Article

Revisiting Techno-Optimism: Multidimensional Inequalities in AI Education across Urban, Suburban, and Rural Primary Schools in China

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Abstract

This study challenges the technologically optimistic narrative that artificial intelligence (AI) naturally promotes educational democratisation by delving into systemic inequalities in AI education across urban, suburban, and rural primary schools in China. Utilising a constructivist grounded theory approach, the research conducted six months of qualitative fieldwork, including in-depth interviews with 15 students, five parents, and five teachers, along with classroom observations at three primary schools located in Shenzhen (urban), Anqing (suburban), and Shangluo (rural). The findings unveil four interconnected layers of inequality: policy-driven infrastructure disparities favouring elite urban schools, regional stratification exacerbating urban-rural divides under standardised policies, intergenerational transmission of cultural and economic capital reinforcing educational privilege, and individual disparities in AI literacy widening the "new digital divide". These insights resonate with the maximally maintained inequality theory, highlighting how AI education policies may inadvertently perpetuate existing inequities. The study advocates for equity-oriented reforms in AI education, emphasising the necessity to address structural barriers such as unequal resource allocation, inadequate teacher training, and disparities rooted in family backgrounds. By illuminating the socio-technical dynamics of AI integration in education, this research not only contributes to theoretical understandings of educational inequality but also offers practical implications for policymakers and educators striving to achieve more equitable AI education outcomes.

Keywords: AI education inequality; urban-rural divide; cultural capital; digital divide; China

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Introduction

The integration of artificial intelligence (AI) into education has emerged as a global priority, driven by its potential to transform teaching practices and equip students with future-ready skills. Governments worldwide, including China, have launched ambitious policies to institutionalise AI education in K-12 curricula. In China, initiatives such as the New Generation Artificial Intelligence Development Plan (State Council of China 2017) and the Education Informatisation 2.0 Action Plan (Ministry of Education of the People's Republic of China 2018) aim to universalise AI literacy, positioning it as a cornerstone of national competitiveness. However, beneath the techno-optimistic rhetoric lies a stark reality: The implementation of AI education is deeply fragmented, exacerbating pre-existing inequalities across urban, suburban, and rural regions.

Urban centres such as Shenzhen and Shanghai have advanced AI laboratories and robotics programmes, whereas rural schools in western China often lack basic computer facilities. Such disparities are not merely infrastructural but reflect systemic inequities in policy prioritisation, resource allocation, and intergenerational resource transmission. For example, elite urban schools receive excessive funding and policy support, whereas rural schools face challenges due to tokenistic compliance. Meanwhile, children from affluent families gain early AI exposure via extracurricular training and parental guidance, while those from disadvantaged backgrounds encounter compounded barriers such as limited digital literacy and economic constraints.

This study tackles two major gaps in existing research. First, while prior work has examined AI's role in education, few studies explore how its implementation interacts with China's unique urban-rural stratification and intergenerational dynamics. Second, despite growing recognition of the "new digital divide", the mechanisms through which AI education perpetuates inequality remain underexplored. Guided by constructivist grounded theory, this six-month qualitative investigation analyses interviews and observational data from three primary schools in Shenzhen (urban), Anqing (suburban), and Shangluo (rural). It answers the following research questions:

RQ1: What forms of inequality persist in AI education across urban, suburban, and rural primary schools?

RQ2: How do policy frameworks, regional disparities, and intergenerational factors shape these inequalities?

By interrogating the interplay of macro-level policies and grassroots realities, this research challenges the assumption that AI inherently democratises education. Instead, it reveals how techno-optimism masks structural inequities, aligning with the theory of maximally maintained inequality (MMI). The findings underscore the urgency of reorienting AI education strategies to prioritise equity, particularly in contexts marked by profound socio-economic divides.

Literature Review

The discourse surrounding artificial intelligence in education is often dominated by techno-optimistic narratives positioning AI as a revolutionary equaliser capable of democratising access to quality learning. Policymakers and industry leaders advocate for AI-driven tools—ranging from intelligent tutoring systems to automated grading—as solutions to persistent educational challenges, promising personalised learning experiences and reduced teacher workloads (OECD 2022; Schiff 2021). In China, this optimism is reflected in national strategies such as the New Generation Artificial Intelligence Development Plan (State Council of China 2017), which emphasises AI education as critical for nurturing future talent and maintaining economic competitiveness. However, critical scholarship cautions against uncritical acceptance of this “technological myth”, arguing that AI integration often exacerbates rather than mitigates existing inequalities (Nemorin et al. 2023).

