationwide
(e.g., upgrading safe and reliable data centers with a hybrid cloud model; promoting effective, efficient and effective use of data; propelling for openness and interoperability of information systems and; widening cyber learning space for education transformation).

- Promoting innovation of teaching, assessment and governance by emerging technologies (e.g., popularizing inquiry and cooperative, experiential learning enhanced by emerging technologies; innovating assessment of learning and teaching by using multi-model data for all subjects; improving the teaching profession across all schools and regions supported by AI, big data and learning analytics; promoting administration in schools and the effectiveness of educational authorities and governmental supervision powered by big data and AI).

- Innovating digital resources provision nationwide (e.g., developing learning tools and resources with AI, big data and VR/AR for all schools and universities; optimizing digital resources provision and services with all stakeholders involved; and creating the mechanism for the adoption and the evaluation of digital resources).

### 3.1.3.3. Invest in Human Capacity

#### National

In 2019, the MOE issued the “Opinions on the Implementation of the Digital Teaching Competence Improvement Project 2.0 for Nationwide Primary and Secondary School Teachers” (MOE of China, 2019c), which further called for the establishment of a new mechanism for the development of teachers’ information literacy. The Opinions identified the overall development goals of “Three Upskill and One Comprehensiveness” which were upgrading principals’ ICT Leadership, teachers’ digital teaching competence and training teams’ supervising ability and furthermore, comprehensively promoting the innovative development of the integration of ICT and education/teaching. As of September 2021, the MOE implemented the second batch of artificial intelligence to promote the construction of teachers’ team pilots. A total of 100 units were deployed in 55 universities, 20 municipalities and 25 districts (China Education Network, 2021c).

#### Regional

**Wuhan City, Hubei Province**

Wuhan City aims to implement the overall improvement of information literacy, to cultivate high-level teachers, students and educational managers. Measures include: 1). Developing norms and standards for information literacy of primary and secondary school principals, teachers (teachers and researchers) and students, 2). Promoting the construction of master’s studios and learner communities in the city, district and school level and 3). Drawing a map of information literacy in all districts of the city and carrying out monitoring of the development level of information literacy of teachers and students based on data and process-orienting (China Education Network, 2019b).
3.1.4. Overarching Considerations Across the Framework

3.1.4.1 Overarching Considerations 1: Inclusion and Equity

**National**

China has undertaken several steps to ensure inclusion and equity in education. For example, the “Action Plan of ICT in Education (2.0 version)” (MOE of China, 2018a) proposed to alleviate poverty in education by using measures including: 1). Supporting the development of ICT in Education in deep poverty-stricken areas with a focus on “Three Regions and Three Prefectures”, 2). Carrying out a series of activities such as the donation of ICT teaching equipment and the sharing of high-quality digital resources. In addition, it is believed that the key to poverty is to enable children in poor areas to receive a fair and better education. Such measures include: 1). The “Three Classroom” national program (MOE of China, 2018b) that is committed to ensuring equity and quality in education. It was first proposed in 2012 and included classroom delivery, outstanding teacher classroom and prestigious school online Classroom and 2). Since February of 2020, in order to expand access to learning resources, relevant courses and resources should be gradually updated through Channel 4 of China Educational Television (CETV4) which covers remote and rural areas where the Internet connectivity is unreliable or not accessible to ensure that “no one would be left behind.”

**Regional**

*Lanzhou City, Gansu Province*

Lanzhou City issued the “Excellent Teacher Online Teaching” (Lanzhou Municipal Education Bureau, 2019), a welfare and inclusion program using after-school time, weekends and winter or summer vacations to carry out remote real-time after-school tutoring for students. Later live-steaming was adopted to support online distance education, which was an effective extension of the 5-day school learning to help students expand and strengthen their knowledge. It provided students with timely, accurate and effective education services. The content of the tutoring course included well-rounded education and difficult knowledge from diverse disciplines, aiming to enhance student’s learning interests and multiply students. Thus, students could learn through the Internet at any location and time, saving a lot of time and energy due to traffic. Other benefits include: 1). Parents do not need to pay any fees to let their children enjoy tutoring from excellent teachers and 2). excellent teachers can teach hundreds of students at the same time, amplifying their influence drastically.

3.1.4.2 Overarching Considerations 2: Continuous Improvement Culture

**National**

The development of ICT in Education has gone through three stages. First, the pre-ICT in Education stage (1978-2000) took “information technology education” as the main feature by focusing on computer teaching experiments and computer-aided teaching. Second, the ICT in Education stage 1.0 (2001-2017) took “reform teaching environment” as the main feature, and focused on the quantitative change caused by ICT in Education by emphasizing the application-driven and integrated development of ICT in Education. Third, ICT in Education stage 2.0 (after 2018) is characterized as a way to “reform the education system” by focusing on the qualitative changes caused by ICT in Education, paying attention to the innovative leading role of ICT in Education and promoting the ecological transformation of the educational system (Wang et al., 2019).
Smart Campus Construction in Haidian District has been divided into 4 maturity levels through the development of the “Capability Maturity Model for Smart Schools” policy. Levels from low to high were initial (multimedia teaching), basic (connecting schools through the broadband network), reform (digital campus) and integration (smart campus). Each level could also define several key practice areas from six dimensions: basic environment, software and resources, management, teaching applications, teachers’ ICT level and students’ ICT level (Haidian Municipal Education Bureau, 2017). For example, the characteristics of each level were as follows: 1). Initial: the school accessed the Internet and had their own portal; the school purchased educational resources, and teachers produced resources, but resources are scattered, 2). Basic: the various interactive information systems are constructed to achieve a high standard of “connecting schools through broadband networks”; schools have a plan and documents for construction of the smart school, and so on, 3). Reform: the information systems are integrated; smart classrooms or future classrooms with different functions are built, and so on and finally 4). Integration: all kinds of information systems will be integrated based on user-centered service; the school will become an open learning community that can support learning activities, such as mobile learning and collaborative learning, and so on.

3.1.4. Overarching Considerations across the Framework

China’s governance model is the MOE leadership and coordination, and multi-party cooperation and co-promotion (MOE of China, 2018a). The directs organizations and individuals into the public education service system, such as schools, academies, institutions, social organizations, professionals and so on. For example, during the outbreak, some private sectors provided simultaneous and asynchronous teaching tools for teachers and students, such as Dingding (Alibaba Group) and Tencent Ketong (Tencent Group). In addition, China also encourages communication and cooperation with international institutions to strengthen the foreign ICT in the education of reference, absorption and reinnovation.

The ecosphere of smart education is not just locked in the walls of the schools or governments as seen in Suzhou City. Suzhou City aims to: 1). Establish government-led, primary and secondary schools, universities and enterprises multi-participation, 2). Build a UGBS educational resources supply mechanism (universities, government, business, primary and secondary schools) and 3). Establish a three-tier screening model of “market selection, research staff selection and user selection” (Suzhou Municipal Education Bureau, 2019 a). Moreover, Suzhou City has used media to advocate for smart education in schools, communities and families as a way to promote intelligent learning as a lifestyle (Suzhou Municipal Education Bureau, 2019b). For example, this can be seen in 1). The progress of the Smart Education Pilot Zone being released regularly to increase the intensity of smart education advertisements and 2). The channels for suggestions were opened to encourage the whole society to participate in building of smart education.
3.1.5. Conclusion

Smart education is a high-end form of ICT in Education (Smart Learning institute of Beijing Normal University, 2021), in which technology infuses every aspect and process of education. China has formulated the following six elements for the development of smart education (MOE of China, 2019b):

- The mechanism and approaches for promoting both teachers’ and students’ digital literacy, awareness, computational thinking, digital learning and information social responsibility is through relevant curriculum and practice.
- The innovative teaching methods and strategies such as hybrid education, learning and assessment, support the deep infusion of ICT into education.
- The precise assessment of the students’ comprehensive quality evaluation is supported by AI and big data.
- The personalized and on-demand service for teachers and students based on data interoperability is provided by the government and private enterprises.
- It is the mechanism for collaborative innovation to promote the supply of open educational resources across regions for equal and inclusive education.
- The new mode of educational governance will be empowered by AI and big data.

3.2.

United States’ Decentralized Governance Model of Smart Education

The governance of U.S. education is uniquely characterized by a decentralized, multi-tiered system. The federal government - including the U.S. Congress, the U.S. Department of Education, the White House and other agencies - sets a national vision around the goals for education, establishes an accountability structure to identify equity gaps, allocates some financial support for schools, research and innovation, enforces statutes and regulations and provides guidance on local practice and policy, among other duties (U.S. Department of Education, n.d.a). However, state and local governments provide a majority of the education funding and largely exercise independent control over the “what” and “how” of teaching and learning (Urban Institute, 2017). Therefore, each level of this system plays a unique role in influencing the quality of digital learning in each classroom.

