Simen Owen Academic Proceedings Series

Vol. 1 2025

Review **Open Access**

From Access to Outcomes: Understanding and Addressing the Digital Divide in China's K-12 Education

Wanyi Zhang [1,*]

[1] School of Management, Xiamen University Tan Kah Kee College, Zhengzhou 363123, China
* Correspondence: Wanyi Zhang, School of Management, Xiamen University Tan Kah Kee College, Zhengzhou 363123, China

Abstract: China's K-12 education system has experienced rapid digital transformation, driven by large-scale state investment in broadband infrastructure and the nationwide deployment of platforms such as Smart Education of China. By 2023, all schools had achieved formal internet connectivity, positioning China as a global leader in educational access. Despite this remarkable progress, significant inequities persist. Prior research has often focused on coverage metrics, neglecting the complex, multi-layered interactions among infrastructure, teacher capacity, pedagogical practice, and student learning outcomes. To address this gap, this study proposes the ICUO framework-Infrastructure, Capacity, Usage, and Outcomes-as an integrated model for analyzing the educational digital divide. Employing a structured literature review, policy analysis, and comparative case studies of Shanghai and Guizhou, the research reveals stark contrasts: Shanghai benefits from stable infrastructure, robust teacher training, and innovative digital practices that foster advanced literacy, whereas Guizhou continues to face unstable connectivity, limited professional development, and persistent outcome disparities. These findings indicate that infrastructural expansion alone is insufficient; equitable digitalization requires parallel investments in human capacity and high-quality usage. The study contributes theoretically by reconceptualizing digital equity as a systemic, process-oriented phenomenon and practically by offering a policy-relevant framework to guide interventions that ensure digital technologies translate into meaningful and equitable learning outcomes.

Keywords: digital divide; K-12 education; China; ICUO framework; educational equity

Received: 20 July 2025
Revised: 05 August 2025
Accepted: 18 October 2025
Published: 22 October 2025

1. Introduction

The digital transformation of education has emerged as a defining trend in global development, fundamentally reshaping how knowledge is produced, disseminated, and acquired [1]. In China, this transformation has been predominantly state-driven, supported by substantial infrastructure investment, the establishment of nationwide digital platforms, and the integration of smart technologies into classrooms and administrative systems [2]. By 2023, all primary and secondary schools were officially connected to the internet, and the "Smart Education of China" platform provided access to millions of educational resources [3]. These accomplishments underscore the global recognition of digital competence as a critical twenty-first-century literacy and align with national priorities to modernize education and mitigate regional disparities.

Despite these advances, digital equity remains a contested and complex issue. The concept of the "digital divide" has evolved from first-order concerns of access to second-order issues of skills, and more recently to third-order considerations of learning outcomes [4]. While rural access gaps have narrowed through targeted investment, dispari-

ties persist in teachers' digital competence and the quality of technology usage [5]. Teachers in under-resourced areas often lack sufficient training to integrate technology effectively into pedagogy, and students' opportunities for higher-order digital practices-such as collaborative problem-solving and creative knowledge production-vary markedly according to socio-economic status. A narrow focus on infrastructure risks obscuring these deeper, outcome-oriented inequalities.

Much existing research remains largely descriptive, emphasizing connectivity statistics or documenting disparities without systematically linking them to educational outcomes. Large-scale primary data studies are limited, creating a need for integrative and diagnostic analyses that synthesize existing evidence into a structured framework. Digitalization is frequently treated as uniform, overlooking the complex interplay among infrastructure, human capacity, governance, and learning outcomes [6]. Comparative studies are often fragmented, complicating efforts to generalize how local conditions mediate the effects of national reforms. Moreover, while international frameworks-such as UNESCO's discourse on "smart education"-advocate holistic approaches to equity, relatively few studies have adapted these perspectives to the Chinese policy context [7]. These gaps highlight the need for an integrated, context-sensitive analytical model.