Global research highlights disparities in AI education implementation, particularly in resource-constrained contexts. While urban schools in affluent regions experiment with advanced robotics and programming curricula, rural and low-income institutions frequently lack basic digital infrastructure (Holstein and Doroudi 2021). China exemplifies this urban-rural divide: Cities such as Shenzhen have established AI laboratories and innovation hubs, whereas rural schools in western provinces struggle with outdated technology and limited internet access (Gu, Li, and Li 2023). This gap is compounded by a “new digital divide” encompassing disparities in digital literacy, usage patterns, and the capacity to leverage AI for educational advancement (Van Deursen and Helsper 2015). For instance, students from affluent families actively engage with AI tools for skill development, while their economically disadvantaged peers often interact passively with entertainment-focused applications, deepening inequality (Wang et al. 2024).

China’s unique institutional framework significantly shapes these disparities. The hukou system, a household registration mechanism distinguishing urban and rural residents, perpetuates unequal resource allocation by restricting rural access to quality education and social mobility opportunities (Luo and Wang 2022; Wu and Treiman 2004). Urban schools, particularly in first-tier cities such as Beijing and Shanghai, benefit from substantial government funding and tech-industry partnerships, enabling cutting-edge AI facilities and highly qualified staff. In contrast, rural schools face inadequate infrastructure and volunteer-dependent faculty (Chen, Wang, and Liao 2021). Intergenerational dynamics further entrench these inequalities: Children of educated parents gain early AI exposure through extracurricular activities and private tutoring, while marginalised students confront barriers such as limited familial support and economic constraints (Bourdieu 1986; Zou and Ma 2019). In rural China, parental scepticism about AI’s relevance to traditional academic success often reduces investment in technology-driven learning (Du 2018).

Standardised policies prioritising urban elite schools reinforce this hierarchical system, relegating rural institutions to symbolic compliance rather than meaningful AI curriculum integration (Tang 2016). Despite growing recognition of these challenges, few studies examine how macro-level AI policies interact with localised socio-economic contexts in China's stratified education system. This gap obscures the mechanisms through which AI education perpetuates inequality, hindering targeted interventions. By synthesising critiques of techno-solutionism with empirical evidence of regional and intergenerational disparities, this review underscores the need for a nuanced understanding of AI's educational role—one that prioritises equity over technological determinism.

International experiences offer valuable lessons. Legislative measures and private-school development have advanced educational equity in the United States (Galliano and Roux 2008), while South Africa's inclusive AI strategies emphasise localised solutions and ethical frameworks tailored to linguistic and cultural diversity (Opesemowo and Adekomaya 2024). These examples highlight the potential of context-sensitive policies and community-based initiatives to address educational inequalities.

Methodology

This study uses a qualitative comparative approach based on the constructivist grounded theory (CGT) framework (Charmaz 2006). Grounded theory is particularly suited for exploring complex social phenomena, as it emphasises inductive reasoning, iterative data analysis, and the generation of theory from empirical data. The constructivist variant of grounded theory further aligns with this study's focus on understanding how inequalities in AI education are perceived and experienced by different stakeholders within their specific socio-economic and cultural contexts.

To capture the multifaceted nature of AI education inequalities, the research design incorporates semi-structured interviews and observational data collected over six months (February to October 2024) from three primary schools in China: X1 (Shenzhen, a first-tier metropolis), X2 (Anqing, a suburban city in central China), and X3 (Shangluo, a rural area in western China). These schools were selected to represent a spectrum of regional development levels, resource availability, and socio-economic backgrounds, enabling a comparative analysis of how AI education policies are implemented and experienced across urban, suburban, and rural contexts.

Data collection involved 25 participants, including 15 students (fifth and sixth graders), five parents, and five teachers, randomly selected from the three schools with the permission of school administrators. Detailed information about the interviewees can be found in Table 1.