Due to the COVID-19 pandemic and the consequent increased use of technology for remote and blending learning approaches (Schwartz et al., 2020), the roles of federal, state and local governments to ensure effective digital learning has been greatly emphasized. Although the United States is far from ensuring that all schools meet every aspect of the Smart Education Framework, the below case study draws from notable national-, regional- and school-level efforts from before and during the pandemic to showcase how they strive towards the framework’s core elements.

3.1.1. Leverage Point 1:
Transformative Teaching and Learning Enabled through Technology

3.1.1.1. Student-Centered Pedagogy

U.S. educators expect a sustained increase in their use of technology following the COVID-19 pandemic (Herold, 2021; Educators for Excellence, 2021). In response, schools have begun proposing and implementing technology-empowered learning models that center around students and
provide enriching opportunities for collaboration and problem-solving (Darling-Hammond et al., 2020b). As part of these efforts, states have expanded and deepened their use of the ISTE Standards as a guiding vision and framework for active uses of technology that go beyond passive content delivery. Every US state and territory has adopted the ISTE standards in some form, and as of July 2021, 24 states have updated to the newest generation of the ISTE Standards (ISTE, 2021e).

**Smart Education Framework Connection:**
Collaborative learning; Project- or problem-based learning

**Regional**

Working with a community of stakeholders — including teachers, instructional technology coaches, school administrators, state policymakers and external experts — Virginia adopted the new Digital Learning Integration Standards, which builds on the language of the ISTE Standards and the “5 C’s” (the state’s framework for competency-based learning which includes critical thinking, creative thinking, collaboration, communication and citizenship) (Virginia Department of Education, 2020). Leveraging these standards, school districts in Virginia, such as Virginia Beach City School District, have begun using technology in ways that allow students to evaluate the accuracy and credibility of online media (ISTE, 2020e) and engage with global issues (ISTE, 2020d).

**Smart Education Framework Connection:**
Collaborative learning; Project- or problem-based learning

**School**

At Sitka High School in Sitka School District, Alaska, educators noticed diminishing enrollment in traditional career and technical education programs, largely driven by a drop in student interest. Educators therefore reimagined the program to center around the student and build skills and habits of mind relevant to their potential future careers. Investments made by district leaders allowed the school to purchase new tools and software that would allow engagement in computer-based projects which strove to allow students to solve real-world problems in the manufacturing industry and engage in a design-based learning process. Furthermore, to foster peer collaboration, educators at Sitka High School partnered with other local schools to allow students to work remotely with others on joint projects (ISTE, 2020b).

**Smart Education Framework Connection:**
Personalized Learning; Design-based learning; Collaborative learning; Project- or problem-based learning

**3.2.1.2. Reimagined Assessments**

**National**

To meet federal accountability requirements, U.S. schools summatively assess students in mathematics and English language arts annually from third to eighth grade and once in high school (Education Trust, 2016). Under federal statute, a maximum of seven states are permitted to pilot reimagined and innovative means of assessing student performance that go beyond traditional, standardized models (U.S. Department of Education, n.d.b).

**Smart Education Framework Connection:**
Assessment of learning
Under the abovementioned statutory flexibility, New Hampshire launched its Performance Assessment of Competency Education (PACE) program. Schools participating in PACE administer locally developed, competency-based assessments that measure whether a student is prepared to advance to the next skill in a given subject. Educators regularly collaborate across the state to calibrate consistent evaluation and scoring for PACE assessments (New Hampshire Department of Education, n.d.). The initial evaluations show promising evidence of a positive impact on student achievement in PACE districts (Evans, 2019).

**School**

At Burlington High School in Cambridge, Massachusetts, students can enroll in the “Student Technology Integration and Innovation Course”. Modeled after technology help desks often leveraged by industry leaders, this innovative course allows students to collaborate and consult with peers and teachers on ways to better integrate technology into instruction. For example, one student built a chatbot that leverages artificial intelligence to give automated responses to common troubleshooting questions. Educators recognized that skills learned in this course could not be accurately measured through traditional methods of assessing. Therefore, they measure students’ oral, written and interpersonal communication skills through a variety of methods including digital portfolios of their accomplishments, peer and faculty feedback and multimedia presentations (ISTE, 2019b).

**National**

Due to the impact of COVID-19 on students’ well-being, whole-child supports that go beyond academics and prepare students to be in the best position to learn have been an increasing area of focus. Under an Executive Order of the President, the U.S. Department of Education designed an online clearinghouse with suggested strategies for supporting healthy, productive and equitable communities in online learning spaces (U.S. Department of Education, 2021c). The Department also published guidance for schools and districts centered on how technology can support students’ mental health and social-emotional development through local policies and practices (WestEd, 2021).

**Regional**

States like Washington continue to reinforce students’ digital citizenship skills by setting a vision around the development of this competency, providing strategic grant funds for schools and recommending model local policies (Song, 2020). Also, local leaders like those in the Los Angeles Unified School District, have launched centralized efforts to coach educators on integrating digital citizenship practices and sharing resources and key learnings districtwide (Los Angeles Unified School District, n.d.).

**School**

- Smart Education Framework Connection: Social-emotional skills
- Smart Education Framework Connection: Digital citizenship competencies

**Regional**

- Smart Education Framework Connection: Assessment of learning; Assessment as learning
By 2018, schools in Rowan-Salisbury School District, North Carolina, ensured that every student had access to a learning device. However, educators quickly realized that the 1:1 initiative would be ineffective unless students received on how to interact productively in a digital community. Using the ISTE Standards as a guiding framework, a working group of educator’s leveraged existing resources from Common Sense Education to develop gradelevel appropriate lesson plans. These plans were not meant to be used as one-off classroom activities, but strategically integrated into the existing curricula. This approach has been effective in reducing school issues related to the improper use of technology tools by students (ISTE, 2018).

**Smart Education Framework Connection:**
Social-emotional skills;
Digital citizenship competencies

### 3.2.2. Leverage Point 2:
Digital Learning Environments Conducive to Smart Education

#### 3.2.2.1. Learning Devices and Support

Over the past decade, schools have made significant progress in ensuring at least one learning device per student. More than three-quarters of all districts currently report this critical achievement (Consortium for School Networking, 2021). However, the remaining digital divide still remains a large concern among leaders. To navigate this issue during the COVID-19 pandemic, the U.S. Congress appropriated three rounds of eligible emergency relief funds to be flexibly spent by schools on a variety of needs, which include educational technologies as an explicit allowable use (U.S. Department of Education, 2021b).

**Smart Education Framework Connection:**
Access to connected digital learning devices

Recent research shows that purchasing digital tools to ensure students can still learn remotely has been one of the top investment priorities of these new relief funds by states and districts (Association of School Business Officials International, 2021). For example, in Connecticut, the governor’s office leveraged federal relief funds to provide 141,000 devices for students’ use becoming the first state in the U.S. to close the access gap (Office of Governor Ned Lamont, 2020).

**Smart Education Framework Connection:**
Access to connected digital learning devices

At the beginning of the COVID-19 pandemic, schools in Glendale Unified School District in California quickly developed an approach to address access to technology and online resources. The district set up a kiosk in the central office lobby, where device distribution took place. By the summer, nearly 8,000 devices and 200 hotspots had been distributed. Glendale Unified District also established a robust remote learning plan, which included webinars and screencasts on how to set up and lead remote instruction, lesson plan templates for students with and without technology and resources organized by grade level. To facilitate communication with students and families, the district developed a dedicated web portal featuring student and family expectations, online resources, mental health support and instructions on how to access meals and technology. Finally, Glendale Unified District also provided translation services for all communication and established special helplines for technical and special education support (COVID-19 Education Coalition, 2020).

**Smart Education Framework Connection:**
Access to connected digital learning devices; Technical support for students and educators
3.2.2.2 Seamless Connectivity

National

Advanced scientific instruments, like scanning electron microscopes (SEM), are expensive and usually only available at universities to select post-secondary students and professors. Using seamless internet connectivity, the US National Aeronautics and Space Administration (NASA) launched the remote Scanning Electron Microscopy (rSEM) project to make these instruments accessible to public school classrooms in support of hypothesis-driven learning activities (Digital Commons @ Cal Poly, 2010). rSEM allows learners at locations around the world to remotely observe and control the SEM without having to travel to the SEM facility center. Custom software interfaces with the rSEM and remote users that permits real-time control of the microscope and allows classroom teachers and students to conduct research or scientific inquiry of their choice all from a personal computer with an internet connection.

Smart Education Framework Connection:
Free learners from artificial time-based or geographical constraints

Regional

The deployment of seamless connectivity alone does not ensure that it will be used effectively for learning. To address this need, the Connecticut Commission for Educational Technology (Connecticut Commission for Educational Technology, 2017) is responsible for adopting education technology standards and best practices for desired learning outcomes when schools and students in Connecticut are connected with digital tools, devices and each other. The commission created a strategic plan to curate, publish and update effective, research-based educational technology standards and best practices. These are shared publicly with schools, libraries, educators and parents. The executive director of the commission gathers quarterly measures on the effectiveness of using these resources. The resources address key policy areas such as leadership, governance, connectivity, procurement, communications, data management and privacy which are the cornerstones of effective use of technology. The commission continues to champion effective pedagogy supported by technology while updating standards and best practices as the need arises.