To address these challenges, this study introduces the ICUO framework-Infrastructure, Capacity, Usage, and Outcomes-as an organizing lens. Unlike conventional three-order models, which often treat access, skills, and outcomes as separate dimensions, ICUO emphasizes their sequential interdependence and feedback loops. Infrastructure provides the necessary foundation, but without capacity-building and supportive institutions, digital resources remain underutilized. Usage determines whether technology supports higher-order learning, while outcomes ultimately measure equity and inform subsequent policy priorities. The ICUO model thus offers a systemic explanation for why infrastructural expansion alone cannot ensure equitable learning results.

Methodologically, the study employs a qualitative, multi-method approach, combining a structured literature review, policy analysis of Ministry of Education documents and international reports, and comparative case studies. Shanghai serves as a representative high-capacity metropolitan system, whereas Guizhou illustrates the challenges faced by under-resourced rural regions. Together, these cases illuminate how national strategies are interpreted and enacted under diverse local conditions.

The study contributes both academically and practically. Academically, it reframes digital divide scholarship by operationalizing the ICUO framework within a concrete national context, revealing the persistence of multi-layered inequalities even after universal connectivity is achieved. Practically, it provides actionable insights for policymakers and educators, emphasizing the need to balance infrastructure investment with teacher training, pedagogical innovation, and outcome-sensitive monitoring. Ultimately, bridging China's digital divide requires a shift from merely "connecting schools" to genuinely "empowering learners," ensuring that technological innovation translates into meaningful improvements in educational equity and justice.

2. Literature Review

The academic discourse on the educational digital divide has developed along three main dimensions, reflecting an evolution from infrastructure-focused debates to broader concerns about digital competence, pedagogical practice, and equity in learning outcomes. This section synthesizes the key strands of scholarship: (i) access-oriented studies addressing the first-order divide, (ii) research on digital competence and pedagogical integration as the second-order divide, and (iii) analyses of higher-order usage and educational outcomes, often referred to as the third-order divide. Each perspective highlights distinct aspects of digital inequality while revealing limitations that this study seeks to address.

2.1. Access-Oriented Perspectives: The First-Order Divide

Early research on the digital divide emphasized physical access to infrastructure, with internet connectivity, devices, and basic technological resources as primary indicators of inequality [8]. In China, this lens has been central to rural-urban comparisons, where large-scale state investment has significantly improved school connectivity. Its strength lies in providing measurable benchmarks for policy, underscoring infrastructure as a necessary precondition for digitalization. Yet, an exclusive focus on access risks overstating progress, since connectivity does not guarantee meaningful use. Without attention to quality, reliability, and pedagogical integration, the first-order perspective offers only a partial explanation of digital inequality [9].

2.2. Competence and Pedagogical Capacity: The Second-Order Divide

The second-order perspective shifts attention from infrastructure to human capacity, emphasizing how teachers and students develop and apply digital skills [10]. Evidence demonstrates substantial disparities in teacher competence, particularly between urban and rural schools, which affect the quality of technology integration. This view highlights the need for sustained professional development and institutional support, as hardware alone cannot ensure pedagogical innovation. Critics note, however, that this perspective risks overemphasizing individual skills while neglecting structural constraints such as workload, rigid curricula, or incentive systems. Despite these limitations, the second-order perspective remains crucial for linking technological access to meaningful classroom practice [11].

2.3. Usage and Outcomes: The Third-Order Divide

More recent scholarship has advanced the concept of a third-order digital divide, which focuses on the quality of technology use and its outcomes for students. From this standpoint, equity is not only about whether students have access to devices or whether teachers possess digital skills, but also about how technology is deployed to foster higher-order competencies, critical thinking, and collaborative learning [12]. This line of inquiry particularly concerns whether digitalization translates into measurable educational benefits and whether such benefits are distributed equitably across different social groups.