Table 1: Details of the interviewees

No.	Category	Gender	City	Grade Level	Family Background	Parental Education Level	Family Income (USD)
S01	Students	Female	Shangluo	Sixth Grade	Parents are rural farmers engaged in breeding	High school	25.5k–30k
S02		Female	Shenzhen	Fifth Grade	Parents are company employees	Master's degree	105k–120k
S03		Male	Shenzhen	Sixth Grade	Mother is a senior executive in a large corporation	Overseas master's degree	≧300k
S04		Male	Anqing	Fifth Grade	Parents are ordinary workers	Bachelor's degree	15k–18k
S05		Female	Anqing	Sixth Grade	Parents are unemployed, doing gig jobs	Primary school	9k–10.5k
S06		Female	Shangluo	Fifth Grade	Left-behind child	Junior high school	12k–13.5k
S07		Female	Shangluo	Sixth Grade	Left-behind child	High school	6k–7.5k
S08		Female	Anqing	Fifth Grade	Parents are chemical plant workers	High school	18k–19.5k
S09		Male	Shangluo	Fifth Grade	Father is a rural entrepreneur	Junior high school	≧60k
S10		Male	Shangluo	Sixth Grade	Father is a primary school teacher	Bachelor's degree	10.5k–12k
S11		Male	Shenzhen	Sixth Grade	Father is an entrepreneur	High school	≧750k
S12		Male	Shenzhen	Fifth Grade	Parents are civil servants	Bachelor's degree	75k–90k
S13		Male	Shenzhen	Sixth Grade	Father is the CEO of a small tech startup	Master's degree	525k
S14		Female	Anqing	Sixth Grade	Father is a taxi driver	Junior high school	≦26k
S15		Female	Anqing	Fifth Grade	Parents are high school teachers	Master's degree	21k–22.5k
T01	Teachers	Female	Shenzhen	-	-	-	-
T02		Male	Anqing	-	-	-	-

T03		Male	Shangluo	-	-	-	-
T04		Female	Shangluo	-	-	-	-
T05		Female	Anqing	-	-	-	-
P01	Parents	Male	Shangluo	-	Farmer	Primary school	7.5k–9k
P02		Male	Shangluo	-	Farmer	Junior high school	7.5k–9k
P03		Female	Anqing	-	University teacher	PhD	≦27k
P04		Male	Shenzhen	-	Foreign businessman	Master’s degree	≧570k
P05		Female	Anqing	-	Supermarket employee	Junior high school	10.5k–12k

Semi-structured interviews were conducted face to face in public spaces such as teacher offices, student activity rooms, and cafes, ensuring a comfortable environment for participants. Each interview lasted between 30 and 70 minutes (average duration: 48 minutes) and was audio-recorded with participants’ consent. The interview protocol featured open-ended questions exploring participants’ perceptions, experiences, and attitudes towards AI education, and their understanding of its challenges and opportunities. The specific interview protocol is provided in Table 2.

Table 2: Interview protocol

Students	Q1 Please describe your understanding of artificial intelligence (AI) and your experiential reflections when engaging with AI technologies.
	Q2 Through what channels (courses, equipment, activities) does your school provide AI learning opportunities? What specific skills have you acquired?
	Q3 What is the most significant difficulty you face in AI learning, and what support do you require to overcome it?
	Q4 How have AI education policies tangibly influenced your family's educational practices?
Parents	Q1 How do you perceive the importance of AI education for your child's future development?
	Q2 Please elaborate on the allocation of educational resources for AI (e.g., qualified instructors, equipment, laboratories) and identify existing gaps.
	Q3 How do you integrate AI applications into your child's academic support? What implementation barriers have you encountered?
	Q4 What measurable impacts have current AI education policies had on promoting educational equity?
Urban Innovative Teachers	Q1 How would you evaluate the current knowledge framework of the school's AI curriculum?
	Q2 What are the primary challenges encountered in AI instruction?
	Q3 What measurable impacts have current AI education policies had on promoting educational equity?
	Q4 How do you incorporate innovative AI tools and methods into your teaching to foster students' critical thinking and problem-solving skills?
Suburban Adaptive Teachers	Q1 How would you evaluate the current knowledge framework of the school's AI curriculum?
	Q2 What are the primary challenges encountered in AI instruction?
	Q3 How do you adapt AI resources and tools to fit the specific needs and context of your school?
	Q4 What measurable impacts have current AI education policies had on promoting educational equity?
Rural Conservative Teachers	Q1 How would you evaluate the current knowledge framework of the school's AI curriculum?
	Q2 What are the primary challenges encountered in AI instruction?
	Q3 What are your views on the basic AI literacy needed for students in rural areas?
	Q4 What barriers do you face in implementing AI education, and how can these be addressed to improve AI learning opportunities for your students?