Smart Education Framework Connection:
Educators are supported in becoming global collaborators through seamless internet connectivity

School

Nearly 5,000 miles separate Paris, France, from Lopez Island in the state of Washington, USA (ISTE, 2019d). Seamless connectivity, online collaboration tools and apps make it possible for middle-school students from these far-flung locations to become global collaborators in an international history project called the Monument Project. The students work onsite and online during the school year to research, curate and share the otherwise forgotten stories of World War I American soldiers buried abroad. These students and others are bringing history to life for cemetery visitors with the use of an app and are inviting others to join their efforts through a crowdsourced website. Tom Neville, the teacher who initiated the project collaborated with colleagues from his own school, including learning coach Claude Lord a strong supporter of technology integration. Their goal is to help teachers “embed technology in a seamless way so that pedagogy takes the lead in engaging students with authentic projects that would not have been possible before.” (ISTE, 2019d) The Monuments Project doesn’t just teach students about history, it challenges them to
do the work of historians using current technologies. In the process, students are learning what it means to be engaged global citizens who can leverage technology to collaborate, research, educate and motivate others.

Smart Education Framework Connection:
Free learners from artificial time-based or geographical constraints

3.2.2.3. Ethical Use of Technology

With the increasing uses of educational technology in the U.S., various stakeholder groups have raised concerns over how digital tools and software collect and use user data (Herold, 2020). School district leaders also anticipate that artificial intelligence will play a transformational role in education in the next five years but are also concerned about implications for student privacy (U.S. Department of Education, 2021b). Federal policy, including the Family Educational Rights and Privacy Act (FERPA), governs what information can be shared by schools and under which circumstances including when using technology services from third-party providers (Future of Privacy Forum, 2019). Additional guidance was published by the U.S. Department of Education during the COVID-19 pandemic to clarify FERPA’s statutory language for schools (U.S. Department of Education, 2020a), parents and caregivers (U.S. Department of Education, 2020c) and the students themselves (U.S. Department of Education, 2020b).

Smart Education Framework Connection:
Data privacy

Regional
Through state-level legislation, various states have created requirements in addition to federal policies to further protect student data. For example, Oklahoma placed restrictions on how the state education agency can collect, safeguard, use and grant access to data. In other states like California, online service providers are prohibited from using student data for commercial purposes (ISTE, 2019c). Furthermore, several school networks have been recognized nationally for their commitment to student data privacy protections (Consortium for School Networking, n.d.).

Smart Education Framework Connection:
Data privacy

School
At Jesse Bethel High School in Vallejo City Unified School District, California, educators empower students on steps that they can take to protect personal data. In a Law and Speech Communication course, educators ask students to take out their mobile devices and check their privacy settings. Then, educators connect this simple activity to a lesson on the topic of the Fourth Amendment of the U.S. Bill of Rights, which prohibits the government from engaging in unreasonable searches and seizures. Educators also host a mock hearing for students to debate the government’s right to access private digital data from its citizens (ISTE, 2020c).

Smart Education Framework Connection:
Data privacy
School

At Pinkerton Local School District in Ohio, all technology applications approved for use must be able to sync with the district’s learning management system. This allows the district to extract critical data into dashboards, so educators can identify students’ specific strengths and needs. Data interoperability, therefore, elevates technology from simply a tool of convenience to a driver of support and achievement. The director of instructional technology for the Ohio district, Brian Seymour notes that “Interoperability is pretty much one of our non-negotiables” (ISTE, 2019c).

Smart Education Framework Connection: Interoperability

School

Over the last 15 years, Raytown Quality Schools in Raytown, Missouri has gone through data governance and security transformation that has resulted in data interoperability. The district, which serves over 8,500 students in 18 schools, has partnered with Project Unicorn (Project Unicorn, 2021b) a national initiative to increase data interoperability across the sector and signed the School Network Pledge (Project Unicorn, 2021d) to commit to interoperability. At Raytown Quality Schools, data interoperability has saved crucial time for teachers and students, provided key insights to inform instruction, created student-centered learning experiences and ensured that student data is secure.

When Melissa Tebbenkamp, Chief Information Officer for Raytown Quality Schools, first joined the district in 2006, the data center was a wall of wires with few security measures in place. Tebbenkamp is a believer in the mentality of “go slow to go fast”, thus over the next several years Raytown Quality Schools overhauled their system by layering the process of data and IT transformation. She started by focusing on the physical security of systems. Then, she moved on to focusing on resources like staff and software and building partnerships between technology and instructional teams – an investment that proved to be invaluable. Finally, the path was laid to take on a variety of nuanced topics including contracts, data work and access control which was key to interoperability. “It took two to two and a half years just to build up the fundamental infrastructure that was needed,” Tebbenkamp says and “without that, data governance is all for naught” (Project Unicorn, 2021a).

Raytown Quality Schools released the first version of its Data Governance Manual in 2017 (Raytown Quality School, 2017). The manual is a 40+ page document detailing the district’s data governance policies which proved integral to managing the security of its system. The effort devoted to building this infrastructure step-by-step was recognized formally when Raytown Quality Schools was nationally recognized for its work and was awarded the Trusted Learning Environment Seal from COSN (Project Unicorn, 2021c). However, their journey is not yet over as Raytown is continually improving its data and privacy practices and is now focusing on an initiative to implement a two-factor authentication for every application.
Underlying the success of Raytown Quality Schools’ work in data governance and security is a prioritization of data interoperability by leadership. This has been key in establishing a culture where all stakeholders understand the importance of interoperability and security, and in building trusted relationships between leadership, IT and instructional teams. Core elements of success rely on these relationships. For instance, all new teachers in the district spend a dedicated 90 minutes on the topic of data governance when they join. Ultimately, this helps ensure that data is accurate and up-to-date, and can be connected between systems (for example, attendance and course grades). Tebbenkamp notes “every person in the district is a data steward because they all touch data, even students. In addition, everyone is responsible for the data that they touch” (Project Unicorn, 2021a). It is this cohesive effort that has allowed Raytown Quality Schools to achieve interoperable, secure data access across the district.

Smart Education Framework Connection:
Interoperability

3.2.3. Leverage Point 3: Forward-Thinking Governance and Policy Initiatives

3.2.3.1. Develop a National Vision and Plan

The U.S. Department of Education’s Office of Educational Technology (OET) is mandated by the U.S. Congress to regularly publish a National Education Technology Plan (NETP) that sets a vision for how technology may be best leveraged to transform teaching and learning. The latest NETP “articulates a shared vision of equity, active use and collaborative leadership to make everywhere, all-the-time learning possible” by providing guidance on topics such as learning, teaching, assessments, leadership and infrastructure (Office of Educational Technology, 2017d). Furthermore, the NETP provides recommendations for educators, state and local policymakers, school administrators and educators preparation programs, as well as numerous examples of successful implementation (Office of Educational Technology, 2017d).

Smart Education Framework Connection:
Shared vision around competencies, infrastructure, procurement, and innovation

Regional

At the state and local levels, various education agencies have developed educational technology plans of their own by outlining specific goals, strategies and metrics of success to best ensure the rollout and sustainability of technology-empowered learning. For example, Utah’s latest plan articulates goals around various themes from leadership and change management to infrastructure and professional learning (Utah State Board of Education, 2015).

Smart Education Framework Connection:
Shared vision around competencies, infrastructure, procurement, and innovation;
Identification of metrics and milestones;
Identification of costs

3.2.3.2. Build Infrastructure Capacity

National

Students’ and educators’ broadband access is another key aspect of the digital divide that the COVID-19 pandemic highlighted. Approximately 15 to 16 million U.S. K-12 students — especially those from rural communities as well as Black, Latino and Native American households — are currently impacted by the divide, alongside 3 million to 4 million postsecondary students and 400,000 educators (Ali et al., 2021). Funds from the federal E-Rate program, which provides discounts for schools and libraries in disadvantaged...
communities to access high-speed internet, are regularly leveraged to ensure that students and educators can be connected at school (Federal Communications Commission, 2014). To ensure at-home access, the Federal Communications Commission oversaw the rollout of the Emergency Connectivity Funds (Federal Communications Commission, 2021c) which reimburses schools and libraries for both on- and off-campus broadband access, as well as the Emergency Broadband Benefit program (Federal Communications Commission, 2021b) which provides discounts for disadvantaged homes. Within the first month of launching the Emergency Broadband Benefit program, over 100.4 million U.S. households enrolled to receive discounted broadband access (Federal Communications Commission, 2021d).

Smart Education Framework Connection:
Connection to the internet at home and at school

Regional
A number of states and districts have upgraded their capacity around providing wireless, at-home connectivity during the pandemic through innovative partnerships. For example, in Nebraska, by leveraging the school districts’ fiberoptic connection to the Network Nebraska (the state education network that serves both K-12 schools and higher education institutions) and various new vertical assets to extend the wireless coverage, the state has made significant progress in ensuring access to underserved tribal regions (Office of Educational Technology, 2021).