Empirical studies indicate that, while access to platforms and resources may be widespread, usage patterns often remain shallow, dominated by content consumption rather than creative or interactive learning [13]. Moreover, socio-economic factors continue to mediate outcomes, with students from more advantaged backgrounds more likely to leverage digital tools for enrichment activities, whereas disadvantaged students use them primarily for rote or remedial purposes [14]. The third-order perspective thus highlights persistent inequities even in contexts where infrastructure and skills appear adequate. Yet, this approach also faces challenges in measurement, as outcomes are difficult to capture and often require complex, multi-dimensional indicators beyond traditional assessments.

2.4. Comparative Perspectives and Theoretical Gaps

Research on the digital divide demonstrates a clear progression: from access to infrastructure, to competence in digital skills, and finally to outcomes of technology use. Each perspective offers valuable insights but remains limited in isolation. Access-oriented studies risk reducing equity to coverage statistics; competence-focused work emphasizes individual skills while overlooking structural barriers; and outcome-based analyses reveal deep inequities but face challenges in operationalization [15].

Two dominant schools of thought emerge from this literature. One assumes that sufficient infrastructure will naturally lead to improved outcomes, while the other stresses that access alone is inadequate without corresponding skills and equitable usage. A growing consensus calls for a holistic approach that captures the interplay among infrastructure, human capacity, and learning outcomes.

Table 1 summarizes the core focus, strengths, and limitations of these three perspectives, highlighting their relevance to this study. The comparison underscores the necessity of an integrated framework. Accordingly, this paper adopts the ICUO model-Infrastructure, Capacity, Usage, and Outcomes-to synthesize these insights and provide a structured lens for analyzing digital inequality in China's K-12 education system [16]. Unlike conventional three-order frameworks, which often treat access, capacity, and outcomes as discrete layers, the ICUO model emphasizes their sequential interdependence and feedback loops, offering a systemic explanation of why infrastructure alone cannot guarantee equitable learning outcomes.

Table 1. Contrasting Perspectives on the Digital Divide.

Perspective	Core Focus	Strengths	Limitations	Implications for This Study
First-Order (Access)	Connectivity, devices, infrastructure	Clear benchmarks; measurable progress	Ignores quality and pedagogical use	Provides baseline indicators but insufficient alone
Second-Order (Capacity)	Teacher/student digital skills, pedagogical integration	Links technology to classroom practice; emphasizes training	Overemphasizes individual competence; overlooks systemic barriers	Highlights importance of professional development and institutional support
Third-Order (Outcomes)	Quality of use, equity in learning outcomes	Reveals deep inequities; links digitalization to achievement	Hard to measure; fragmented evidence	Directly informs ICUO's focus on usage and outcomes

3. Theoretical Framework and Methodology

3.1. Theoretical Framework: The ICUO Model

This study adopts the ICUO Framework-Infrastructure, Capacity, Usage, and Outcomes-as the guiding lens for analyzing the educational digital divide in China's K-12 system. The model synthesizes insights from first-, second-, and third-order digital divide research, while adapting them to the distinctive features of China's educational landscape. Within this framework, infrastructure encompasses the physical and technical foundations of digital learning, including broadband connectivity, device availability, and access to digital platforms. Capacity refers to the human and institutional dimensions, such as teachers' digital competence, students' information literacy, and the ability of schools to provide effective support for digital integration. Usage highlights actual classroom practices of technology adoption, distinguishing shallow, consumption-oriented activities from deeper forms of engagement, such as collaborative projects, creative production, and problem-solving exercises. Finally, outcomes focus on the broader educational effects of digitalization, including academic performance gains, reductions in equity gaps, and the development of twenty-first-century skills.

The ICUO model posits that these dimensions are sequential yet interdependent. Adequate infrastructure forms the foundation for digitalization, but equitable outcomes require parallel investments in capacity and the promotion of meaningful usage. The model also emphasizes feedback loops across stages: strong learning outcomes may reinforce the need for expanded infrastructure and continued capacity-building, whereas weak outcomes may indicate deficiencies in earlier stages. By conceptualizing the digital divide as a systemic, multi-layered phenomenon, the ICUO framework allows for a more comprehensive assessment than binary measures of access alone. It situates digitalization within an interconnected cycle linking resource provision, human development, pedagogical practice, and equity in learning outcomes, thereby offering a robust foundation for both diagnosis and policy intervention.