To complement the interview data, observational notes were taken during school visits, focusing on the availability and use of AI-related infrastructure (e.g., computer labs, robotics kits) and the integration of AI concepts into classroom activities. These observations provided contextual insights into the disparities in resource allocation and pedagogical practices across the three schools. Data collection occurred in two phases:

1) Descriptive Sampling: Initial interviews focused on capturing a broad range of perspectives on AI education from students, parents, and teachers.

2) Theoretical Sampling: Subsequent interviews were guided by emerging themes from the initial data analysis, allowing for a deeper exploration of specific issues, such as the role of parental support and the impact of regional resource disparities.

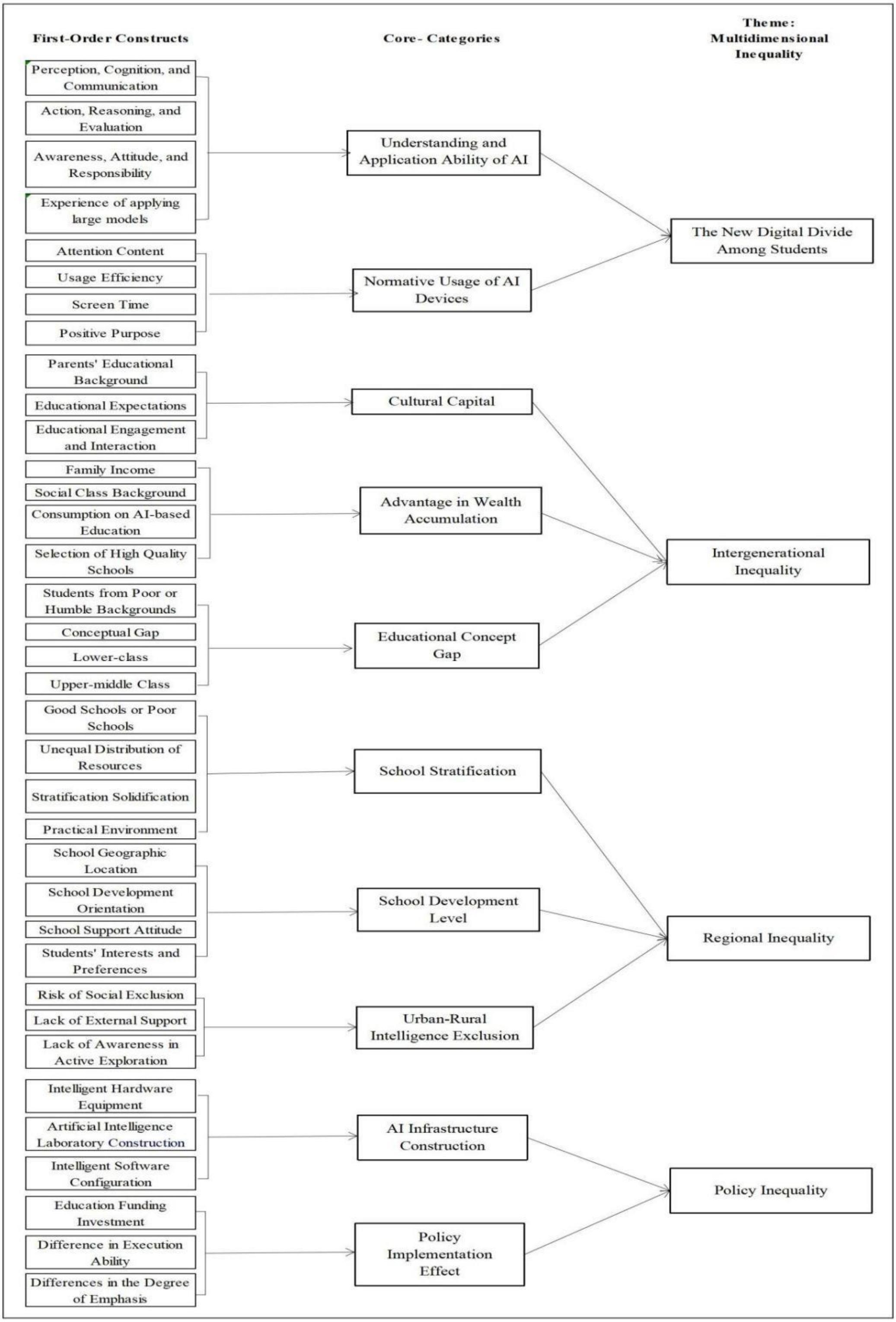

Figure 1: Coding of data

Data analysis followed an iterative process that combined inductive and deductive approaches. All interview transcripts and observational notes were transcribed verbatim and analysed using NVivo 12, a qualitative data analysis software. The analysis began with open coding, where researchers independently coded half the transcripts to create initial categories and themes. This process yielded over 100 codes, which were then compared and discussed to identify recurring patterns and relationships. The detailed coding of data is presented in Figure 1 above.

Next, axial coding was employed to organise the initial codes into higher-order categories, such as “policy implementation disparities”, “regional resource gaps”, and “intergenerational inequality”. These categories were further refined through selective coding, which focused on identifying the core themes that best explained the inequalities in AI education. The final thematic framework consisted of four nested layers of inequality: policy orientation, regional disparities, intergenerational transmission, and individual digital divides (see Figure 2).

To ensure the findings’ rigour and credibility, the researchers used member checking by sharing preliminary results with some participants for feedback. Additionally, intercoder reliability was assessed through regular discussions and consensus-building between the two researchers, minimising potential biases in the coding process. An illustration of the coding process is provided in Table 3.

Table 3: An illustration of the coding process

Transcripts example	**Open codes**	**Core categories**	**Theme**
Our school computers are better now, and I use them daily. Last weekend, I learned programming online, which was fun. But finding smart course resources is tough; I need my dad’s help. The chatbot knows a lot; asking it questions is fun!	Perception, cognition, and communication; Action, reasoning, and evaluation; Awareness, attitude, and responsibility; Experience of applying large models	Understanding and application ability of AI	The new digital divide among students
The child says they are using my phone to study, but in fact, they have been playing games the whole time. I can’t control it anymore, and whenever I criticise him, he throws a tantrum.	Attention content; Usage efficiency; Screen time; Positive purpose	Normative usage of AI devices	