Smart Education Framework Connection:
Deployment, maintenance, and update of wired and wireless networks; connecting rural and remote communities

National
U.S. leaders have expressed a vision that digital infrastructure is a necessary component of success for all Americans (Klein, 2021). Under the 2013 federal ConnectED initiative, various private-sector stakeholders committed to investing resources to ensure that underserved students can access the internet from home (The White House, 2013). Furthermore, the U.S. Department of Education released guidance around key considerations for school districts as they update their infrastructure to ensure connectivity in schools (Office of Educational Technology, 2017c). As of 2021, federal policymakers are considering large-scale investments to ensure one-hundred percent high-speed broadband coverage (The White House, 2021).

Smart Education Framework Connection:
Deployment, maintenance, and update of wired and wireless networks

Regional
Nevada has long recognized the critical role that technology plays in schools. In 1997, then Governor Bob Miller and the state legislature established the state EdTech commission which is responsible for developing the statewide EdTech plan and distributing funds necessary for its implementation. Since then, the commission’s actions have successfully led to significant improvements in connectivity and EdTech access (Song, 2020). In 2021, Nevada reported that in all school districts and charter schools, all students had access to an internet connection and a learning device (Nevada Department of Education, 2021).

Smart Education Framework Connection:
Connection to the internet at home and at school
School

Schools in Rowan-Salisbury School District, North Carolina have taken a multi-faceted approach to address the digital divide that exists for students and their families and caregivers. Schools relied heavily on partnerships with community organizations, including faith-based organizations, businesses and libraries that can help students connect online after school. To help students most in need, school buses equipped to extend Wi-Fi access were deployed in strategic locations and mobile hotspots were distributed. Furthermore, educators made sure to host open events where they could communicate to families and caregivers about the impact of the digital divide and resources that they can access to alleviate this issue (ISTE, 2021f).

Smart Education Framework Connection:
Connection to the internet at home and at school

3.2.3.3 Invest in Human Capacity

National

The U.S. Department of Education’s NETP notes that a “digital use divide continues to exist between learners who are using technology in active, creative ways to support their learning and those who predominantly use technology for passive content consumption,” and hence emphasizes the critical need to reinforce educators’ skills to narrow this divide for their students (Office of Educational Technology, 2021). Through federal investments, such as those authorized under Title IV, part A of the Every Student Succeeds Act, the U.S. Congress has provided funds that can be used towards educators’ professional development and coaching on the effective use of technology (T4PA Center, n.d.). The U.S. Department of Education has also issued further guidance on how these funds may be invested to best build capacity at the local level (South, 2017).

Smart Education Framework Connection:
Funding for professional development and coaching

Regional

Various state leaders have leveraged their state’s education funding sources to ensure that educators have an opportunity to earn credentials that ensure they are prepared to use technology effectively. For example, in Wyoming, the state leveraged its own share of federal Title IV, part A funds to develop a state cohort of ISTE-certified educators who additionally qualify for the state’s instructional technology endorsement (Song, 2020).

Smart Education Framework Connection:
Funding for professional development and coaching

3.2.4. Overarching Consideration

3.2.4.1. Overarching Consideration 1: Inclusion and Equity

National

The COVID-19 pandemic illuminated and exacerbated existing gaps among learners, especially for those from underserved communities. Emergency relief funds appropriated from the U.S. Congress have aimed to ensure that all students can continue to be connected to their schools and other support services during the pandemic. These funds are distributed to states and districts using the Title I formula that prioritizes communities that enroll underserved student populations (U.S. Department of Education, 2018).

Smart Education Framework Connection:
Addressing needs of diverse student groups
Some states have begun inviting community stakeholders to ensure that their voices are reflected in policy decisions. For example, in California, where English learners, young students, and students with disabilities were expected to be hardest hit by the pandemic (Pier et al., 2021), the state’s education agency invited the voices of parents and students to help develop guidance for effective digital learning. The final guidance emphasized strategies for educators on how to navigate research-based uses of technology to help English learners, young students, and students with disabilities (California Department of Education, 2021).

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### Smart Education Framework Connection:  
Addressing needs of diverse student groups

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### School

Research currently reveals disparities between low-income schools and districts and their well-resourced counterparts when it comes to whether technology is used for passive or active learning (Utah State Board of Education, 2015). Recognizing this equity challenge which has dire implications for postsecondary and workforce readiness, schools in Darlington County, South Carolina sought to provide better opportunities for students in their rural communities. This work began by ensuring that educators in Darlington were up to speed on how to best integrate technology into teaching and learning. School leaders invested in an in-house Digital Transformation Conference, as well as a Digital Transformation Academy, where educators would regularly be able to see first-hand how technology could accelerate the mastery of critical skills like collaboration, communication, critical thinking and creativity (ISTE, 2021a).

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### Regional

Through the state’s Classroom Connectivity Initiative, Wyoming’s leaders engaged in interagency efforts to provide support for districts using E-Rate funds, which drastically increased the number of connected classrooms. However, this milestone has not been equated to “mission accomplished” yet. To better understand the next steps in best leveraging this expanded internet access, state leaders surveyed hundreds of district and school staff about their needs. Stakeholders agreed on the importance of digital learning opportunities for student success and the benefits of professional development in integrating technolo-
gy into instruction. This information was used to develop a statewide digital learning plan, which outlines how the state will systematically help educators use technology effectively (The White House, 2021).

**Smart Education Framework Connection:**
Evaluation of professional development

**School**

Leaders at Beaverton School District in Oregon regularly survey parents, administrators and staff for feedback on a variety of issues, including student empowerment and voice, safety, communication, school climate, culture and instructional models. The responses, which are made publicly available, are analyzed by district and school leaders so as to improve district policies and practices (Beaverton School District, 2021). For example, some district-wide professional development decisions are influenced by feedback from staff, parents and students. In addition, at South Eugene High School in Oregon, the school surveys parents three times a year which has led to improvements in instructional technology, counseling services and student schedules. For example, a parent recommended improvements in school-to-home communication about attendance, and the district responded by increasing the frequency of outreach. The school saw an increase in attendance after these recommendations were implemented (Beaverton School District, 2021).

**Smart Education Framework Connection:**
Evaluation of technology infrastructure;
Evaluation of professional development

3.2.4.3 Overarching Consideration 3: Multi-Sector Cooperation and Partnerships

**National**

To help states and school districts navigate the high cost and inflexibility of proprietary educational resources, the U.S. Department of Education launched the #GoOpen initiative, promoting the broad use of open educational resources (OER). The initiative consisted of not only the issuing of policy guidance on how local education leaders can begin using OER, but also the establishment of the #GoOpen Network (U.S. Department of Education, 2017b), a coalition of state and district leaders making a commitment to strategically integrate OER. Supporting organizations from the nonprofit and for-profit sectors supported the network by helping amplify the initiative and sharing models of successful implementation.

**Smart Education Framework Connection:**
Partnerships with private and social sectors, higher education institutions, and other domestic non-governmental organizations;
Cooperation to overcome new and ongoing barriers to student learning and accelerate the scaling of evidence-based solutions

**Regional**

Arizona’s leaders involved the higher education and nonprofit communities in coordinating their response to COVID-19 and consequent school closures. State leaders partnered with the Arizona Virtual Teacher Institute at Arizona State University to provide a free professional development series on best practices for online learning which resulted in 11,000 trained educators. Arizona districts also partnered with organizations like Act One to leverage virtual reality technology and bring art experiences to remote communities, including schools in Native American reservations (ISTE, 2021d).
Moving from Disruption to Innovation

As with many schools around the world, U.S. schools faced a major disruption due to the impact of COVID-19 and school closures. However, the same disruption provided a unique opportunity to reexamine existing policies and practices and develop innovative methods to redefine what a “good” educational experience looks like. For example, many U.S. schools doubled down on efforts to address student-educator relationships and social-emotional development, while others began developing standards and frameworks to support competency-based learning approaches (ISTE, 2021c). Furthermore, schools have become more involved in ensuring that parents and caregivers are included in supporting students’ learning (National Parents Union, 2021). By considering how the Smart Education Framework can be a useful tool to organize coordinated efforts from a systems perspective, national, regional and school leaders have an opportunity to ensure that these innovations do not remain in the past as the world slowly emerges from the pandemic.

3.3. Uruguay’s Three Institution Governance Model of Smart Education

The education system of Uruguay is managed by three large organizations: The Ministry of Education and Culture (MEC), the National Administration of Public Education (ANEP) and the University of the Republic (Udelar). These three institutions are responsible for outlining the general principles of the national education system and for planning and managing all levels of education in the country. The ANEP plays an important role, since it is in charge of the administration of state and private education at the levels of initial, primary, secondary, technical-technological education and training in education, and is an autonomous entity, which makes it different from most educational systems (ANEP, 2017).