3.2. Research Design and Methodological Approach

This study employs a qualitative, multi-method design to operationalize the ICUO framework. A structured literature review of studies from 2023 to 2025 establishes the evidentiary base, complemented by policy analyses of Ministry of Education documents and international reports, including UNESCO evaluations, which reveal institutional priorities and strategies. A comparative case study of an eastern urban district and a western rural county illustrates how national frameworks interact with local realities, while a brief historical review of initiatives-from the "Three Connections, Two Platforms" program to the Smart Education platform-situates current reforms in context. By combining these approaches, the research achieves methodological triangulation, ensuring validity and grounding the framework in both empirical and policy-relevant evidence.

3.3. Case Selection: Rationale and Context

The selection of Shanghai and Guizhou reflects a deliberate contrast between a high-capacity metropolitan system and an under-resourced rural county, illustrating the structural diversity of China's K-12 education and providing a meaningful lens to explore regional disparities. While not representing the full spectrum of China's regions, these cases serve as illustrative extremes to highlight the structural dynamics of the ICUO framework.

3.3.1. Eastern Urban District: Shanghai

Shanghai represents a high-capacity urban system with advanced infrastructure and institutional support for digitalization. By 2023, all schools achieved broadband coverage, and most classrooms were equipped with smart devices and learning platforms. Teacher training was reinforced through mandatory ICT competency programs, and blended learning has become common, particularly following the COVID-19 pandemic. Nevertheless, disparities persist: elite schools often employ data analytics and AI for personalized learning, whereas other schools primarily use platforms for routine instructional tasks. Within the ICUO framework, Shanghai demonstrates that strong infrastructure and capacity do not automatically guarantee uniform outcomes, underscoring the importance of deepening usage quality.

3.3.2. Western Rural County: Guizhou Province

Guizhou illustrates the challenges of implementing digitalization in under-resourced contexts. Although broadband access expanded following the 2023 national mandate, bandwidth remains unstable, device-to-student ratios are low, and classroom integration is limited. Teacher development opportunities are scarce, leaving many educators reliant on basic tools such as video playback or slide presentations. Consequently, students display lower digital literacy and limited engagement in higher-order technology use. In ICUO terms, Guizhou demonstrates that infrastructure alone cannot bridge the digital divide without capacity-building and supportive local policies, highlighting the need for targeted interventions.

3.4. Research Process

The research followed four stages aligned with the ICUO framework. First, relevant sources were collected, including recent academic studies, Ministry of Education policy documents, UNESCO reports, and CNNIC statistics on school connectivity. Second, materials were coded thematically according to ICUO dimensions, such as infrastructure quality, teacher training, usage depth, and learning outcomes. Third, a comparative analysis of Shanghai and Guizhou was conducted using indicators such as device-to-student ratios, teacher ICT participation, and platform engagement, highlighting contextual differences. Finally, findings were synthesized and triangulated across literature, policy texts, and case evidence, allowing the ICUO framework to be tested and refined in relation to how infrastructure and capacity shape usage and outcomes.

3.5. Methodological Strengths and Limitations

This methodology offers several strengths. First, by combining literature review, policy analysis, and case comparison, the study achieves triangulation, enhancing validity and reducing reliance on any single data source. Second, situating the ICUO model within the real-world contexts of Shanghai and Guizhou demonstrates its practical applicability, ensuring that the framework is grounded in evidence rather than abstraction. Third, integrating historical policy analysis provides a temporal dimension, capturing not only current conditions but also the trajectory of digital education reforms in China.