My mother is a teacher, and she often tells me about the high-tech subjects she teaches at the university. I want to become a scientist when I grow up.	Parents' educational background; Educational concepts and habits; Educational engagement and interaction	Cultural capital	Intergenerational inequality
We don't have a computer at home. Dad says buying a computer is too expensive, so we should prioritise purchasing school supplies like backpacks, books, notebooks, and pens first.	Family income; Social class background; Consumption on AI-based education; Selection of high quality schools	Advantage in wealth accumulation	
Only by studying can one succeed and rise above others, so I am currently determined to study hard. I am not interested in artificial intelligence, and I won't need it.	Students from poor or humble backgrounds; Conceptual gap; Lower-class; Upper-middle class	Educational concept gap	
Our school is located in the city centre, where many technology companies come to give lectures, and I even have the opportunity to visit their research and development centres.	Good schools or poor schools; Unequal distribution of resources; Stratification solidification; Practical environment	School stratification	Regional inequality
We don't have a dedicated teacher for an artificial intelligence course; instead, our course is called Information Technology, and it's taught by our physical	School geographic location; School development orientation; School support attitude; Students' interests	School development level	

education teacher on a part-time basis. During the class, he tells us many stories about new technologies and shows us some pictures and videos. However, our classroom lacks computers and robots, and currently, I am not proficient in using a computer.	and preferences;		
Prior to attending university, concepts such as digitisation and programming were highly abstract for students in remote rural areas, who often had no access to computers until their university years. This resulted in a slower learning process for them and, at times, even ridicule from their peers.	Risk of social exclusion; Lack of external support; Lack of awareness in active exploration	Urban-rural artificial intelligence exclusion	
Primary schools in major cities receive substantial government support and spare no efforts in acquiring intelligent hardware equipment for teaching, including smart robots, sensor kits, and so on. In contrast, schools in remote areas struggle to even provide basic electronic devices, which severely limits the depth and breadth of our efforts in implementing artificial intelligence education.	Intelligent hardware equipment; Artificial intelligence laboratory construction; Intelligent software configuration	AI infrastructure construction	Policy inequality
Our science teacher is perfunctory in teaching. Sometimes, the physical education teacher takes the science class, and sometimes we are just asked to do some hands-on little games.	Education funding investment; Difference in execution ability; Differences in the degree of emphasis	Policy implementation effect	