In the area of educational technology, Uruguay has the Plan Ceibal Center (Educational Connectivity of Basic Computing for Online Learning) through which it has managed to become a model
country in terms of the development of socio-educational policies that relate technology with human development, digital inclusion and equal opportunities in the information society. The beginning of this support through public policies in Uruguay was given by means of a decree signed by the current government in 2007, where it was announced that within three years a laptop would be delivered to every child and teacher in all public schools in Uruguay (Plan Ceibal, n.d.b).

Despite the fact that during the COVID-19 pandemic Uruguayan education was affected, as in all countries, due to its long history and preparation of more than ten years of investment in infrastructure, digital content and teacher training, Uruguay became a successful example of effective use of technology in education in the midst of a crisis.

The educational system of Uruguay still does not comply with all the aspects specified in the Smart Education Framework, but through the following case study, we will be able to see the path traveled and the current work with a view to the future at the national level to achieve it.

### 3.3.1 Leverage Point 1: Transformative Teaching and Learning Enabled through Technology

#### 3.3.1.1. Student-Centered Pedagogy

Uruguay, through Plan Ceibal, does not promote a specific educational model but rather an ecosystem of innovative pedagogies framed in the Uruguayan version of the New Pedagogies for Deep Learning (Global Learning Network) which are integrated through different ways of learning and teaching (UNESDOC, 2018).

An example of how the development of personalized learning is promoted is the use of the Adaptive Mathematics Platform (PAM). It is an online platform to learn mathematics in primary and secondary education designed to provide an effective learning opportunity for students to improve their mathematical knowledge. The platform adapts to the rhythm of each student and offers individualized support (Plan Ceibal, 2020c).

Currently, more than seven hundred Uruguayan education centers nationwide participate in this Global Learning Network, promoting an educational approach where learning is done by doing projects linked to real-life experiences with the student as the protagonist and the teacher as the activator (Plan Ceibal, n.d.c).

Design-based learning is also promoted through the Designing Change project, which is aimed at teachers and students who use design thinking to offer solutions to changing needs in schools. Through this project, collaborative work is also promoted, and the notion that each member of the educational community is in a position to generate favorable actions is strengthened.

Computational thinking is becoming popular in Uruguay as well, which covers 60% of urban schools hence covering around 34,500 students. The model (Plan Ceibal, 2020e), which is similar to the English teaching program, is implemented by a remote expert teacher in computational thinking and the classroom teacher facilitating the class and following the learning process in the LMS (Crea). Thus, teachers and experts coordinate as a team to put students at the center of learning.
### 3.3.1.2. Reimagined Assessments

The educational system of Uruguay, through Plan Ceibal and the National Administration of Public Education (ANEP), uses an innovative learning evaluation system that includes: adaptive evaluations, options to create your own evaluation test, digital badges, rubrics, computational thinking assessment and learning analytics (ANEP, n.d.b).

Furthermore, the evaluations are applied online, taking advantage of the technological infrastructure installed in the educational centers by the Ceibal Plan, to reflect and intervene in the learning of the students on a national scale (ANEP, n.d.a).

**Smart Education Framework Connection:**
- Assessment of learning;
- Assessment as learning

### 3.3.1.3. Learner Community-Building

Uruguay has a National Strategy for Digital Citizenship, which was developed by Plan Ceibal together with different organizations. The National Strategy focuses on the critical, responsible and creative use of technology in different spaces (UNESCO, 2020a).

These are some examples of the actions carried out through the Digital Citizenship Working Group (GTCD):

- Training and awareness: Online courses with free entry, safe use workshops for teachers and the general public and Digital Citizenship.
- Day Research: Research on citizen participation mediated by ICT.
- Content development: Development of platforms and robotics and programming programs.
- Participation: Sowing experiences that collect experiences of teachers and students with the use of ICT.

Uruguay, through Plan Ceibal, does not promote a specific educational model but rather an ecosystem of innovative pedagogies framed in the Uruguayan version of the New Pedagogies for Deep Learning (Global Learning Network) which are integrated through different ways of learning and teaching (UNESDOC, 2018).

The need for social-emotional skills has also been evident during the handling of the COVID-19 pandemic. To develop these skills and have a healthy coexistence in Uruguayan homes, different initiatives have been carried out, such as the following:

- Life Skills Education Course for Teachers.
- Learning objects on socio-emotional education.
- Curation of life skills resources through the CREA platform.
- Participation in the Responsible Education program.

**Smart Education Framework Connection:**
- Social-emotional skills;
- Digital citizenship competencies

### 3.3.2. Leverage Point 2: Digital Learning Environments Conducive to Smart Education

#### 3.3.2.1. Learning Devices and Support

Uruguay has become a model country in terms of access to devices and connectivity in their educational system. Each student receives a device that becomes his/her property starting in their 1st year of primary school, which is then changed every two or three years. In initial education, tablets are delivered in library mode for use in the classroom by boys and girls aged 4 and 5. Teachers also receive a personal handheld device.
3.3.2.2. Seamless Connectivity
Uruguay is the only country in the world in which the entire student body that attends public educational centers, nationwide, receives a proprietary computer with free internet access (Plan Ceibal, 2020b).

The educational system of Uruguay has a connectivity network that is present in 100% of educational premises and serves the entire beneficiary public. It also has a high-quality video-conference network and Teaching Points from which English classes are taught. About half of the Teaching Points are in countries like Argentina, Chile and the Philippines (Plan Ceibal, 2020d).

3.3.2.3. Ethical Use of Technology
In 2018, Plan Ceibal promoted the creation of an Ethics Committee in the use of Data for Education, which is currently integrated together with the National Administration of Public Education (ANEP), the Information and Knowledge Society (AGESIC), universities and other organizations. The purpose of this committee is to set ethical standards for the use of personal data.

3.3.3 Leverage Point 3: Forward-Thinking Governance and Policy Initiatives
3.3.3.1. Develop a National Vision and Plan
Within the framework of the principles and goals established in the National Educational Policy Plan of the Ministry of Education and Culture (MEC) in conjunction with the National Administration of Public Education (ANEP), Plan Ceibal has established its Strategic Plan to ensure that each student acquires the necessary skills to function in the information society, through innovative technologies and methodologies applied in various areas of knowledge.

The vision of Plan Ceibal for the coming years includes the following Strategic Objectives: ensuring access to technology at the service of learning, innovating in technological infrastructure, content, experiences and digital environments, contributing to the continuous improvement of teaching processes and learning and developing skills for digital citizenship.

3.3.3.2. Build Infrastructure Capacity
Uruguay is one of the countries with the largest number of centers connected to the Internet and with the greatest expansion of broadband in education. The connection rate in educational centers is more than 95% in primary and 96% in secondary schools.

The government of Uruguay is currently working on the development of digital skills, investment in infrastructure, strengthening digital government and promoting Information and Communication Technologies (Uruguay Digital, 2020).
3.3.3.3. Invest in Human Capacity

Plan Ceibal offers a proposal for teachers’ professional development articulated and coordinated with the different education authorities in the country. One of the objectives of Plan Ceibal’s Strategic Plan is to provide an accessible and flexible teacher professional development system that allows the generation of personalized training routes (Plan Ceibal, n.d.a).

The role of teachers in such a developed environment in the area of technology is essential, which is why Plan Ceibal offers professional development opportunities in different formats such as workshops, online seminars and blended courses. The focus is on new technologies and innovative ways of teaching to enhance the learning process. One of the most successful current teacher training programs is the Summer School, which consists of a permanent training space whose purpose is to generate opportunities for exchange, learning and collaboration on emerging issues (Plan Ceibal, 2022).

The National Educational Policy Plan of Uruguay has a line of action that seeks to have better trained teachers for a better education. To accomplish this, they have established the goal of designing and putting into operation a National System of Scholarships for training in education and supporting the MEC, ANEP and Plan Ceibal in the development of accompaniment, training and monitoring actions (ANEP, 2021).

3.3.4 Overarching Consideration

3.3.4.1 Overarching Consideration 1. Inclusion and Equity

The Digital Agenda of Uruguay establishes as one of its main areas of action the development of an Inclusive Digital Society. For this, one of its objectives has been to ensure that all people can acquire knowledge and skills to exercise their rights and obligations in the digital environment, as a fundamental space for socialization and participation.

Through Plan Ceibal, innovation has been distributed equitably in the country, and the access gap between the highest and lowest income quintiles has been reduced, consolidating an equity scenario that has remained stable since 2010.

An example of the achievements in terms of inclusion and equity is that Plan Ceibal has received global funds from UNICEF to develop the "Digital Bridges for Educational Equit" project, which seeks to promote solutions based on digital technologies to strengthen education, inclusion and quality (Uruguay Presidencia, 2021).