Nonetheless, limitations exist. Reliance on secondary sources restricts direct engagement with teachers and students, preventing full capture of lived classroom experiences. The two selected cases, while illustrative, cannot represent the full diversity of China's provinces and socio-economic contexts, raising questions of generalizability. Outcome measurement remains constrained, as publicly available data rarely provide detailed, disaggregated links between digitalization initiatives and student achievement. Moreover, the figures presented are illustrative indices based on secondary reports, intended to visualize relative disparities rather than provide precise statistical values; they should be interpreted as indicative rather than causal evidence. Accordingly, the study primarily contributes a conceptual and diagnostic framework rather than a fully empirical evaluation. These limitations point to the need for future research using longitudinal, mixed-method designs-including surveys, classroom observations, and student-level assessments-to provide a more comprehensive evaluation of the digital divide.

4. Findings and Discussion

4.1. Infrastructure: Uneven Foundations Beneath Universal Coverage

China has made remarkable progress in bridging the first-order digital divide. By 2023, official statistics reported that all primary and secondary schools had achieved internet connectivity, positioning the country as a global leader in digital access. In metropolitan areas such as Shanghai, connectivity extends beyond basic broadband to high-speed fiber networks and classroom Wi-Fi, supported by interactive whiteboards and integrated learning platforms. These conditions facilitate daily digital learning and experimentation with advanced applications, creating a strong foundation for pedagogical innovation.

In contrast, Guizhou and other western provinces face uneven access. Bandwidth interruptions in mountainous regions and limited device availability often force students to rely on shared computer rooms, restricting opportunities for individualized learning. Figure 1 illustrates these disparities: Shanghai maintains stable broadband and near one-to-one device ratios, whereas Guizhou, despite meeting formal connectivity targets, continues to lag in reliability and infrastructure quality. This comparison demonstrates that while Shanghai can leverage robust foundations to support advanced digital applications, Guizhou still struggles to ensure dependable basic infrastructure, highlighting that universal coverage alone is insufficient to guarantee equitable learning opportunities.

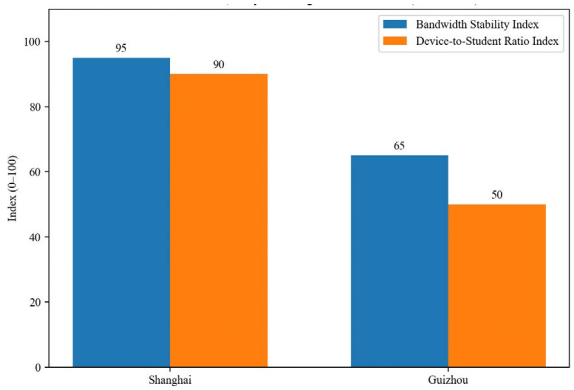

Figure 1. Infrastructure quality in Shanghai and Guizhou: bandwidth stability and device-to-student ratios (illustrative index).

Note: Values are normalized indices (0-100) derived from qualitative trends reported in Ministry of Education and CNNIC reports. They are intended to illustrate relative disparities rather than provide exact statistical measurements.

4.2. Capacity: Persistent Gaps in Teacher Competence

The second dimension of the digital divide concerns teacher digital competence. In Shanghai, educators are required to complete ICT integration certification and participate in continuous professional development, often supported by municipal funding and collaborations with technology firms. Many teachers design blended courses and utilize digital assessment tools to enhance instruction. Nevertheless, disparities persist: elite schools with strong institutional support implement advanced practices, whereas ordinary schools tend to focus training primarily on basic platform usage.

In Guizhou, gaps in teacher capacity are far more pronounced. Formal training opportunities are infrequent, and many educators rely on self-study or peer assistance to navigate new digital platforms. Heavy workloads and limited incentives further restrict experimentation with innovative pedagogical approaches. Figure 2 illustrates this contrast: Shanghai exhibits higher participation in professional development and stronger ICT competence, while Guizhou lags in both areas. These cases demonstrate that infrastructural improvements alone are insufficient; systematic investment in human capital is essential, as technology cannot be effectively leveraged without competent and confident teachers.