3.3.4.2 Overarching Consideration 2: Continuous Improvement Culture

The Uruguayan education system has the Ceibal Foundation Research Center, which is an institution that promotes, supports and produces excellent research in the field of education and technology for the development and use of scientific knowledge. The Foundation’s mission is to provide guidance to Plan Ceibal and other national and international education actors in the areas of learning and technology mediation both within and outside the formal education system (Fundación Ceibal, 2021).
3.3.4.3 Overarching Consideration 3: Multi-Sector Cooperation and Partnerships

Uruguay is part of the Global Learning Network. This is an international collaborative initiative that integrates new learning pedagogies in 10 countries on different continents through a common framework of actions and research. Uruguay, through ANEP and Plan Ceibal, participates in this network along with nine other countries and regions including Australia, Canada, the United States, Finland, the Netherlands, New Zealand, Hong Kong (China), Japan and Taiwan (China).

This network places the student at the center with the aim of introducing them and deepening the pedagogical approach of deep learning, through which the development of skills such as collaboration, communication, character, citizenship, critical thinking and creativity is promoted.

3.3.5 Conclusion: Moving from Disruption to Innovation

As in most educational systems worldwide, education in Uruguay was also interrupted by COVID-19. However, Uruguay has been prepared for more than ten years with educational policies, devices, resources, trained human capital and a specialized center, such as Plan Ceibal. Thus, we can see that the effects were smaller if we make a comparison with other countries.

Uruguay, through the “Ceibal at Home” program, was recognized internationally by important publications from the Organization for Economic Cooperation and Development (OECD), the World Bank (WB), the Inter-American Development Bank (IDB), the Broadband Commission, the Finnish organization HundrED and through media channels such as BBC, EFE, France 24 and INFOBAE. In addition, Uruguay was the first country in Latin America to reopen its educational system after the pandemic (Plan Ceibal, 2020a).

The educational system in Uruguay still has many challenges, but without a doubt, it is well on its way to advanced smart education.

3.4. Russia’s Centralized and Decentralized Governance Model of Smart Education

Educational management in the Russian Federation combines both centralized and decentralized governance models (EDUNews, n.d.). Since 2018, the education system in Russia has been managed by the Ministry of Education (for preschool, general education, additional education of children and secondary vocational education) and the Ministry of Science and Higher Education (for higher education), which are engaged in the elaboration of policies and the development of regulatory and legislative documents. Most higher education organizations are directly subordinate to the Federal Ministry of Science and Higher Education of the Russian Federation or sectoral ministries (for example, the Ministry of Culture or the Ministry of Health).

At the level of the constituent entities of the Russian Federation, regional ministries are engaged in the management of the systems of preschool, general and secondary vocational education (SVE). They directly manage SVE organizations. However, direct management of preschool and general education organizations is carried out by municipal educational authorities.
At each level, educational authorities have their own clearly specified powers, which are transferred from the highest to the lowest levels and do not have the right to implement certain actions in educational policy. This does not mean delegating the right to finance certain activities without coordination with the higher structure.

Inspection of general compliance with legislative provisions is carried out by the state-public education management system in the Russian Federation. Its member organizations are engaged in the functioning of schools and monitoring the implementation of the following principles: a humane and democratic approach to management, consistency and integrity and finally truthfulness and completeness of information.

3.4.1 Leverage Point 1: Transformative Teaching and Learning Enabled through Technology

3.4.1.1. Student-Centered Pedagogy

At the end of the 2000s, a federal collection of digital educational resources (Education system of the Russian Federation, n.d.) was created with the support of the Russian Ministry of Education. Pedagogical innovations use mostly publicly available digital user tools of global IT companies (Google, Microsoft, Vkontakte, Yandex, etc.) as well as the services of numerous providers of digital educational services Uchi.Ru (UCHi, n.d.), SkyEng (Skyeng, n.d.) and Yandex Tutorial (Yandex, n.d.) among others.

A detailed overview of digital learning resources can be found in Russian (College of Economics, National Research University, 2020).

To support the best teachers, teaching and learning innovations, the Teacher of the Future, Teacher of the Year and Innovation in Education competitions are held annually. The latter is held annually by NRU HSE (HSE, n.d.), where between 500 and 1,000 educational projects participate each year.

The winner of the 2019 Teacher of the Year competition mentions using interactive lessons and a series of Dmitry Bykov’s (Russian writer and literature teacher) lectures from the internet, inserting some interesting bits into the program. The Teacher of the Year in 2019 explains “My students and I use gadgets. For example, when we study poetry, we switch to the Mentimeter app. It is so exciting when children enter the lines, they remember the best, and you analyze which idea has captivated them the most. We also do booklets” (Youtube, 2019).

3.4.1.2. Reimagined Assessments

In 2006, Russia introduced a unified state exam for secondary school graduates in their main subjects, with automated collection and processing of student results. A video surveillance system is used to monitor its occurrence throughout the country. And since, assessment methods have been regularly updated over the past years. In 2021, examinations for informatics and foreign languages were held on computers. In recent years, the use of the digital assessment system for final tests has been extended for students from all school grades.

In addition, in recent years, the practice of carrying out national testing (All-Russian test works) in various subjects has expanded. These tests, which are usually conducted annually in the middle of the school year for two subjects (determined by draw) of the school curriculum, have become mandatory. At the state level, these controlled activities are usually regulated by the Federal Education Supervision Service. Methodological
support at the federal level is prepared by scientific institutes subordinate to the Ministry of Education (the Federal Institute for Pedagogical Measurements and the Federal Institute for Educational Quality Assessment). At the regional level, assessment materials are usually prepared by the Institutes of Education Development, which works in each region and provides scientific and methodological support for education at the regional level.

3.4.1.3. Learner Community-Building

The development of students’ digital competencies is the task of informatics (computer science) subjects within the compulsory general education, as well as the use of digital technologies in the study of other disciplines in accordance with the curricula.

In recent years, the Ministry of Digital Development has started to pay attention to the formation of competencies of digital citizenship within such projects as Lesson in Numbers (Digital course, n.d.) and others that have been launched. Some of the projects can be found in Russian (Digital economy autonomous non-profit organization, n.d.).

3.4.2 Leverage Point 2: Digital Learning Environments Conducive to Smart Education

3.4.2.1. Learning Devices and Support

As required by the Ministry of Education, all recommended school textbooks have digital versions, which are available on the websites of educational publishers.

All general education schools are equipped with computers, digital projectors and other digital devices to support the educational process in accordance with federal, regional and municipal programs. The time of digital technology continuous use in educational work is limited by federal health requirements.

The use of personal digital devices by pupils is not prohibited in Russian schools, but in many schools, it is restricted because of the decisions of local education authorities.

Further, the use of digital devices is governed by health regulations that are issued at the federal level. They stipulate the minimum required characteristics for the digital devices and the possible duration of their use in the classroom.

3.4.2.2. Seamless Connectivity

Almost all schools in Russia have access to the Internet. According to the results of the Monitoring of Quality and Cost of Services Offered by Internet Providers in General Education Institutions, which surveyed 2,689 heads of schools from 73 Russian regions, 42% of urban schools and 34% of rural schools have internet access at a speed of 100 Mbit/s or higher. However, 23% of those surveyed reported problems with internet access equipment (due to few access points and outdated equipment). According to the Priority National Education Project, all schools should be equipped with high-speed internet by 2024.

3.4.2.3. Ethical Use of Technology

All information traffic available to the school via the internet is filtered according to the requirements of the Russian educational authorities.

The need for laws requiring the use of artificial intelligence methods is being discussed today. In particular, the head of the Laboratory for Digital transformation of Education, NRU HSE, Ivan Karlov, participated in the development of a system of standards for artificial intelligence in education, which was adopted at the federal level at tshe at the end of 2021. NRU HSE has been an official Center of Competence in Artificial Intelligence in education at the federal level since 2021.
In 2021, digital ethics has been selected as one of HSE’s research and development priorities.

3.4.3 Leverage Point 3: Forward-Thinking Governance and Policy Initiatives

3.4.3.1. Develop a National Vision and Plan

The programs for digital transformations at the federal and regional levels, contain sections devoted to education.

In addition, the Priority National Education Project (Russian Ministry of Education, 2021b) which consists of several federal projects devoted to different areas and levels of educational development, is currently being implemented in the country. Each federal project includes measures devoted to the development of ICT in education. Furthermore, there is a separate federal project within this framework called Digital Educational Environment.

The Russian Ministry of Education plans to develop a description of the Ideal School in 2022, which will serve as the basis for the renewal of schools (digital transformation) in Russia’s regions (TACC, 2022).

3.4.3.2. Build Infrastructure Capacity

In 2001, the Russian federal targeted program called Development of a Unified Educational Information Environment was adopted. It aimed at creating a digital educational environment providing:

- Unified educational space throughout the country.
- Quality of education improvement in all Russian regions.
- Preservation, development and effective use of the country’s scientific and pedagogical potential.
- Conditions for a gradual transition to a new level of ICT-based education.
- Conditions for the provision of Russian educational services to the Russian-speaking population abroad.