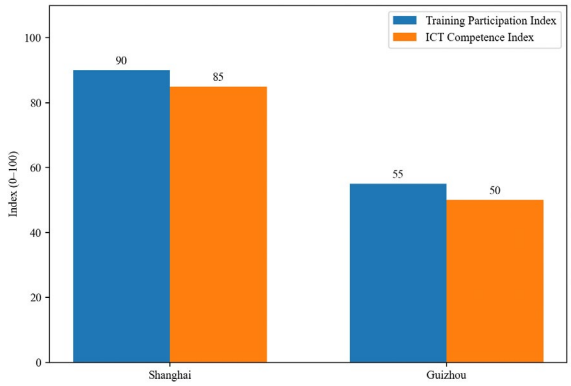

Figure 2. Teacher digital competence and ICT training participation rates in Shanghai and Guizhou (illustrative index).

4.3. Usage: Shallow Adoption Versus Innovative Integration

Classroom practices reveal the depth of the digital divide. In Shanghai, blended learning has become widespread since the COVID-19 pandemic, with digital platforms

supporting synchronous instruction, asynchronous assignments, and even AI-assisted tutoring or virtual laboratories. These practices illustrate how robust infrastructure and teacher competence enable more creative, interactive, and collaborative approaches to digital learning.

In contrast, in Guizhou, digital technology often plays only a supplementary role, such as playing videos or displaying slides. Student interaction with digital resources is largely confined to exam preparation or rote practice. Figure 3 highlights this divergence: in Shanghai, a substantial portion of classroom use involves creative and collaborative activities, whereas in Guizhou, content consumption predominates. This comparison demonstrates that institutional culture and teacher capacity critically shape whether technology reinforces traditional pedagogical practices or facilitates transformative learning.

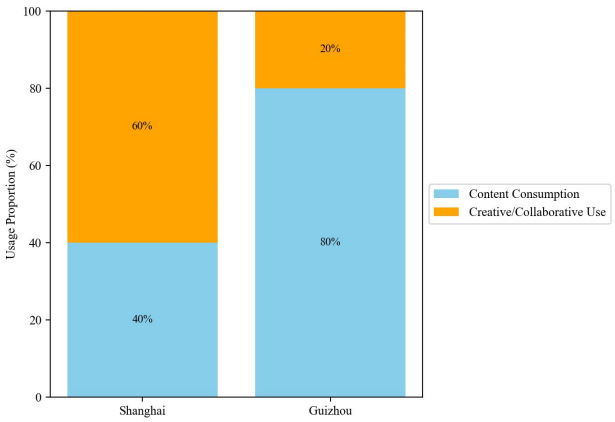

Figure 3. Classroom digital usage patterns: content consumption vs. creative and collaborative activities (illustrative proportions).

4.4. Outcomes: Uneven Benefits and Emerging Inequities

Disparities become most apparent at the level of learning outcomes. In Shanghai, available evidence suggests that students benefit from a well-developed digital ecosystem that supports higher academic performance and fosters competencies such as problem-solving and digital literacy. Pilot studies and surveys indicate that students in urban schools demonstrate stronger collaborative learning skills and greater adaptability to new digital tools.

In contrast, outcomes in Guizhou remain constrained. Despite improved connectivity, students have limited opportunities to engage in advanced digital tasks, and assessments reveal lower levels of digital literacy compared with their urban peers. The prevalence of exam-oriented practices further restricts the transformative potential of technology. Figure 4 illustrates these uneven outcomes: students in Shanghai consistently outperform those in Guizhou on digital literacy measures. Collectively, these cases demonstrate that infrastructure and access policies alone have not yet translated into equitable educational results, reaffirming the ICUO model's emphasis on outcomes as the ultimate indicator of digital equity.

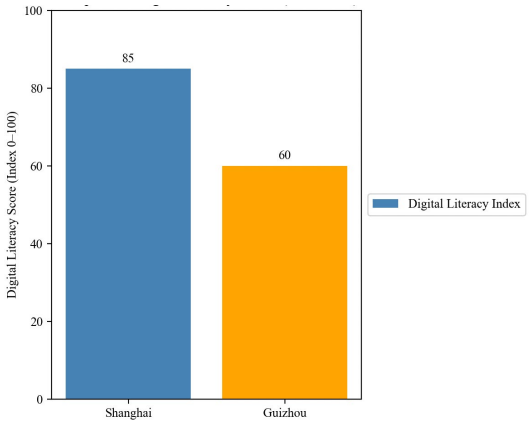

Figure 4. Comparative digital literacy scores of students in Shanghai and Guizhou (illustrative index).

4.5. Comparative Analysis with Existing Research

These findings align with international studies showing that first-order digital divides are narrowing while deeper divides persist. The Chinese case illustrates both the achievements of centralized infrastructure investment and its limitations when not coupled with capacity-building and pedagogical reforms. Shanghai demonstrates how advanced infrastructure and strong teacher competence can support innovative practices and improved outcomes, whereas Guizhou highlights that infrastructural expansion alone cannot eliminate inequities.

The study's innovative contribution lies in applying the ICUO framework to concrete regional cases, integrating infrastructure, capacity, usage, and outcomes within a single explanatory structure. This layered approach moves beyond earlier binary accounts of connectivity to provide a multidimensional understanding of the digital divide, linking policy, practice, and equity outcomes in a systemic manner. Despite relying on secondary evidence, the patterns observed consistently reflect broader international findings, reinforcing the validity of the comparative analysis.

4.6. Theoretical and Practical Implications

Theoretically, the ICUO framework clarifies why inequities persist despite substantial investment, emphasizing the interdependence of multiple dimensions. Practically, the findings suggest that future strategies must balance infrastructure expansion with targeted teacher training, incentivize innovative classroom usage, and monitor outcomes using equity-sensitive indicators. The comparison between Shanghai and Guizhou underscores that policies must remain adaptable to local contexts if digitalization is to promote genuine educational equity. By framing the digital divide as a systemic and multi-layered phenomenon, the ICUO model provides actionable insights for both policymakers and educational practitioners seeking to transform access into meaningful learning outcomes.

5. Conclusion

This study examined the digital divide in China's K-12 education system through the ICUO framework, focusing on infrastructure, capacity, usage, and outcomes. By comparing Shanghai and Guizhou, the analysis demonstrated that although nationwide connectivity targets have been achieved, significant disparities persist in infrastructure quality, teacher competence, pedagogical practices, and student learning outcomes. The findings underscore that digitalization cannot be understood solely as a matter of access; rather, it should be analyzed as a layered process linking resources, human capital, and educational equity.

Academically, this research contributes by operationalizing the ICUO model in a concrete national context, illustrating its explanatory power in capturing the interdependence of multiple dimensions of inequality. It also enriches comparative scholarship by showing how centralized infrastructure investment can produce rapid gains while leaving second- and third-order divides largely unaddressed. For policymakers, the findings highlight the necessity of balancing infrastructure expansion with targeted teacher training, curriculum reform, and outcome-oriented monitoring systems that prioritize equity over mere coverage. The added value of this study lies in demonstrating how the ICUO framework systematically integrates infrastructure, capacity, usage, and outcomes into a coherent analytical lens.

It should be noted that the figures presented are illustrative indices derived from secondary sources, intended to visualize relative disparities rather than provide precise statistical values. Similarly, while the analysis identifies associations between digital literacy and educational equity, it does not establish causal relationships, which remain a subject for future empirical research. Consequently, the contribution of this study is primarily conceptual and diagnostic, offering a structured framework for interpreting existing evidence and guiding future investigation.

Future research should extend this analysis by employing longitudinal, mixed-method designs, including large-scale surveys, classroom observations, and student assessments, to capture both quantitative and experiential dimensions of digitalization. Comparative studies across additional provinces or international contexts would further illuminate how local conditions mediate the implementation and outcomes of national policies. Ultimately, bridging the digital divide requires sustained commitment to integrating technological, pedagogical, and equity considerations within a coherent, context-sensitive strategy that ensures meaningful and equitable learning opportunities for all students.