The program provided for the restoration of the technological infrastructure of the education system, supplying educational institutions with computer equipment, connecting them to the internet for access to global information resources and creating and using digital (electronic) learning materials in the learning and teaching processes.

Not all of the Development of a Unified Educational Information Environment program tasks were achieved before its completion in 2004. Nevertheless, the degradation of the technological infrastructure of the education sphere has been halted. As a result, the number of personal computers in schools has grown more than tenfold in 2000, the ratio was 1 computer per 500 students but in 2004 it was already 1 computer per 46 students. Seventeen federal-level educational portals have been created, and around 100 educational multimedia products have been deployed. More than 220,000 teachers have been retrained in ICT. The program has come to an end, but there have been no visible shifts in addressing the challenges of the modern school. The participants of the program preferred to consider the informatization of education only as a technological (not pedagogical) problem. They installed computers in schools, connected them to the internet, launched educational portals and developed digital educational resources (e-learning materials). Teachers have been introduced to new information and communication technologies. However, all this has not led to an improvement in the performance of schools.
Since 2006 Russia has been implementing the Priority National Education Project. This is a large-scale longitudinal program for the development of education, which is still being implemented in several directions, including equipping educational institutions with digital equipment and other ICT tools.

The Digital Learning Environment Project (Russian Ministry of Education, 2021a) was implemented in 2019 and is expected to continue until 2024.

In 2021, the Ministry of Education and the Ministry of Digital Development of the Russian Federation have developed and submitted for discussion a technical standard for equipping ‘schools’ ICT infrastructure.

3.4.3.3. Invest in Human Capacity
Mass training of teachers in the field of digital technology, as decided by the central authorities, began in the late 1980s, has continued throughout the years, and is ongoing until the present day. The system that has been established covers all categories of educators, including educational and school leaders, teachers of different subjects and specialists in supporting the digital environment. All students of educational institutions that instruct future teachers also receive such training.

3.4.4. Overarching Consideration
3.4.4.1. Overarching Consideration 1: Inclusion and Equity
The intensive use of digital technologies in teaching children with special needs began with the successful implementation of the Moscow city i-school project, which tested remote education for children with disabilities (Alexander Ez dov, 2007). This project was supported by the Russian government and since then the experience of remote learning for disabled children has eventually emerged across all regions of the country.

The principles of inclusive education are now being implemented in all schools.

In addition, there are separate federal projects dedicated to identifying talented children regardless of where they live and projects to develop social lifts (opportunities). The link above about the Priority National Education Project provides more details about this project.

3.4.4.2. Overarching Consideration 2: Continuous Improvement Culture
The use of ICT in education has grown steadily in recent decades (Uvarov, 2019). Today, the advanced Russian regions have integrated school support systems (e.g., the Moscow E-School system supports all schools and teachers in the city) (Moscow Electronic School, n.d.). Each of the regions has its own education systems, which are usually integrated by data both downwards (aggregating and analyzing information of individual educational organizations and municipalities) and upwards (with information systems of federal ministries). However, the term smart Education (or smart school) is not used in official documents and is mostly used as a commercial label or figurative name.

3.4.4.3. Overarching Consideration 3: Multi-Sector Cooperation and Partnerships
There are examples of integration of commercial educational technologies into the educational processes (most prominent are integrations with uchi.ru and skysmart.ru) but these are usually non-governmental initiatives. Issues in cooperation and partnership will be discussed separately at the school level during the implementation of the state information system My School, which promises to merge (at least in terms of data) all educational solutions at the state level. Pilot implementations of the My School governmental information system are currently expected by 2023-2024.
The practice of organizing “federal innovation platforms” in Russia gives greater freedom to choose solutions and technologies than conventional educational organizations. However, this practice is currently relaunching (in 2020, all the statuses of innovation platforms were revoked, and a new competition was held at the end of 2021, the results of which are not yet available). We will continue monitoring this situation in terms of innovation platforms’ development.
CONCLUSION

In this uncertain, complex, diverse and intelligent world, the concept of smart education is proposed to address the needs of students, teachers, parents, leaders, policymakers, etc. One such need in the intelligent era is cultivating qualified talents for the rapidly evolving society. The construction of a smart education plan for teaching and learning will promote the ability of learners, educators and citizens to adapt to an uncertain, complex and diverse world for their immediate and long-term well-being. And furthermore, to build a community around a shared vision for humankind by providing accessible, engaging and effective learning opportunities for everyone everywhere.

Smart education has become an important strategy for building a smart society. However, how to build smart education at the national level requires deliberate, collaborative leadership and planning for ICT in education. Therefore, this report proposes a national smart education framework including: transformative teaching and learning enabled through technology, digital learning environments conducive to smart education, forward-thinking governance and policy initiatives, and moreover three overarching considerations for stakeholders to consider when constructing a national vision and plan.

The four cases presented above are based on the national smart education framework. Clearly, China, the U.S., Uruguay and Russia share some similarities in their approach to smart education. However, due to different cultural backgrounds, different economic and social constraints and opportunities and lastly differing education and technology levels in each country, they diverge in several areas. This can particularly be seen in how and where they focus their efforts on implementation. Other countries, including Uruguay and Russia, show similarities and differences in how they approach this work.

Create a National Plan: Prioritize the Formulation of ICT in Education Planning at the National Level

China, the U.S., Uruguay and Russia, all have stated national priorities for ICT in education and all publish national plans that lay out a vision for the education system to innovate and modernize their approach. The Department of Education in the U.S. regularly publishes a “National Education Technology Plan (NETP)” which sets a national vision and plan for learning enabled by technology (Office of Educational Technology, 2017d). The NETP is normally updated on average every 5 years. With a host of case studies, examples and practical suggestions, the NETP addresses emerging topics in the field of education and technology and explores how technology can improve learning to ensure that all students have an equitable and high-quality educational experience. While the U.S. government does not create national standards for ICT, the NETP does reference well-known international standards such as the ISTE Standards, which have been adopted by all 50 states and territories. The MOE of China also issues ICT policies in education every five years, such as the “13th Five-Year Plan of ICT in Education” (MOE of China, 2016). The MOE of China issues other action plans to guide the construction of ICT in education, including guidance to regions and schools at a macro level which emphasizes the shared vision, objectives and tasks.
Russia takes a hybrid approach to education governance between national and regional ministries of education. Russia has established a National Education Project, which consists of several federal projects devoted to different areas and levels of educational development, each of which includes measures devoted to the development of ICT in education. Furthermore, Russia has established a separate federal project within this framework called the Digital Educational Environment (MOE of Russia, 2022).

Uruguay also has a national plan, Plan Ceibal, that emerged in 2007 when Uruguay committed to providing one laptop to every child and teacher in the country and has been a guiding and evolving vision ever since (Plan Ceibal, n.d.b). Over time, the focus of the plan has shifted from a priority on infrastructure, to integration of technological, educational and social support, to finally a focus on new educational pedagogies and practices enabled by the success of previous phases. Like China, Uruguay has a centralized education system that allows them to fully engage schools in implementing their ICT vision. As a small country, Uruguay has considerably less territory and fewer students and teachers than China or the U.S., to which they must supply infrastructure and devices. This gives them some advantage in ensuring equity of access to connectivity and digital resources than larger countries, though their national budget is of a much smaller scale than that of China or the U.S.

Establish Foundational Infrastructure: Emphasize the Construction of Infrastructure to Lay a Solid Foundation

China, the U.S. and Uruguay also take action to build infrastructure capacity, particularly in terms of learning devices and support and seamless connectivity such as developing relevant policies and increasing national funding. Each country strives to achieve full coverage and improve the quality of learning devices and networks, and each has achieved remarkable results. Regarding learning devices and supports, in China, as of the first quarter of 2021, 98.7% of primary and secondary schools in China have built multimedia classrooms (China Education Network, 2021a). In the U.S., more than three-quarters of districts have made significant progress in ensuring at least one learning device per student (Consortium for School Networking, 2021). Nevertheless, Uruguay leads the US and China as the only country in the world in which the entire student body that attends public educational centers nationwide receives a proprietary computer with free Internet access (Plan Ceibal, 2020b).

At this stage, China pays more attention to the provision of devices in schools, while the U.S. is shifting focus to the challenge of ensuring that every student has access to broadband and a learning device at home. In terms of seamless connection, in China, as of December 2020, the network access rate of primary and secondary schools in China reached 100% (China Education Network, 2021b). As a result, China has achieved full coverage of school network connectivity.
Build a Learning Community: Emphasize the Exploration of Learner Community-building to Promote Learner Development

In terms of learner community-building, China, the U.S. and Uruguay each recognize the importance of this priority and have developed corresponding frameworks about key competencies to help students grow into civic-minded members of local and global societies, developing and strengthening key competencies. For example, core competencies in China, the ISTE Standards (ISTE, 2021e), 21st-century skills in the U.S. and so on. In addition, digital citizenship including digital literacy and skills is critical to helping students make informed decisions online and to build inclusive online communities. Thus, all three countries also propose frameworks and measures to ensure that students can continue to receive instruction and interact with peers online, thereby cultivating digital citizens with digital awareness, computational thinking, lifelong learning and social responsibility (UNESCO, 2020a). In Russia, in recent years, the Ministry of Digital Development has begun the formation of competencies of digital citizenship within such projects as Lesson in Numbers (NUMBER LESSON, n.d.) and others that have been launched (Экономика, 2022).