References

1. B. Mann, W. Li, and K. Besnoy, "Digital divides: K-12 student profiles and online learning," *Education Policy Analysis Archives*, vol. 29, no. August-December, 2021.
2. T. He, "East Asian authoritarian developmentalism in the digital era: China's techno-developmental state and the new infrastructure initiative amid great power competition," *Asian Survey*, vol. 64, no. 6, pp. 942-972, 2024.
3. C. H. I. N. A. National Academy of Educational Sciences copyright@ esph. com. cn, "Policy Promotion of China Smart Education," In *Report on China Smart Education 2023: Towards a Higher Level of Digital Education*, 2024, pp. 9-26.
4. O. Kolotouchkina, L. Ripoll González, and W. Belabas, "Smart cities, digital inequalities, and the challenge of inclusion," *Smart Cities*, vol. 7, no. 6, pp. 3355-3370, 2024. doi: 10.3390/smartcities7060130.
5. M. de Clercq, M. D'Haese, and J. Buysse, "Economic growth and broadband access: The European urban-rural digital divide," *Telecommunications Policy*, vol. 47, no. 6, p. 102579, 2023. doi: 10.1016/j.telpol.2023.102579.
6. M. Sira, and A. Kuzior, "Digitalization of Government Management Processes in the Context of Sustainable Development," *Management Systems in Production Engineering*, 2025. doi: 10.2478/mspe-2025-0029.
7. B. E. Reforms, "Sustainability in Algerian Higher Education,".
8. L. Yang, "The evolution of ballet pedagogy: A study of traditional and contemporary approaches," *Journal of Literature and Arts Research*, vol. 2, no. 2, pp. 1–10, 2025, doi: 10.71222/2nw5qw82.
9. A. Afzal, S. Khan, S. Daud, Z. Ahmad, and A. Butt, "Addressing the digital divide: Access and use of technology in education," *Journal of Social Sciences Review*, vol. 3, no. 2, pp. 883-895, 2023. doi: 10.54183/jssr.v3i2.326.
10. A. Cataldo, N. Bravo-Adasme, J. Riquelme, A. Vásquez, S. Rojas, and M. Arias-Oliva, "Multidimensional Poverty as a Determinant of Techno-Distress in Online Education: Evidence from the Post-Pandemic Era," *International Journal of Environmental Research and Public Health*, vol. 22, no. 7, p. 986, 2025. doi: 10.3390/ijerph22070986.
11. B. C. Akyar, "Examining the Relationships Between First-Order, Second-Order Barriers and Digital Competence of Early Childhood Educators (Doctoral dissertation, Middle East Technical University (Turkey))," 2024.
12. P. Drijvers, and N. Sinclair, "The role of digital technologies in mathematics education: Purposes and perspectives," *ZDM-Mathematics Education*, vol. 56, no. 2, pp. 239-248, 2024. doi: 10.1007/s11858-023-01535-x.
13. K. Ramlackhan, "Creativity and critical thinking in online learning: addressing social justice, equity and inclusion in a graduate course in the United States," *Creativity in Education: International Perspectives*, pp. 113-131, 2024.

14. J. Yang, and M. Zhang, "Beyond structural inequality: a socio-technical approach to the digital divide in the platform environment," *Humanities and Social Sciences Communications*, vol. 10, no. 1, pp. 1-12, 2023. doi: 10.1057/s41599-023-02326-1.
15. B. M. Joshi, S. P. Khatiwada, and R. K. Pokhrel, "Influence of socioeconomic factors on access to digital resources for education," *Rupantaran: A Multidisciplinary Journal*, vol. 8, no. 01, pp. 17-33, 2024. doi: 10.3126/rupantaran.v8i01.65197.
16. D. KC, P. KC, I. Rado, and N. Vichit-Vadakan, "Digital inequality and learning outcomes: evidence from Thailand," *Education and Information Technologies*, pp. 1-26, 2025.