Expand Educator Capacity: Emphasize on Investing in Human Capacity to Promote Teachers’ Digital Teaching Competence

In terms of investing in human capacity for educators, both China and the U.S. have developed corresponding frameworks about digital teaching competencies. The MOE of China developed a framework for the development of teachers’ digital teaching competence (MOE of China, 2021b) and the ISTE standards for educators are used in the U.S. In order to ensure that they are prepared to use technology effectively, educators have an opportunity to earn ISTE certification to improve educators’ digital teaching competence in education. Through federal investments, the U.S. Congress provides funds that can be used towards educators’ professional development and coaching on the effective use of technology (U.S. Office of Educational Technology, 2017). In Uruguay, one of the objectives of Plan Ceibal is to provide an accessible and flexible teacher professional development system that allows the generation of personalized training routes (Plan Ceibal, n.d.a). They offer professional development opportunities in different formats such as workshops, online seminars and blended courses. The focus is on new technologies and innovative ways of teaching to enhance the learning process. In Russia, to recognize exemplary teachers and to support teaching and learning innovation, the Teacher of the Future, Teacher of the Year and Innovation in Education competitions are held annually. The latter is held annually by NRU HSE (NRU HSE, 2022), where between 500 and 1,000 educational projects are submitted each year.

Focus on Transformational Learning Environments: Emphasize New Teaching and Learning Models Transformed by Technologies

China, the U.S. and Uruguay innovate in teaching models using technology, pointing out the importance of personalized learning and emphasizing some of the same teaching and learning models such as project-based learning and cooperative learning. Yet, there are some differences. The U.S.
encourages schools and teachers to use technology to transform the learning environment in face-to-face, blended or remote learning and stimulate the passion and personal interest of learners. However, China puts more emphasis on the construction of a smart learning environment. They build an intelligent student-centered teaching environment, promote the application of artificial intelligence in teaching, use intelligent technology to accelerate the reform of pedagogy and explore ubiquitous, flexible and intelligent new environment models. Uruguay does not promote a specific educational model, but rather an ecosystem of innovative pedagogies framed in the Uruguayan version of the New Pedagogies for Deep Learning (Global Learning Network), which are integrated through different ways of learning and teaching (UNESDOC, 2018). Russia’s approach to pedagogical innovations focuses primarily on publically available digital user tools of global IT companies (Google, Microsoft, Vkontakte, Yandex, etc.) as well as the services of numerous providers of digital educational services such as Uchi.Ru (UCHi, n.d.), SkyEng (Skyeng, n.d.) and Yandex Tutorial (Yandex, n.d.), among others.

**Engage Multi-Sector Partnerships:**
**Emphasize Multi-sector Cooperation and Partnerships to Support the Construction of ICT in Education**

In the whole process of carrying out ICT in education, China, the U.S. and Uruguay attach great importance to multi-sector cooperation and partnerships, including the governments, schools, private and social sectors, higher education institutions, enterprises and other domestic non-governmental organizations, as well as international cooperation. However, in the process of cooperation, there are some differences. Education in China is characterized by a centralized governance. China’s governance model is centered in the MOE’s leadership and coordination, which then draws in multi-party cooperation and co-promotion. The governance of U.S. education adopts a decentralized, multilayered system. Federal and state entities, higher education and non-profit institutions and local districts and schools have initiated their own projects to cooperate with stakeholders to strengthen ICT in education. Uruguay is part of the Global Learning Network. This is an international collaborative initiative that integrates new learning pedagogies in 10 countries on different continents through a common framework of actions and research. Uruguay, through ANEP and Plan Ceibal, participates in this network along with nine other countries and regions including Australia, Canada, the United States, Finland, the Netherlands, New Zealand, Hong Kong (China), Japan and Taiwan (China).

While each country takes different approaches, the converging themes discussed in this document demonstrate that the Smart Learning Framework can serve a wide range of governing philosophies including national, provincial and local education structures, various funding and public/private partnership strategies and countries of vastly different sizes, cultures and complexity. We feel that the Smart Learning Framework represents a distillation of some of the most impactful approaches that are being implemented around the world to transform teaching and learning with the power of technology. We hope that the examples and recommendations in this document will serve as a guide and a rallying point for governments and other key stakeholders around the world that need to develop national plans for ICT in learning or update existing plans to address emerging challenges and opportunities. We stand with you in this effort.
Smart Education
Smart education (system) is considered as the educational behaviors (system) provided by schools, regions or governments, with the characteristics of high learning experience, learning content adaptation and teaching efficiency. Modern science and technologies are used to provide diversified supports and on-demand services for students, teachers and parents, etc. The data of participants and learning and teaching processes are recorded and used to promote the quality and equity of education (Huang, 2014).

Smart learning
In a smart learning environment, a learner can learn at anytime, anywhere, in any way and at any pace which is short for “4A”. Such an environment is capable of supporting “Easy Learning”, “Engaged Learning” and “Effective Learning” which is short for “3E”. In such a smart learning environment, easy, engaged and effective learning (3E) at anytime, anywhere, in any way and at any pace (4A) could be regarded as smart learning (Liu et al., 2017).

Smart learning environment
A smart learning environment refers to a learning place or activity space that can perceive learning situations, identify learners' characteristics, provide appropriate learning resources and convenient interactive tools, automatically record learning processes and evaluate learning results, so as to promote learners' effective learning (Huang et al., 2012b).

Smart campus
A smart campus is a kind of open education teaching environment and convenient and comfortable living environment with the concept of personalized service for teachers and students, which can fully perceive the physical environment, identify the individual characteristics and learning situations of learners, by providing a seamless network communication and effectively supporting the analysis, evaluation and intelligent decision-making of the teaching process (Huang et al., 2012c).

Smart classroom
A smart classroom is a typical materialization of a smart learning environment and is the high-end form of network classroom, where the “intelligence” involves five dimensions: showing, manageable, accessible, real-time interactive and testing (Huang et al. 2012a).

Information Communication Technology (ICT) in Education, Education Informatization
ICT in education refers to the process of comprehensively and deeply using modern information technology in education to promote educational reform and development, and the result is bound to be the formation of a new form of education — information education (Huang, 2011).

Digital citizens
Students recognize the rights, responsibilities and opportunities of living, learning and working in an interconnected digital world, and they act and model in ways that are safe, legal and ethical (International Society for Technology in Education, 2021e).
Digital literacy and skills
Digital literacy and skills are a series of competencies that all citizens of a digital society need to acquire, produce, use, evaluate, interact with, share, innovate and secure data and ethics in their study, work and life (Cyberspace Administration of China, 2021).

Comprehensive literacy evaluation (CLE)
Comprehensive Literacy Evaluation (CLE) is to cultivate students’ comprehensive development in five aspects including morality, intelligence, physical education, beauty and labor (State Council, 2019).

Core competencies
Core Competencies and Values are the high-order ability and humanistic ability to solve complex problems and meet unpredictable situations. The Core Competencies have responded to the basic question of what kind of people education should cultivate, which can be divided into three aspects: cultural foundation, independent development and social participation in the six competencies of cultural heritage, scientific spirit, learning strategies, healthy life, responsibility, practice and innovation (Guangming Education, 2016).

Nation Network for Education (N2E)
The N2E is managed by the education administrative department, covering all types of schools at all levels and the education administrative departments at all levels, providing high-speed, convenient, inclusive and safe network services (Education INFO, 2021).

New Infrastructure Construction in Education
New Infrastructure Construction in Education is led by the new development concept, which is further led by informatization, facing the needs of high-quality development of education, focusing on the new infrastructure system of networks and connection, ICT infrastructure, smart campus, learning management and administration information system, innovation of teaching, assessment and governance and lastly, digital resources (MOE of China, 2021a).

Three classrooms (MOE of China, 2018b)
- Delivery classroom is committed to addressing the problem that rural and one-teacher schools lack teachers and are unable to deliver compulsory courses for students. It provides students in rural and one-teacher schools with online special courses, simultaneous courses, or delivering them with appropriate digital learning resources through the Internet to promote the equity and balance of education in China.
- Outstanding teacher classroom aims at addressing problems of inadequate teaching ability and low professional level among some teachers. It not only offers teachers opportunities to collaborate with outstanding teachers remotely but also provides them with excellent teaching methods and experience via videos or live streaming which record typical teaching processes from outstanding teachers.
- Prestigious school online classroom aims at closing the gap between regions, urban and rural areas, and the schools themselves. With high-quality schools as the main force, it promotes the sharing of high-quality educational resources on a national scale through online schools, online courses, etc., as a way to meet students’ needs for personalized development.
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