Results

In this section, we employ the four-layered framework of inequality diversity depicted in Figure 1 to analyse the multilevel dimensions of inequality in artificial intelligence (AI) education for elementary school students in China. As noted by Dai (2023), AI education at the K-12 level operates within a complex and dynamic environment. Disparities between students and teachers, gaps in school and regional development, and parental economic backgrounds and attitudes collectively constrain the promotion of AI education in K-12 settings. Despite policy-driven curriculum reforms in many cities, any such reform must comprehensively consider three interdependent factors: individual factors, regional characteristics, and external macro policies. Therefore, organising data to illustrate the manifestations of inequality in AI education for elementary school students across different levels is critical.

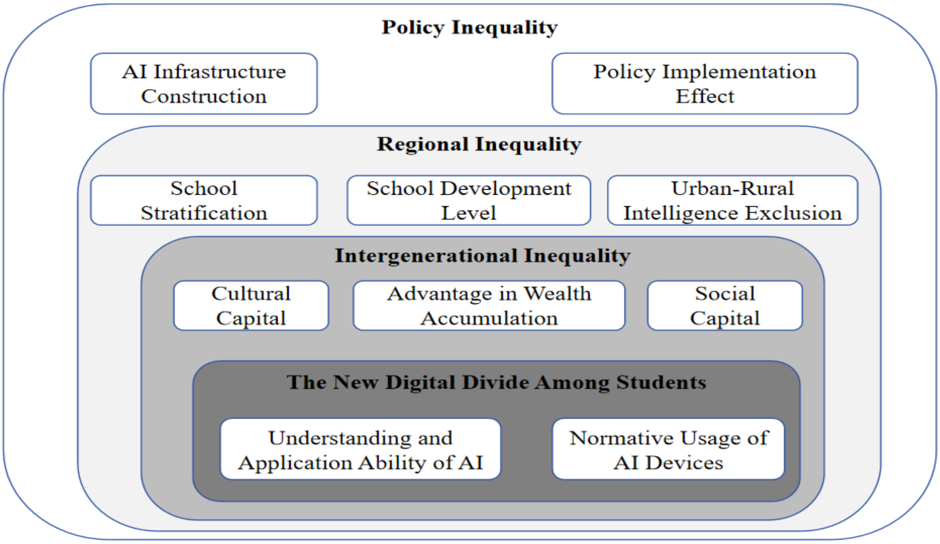

Figure 2: Multilevel inequality in AI education for elementary school students

Figure 2 illustrates four nested layers of inequality in AI education for elementary school students: policy orientation, regional disparities, intergenerational inequality, and emerging individual gaps. Policy orientation integrates AI education into national education policies, driving reforms in some schools while exacerbating uneven development. Regional disparities result in school stratification due to uneven economic development. Family background contributes to the intergenerational transmission of educational inequality. At the individual level, digital divides and disparities in digital capital accumulation begin to emerge.

Research findings indicate that as advocates of AI education policies, governments could leverage national resources to promote the construction of smart education infrastructure in some regions and schools, eliminating developmental barriers.

However, in practice, significant gaps and imbalances exist across regions and schools in the implementation of national policies. This is evident in interviews with teachers from Shenzhen and Shangluo:

> As a key city elementary school, our school has received more policy and financial support in AI education. We offer elective courses such as VEX robotics, programming, and drone operation, along with specialised mentors. (T01)

> In our rural elementary school, we don't even have a computer lab, let alone AI equipment. Students are completely unfamiliar with smart products and have no knowledge of programming. (T03)

These disparities do not stem from differences in the innate talents of children in these cities but rather from inconsistent government investments in AI education infrastructure. This results in key schools becoming increasingly wealthy and excelling in AI education, while underdeveloped regions and ordinary elementary schools fall further behind, widening the gap. As Ruha Benjamin (2019) warns, "The path to inequality is paved with technological solutions", as these solutions often mask, accelerate, or even deepen existing divides.

At the national level, the Chinese government has issued policies to strengthen the construction of educational informatisation and smart education scenarios. For example, the New Generation Artificial Intelligence Development Plan and the Education Informatisation 2.0 Action Plan aim to promote the application of AI in education systems. Overall, schools that receive priority support and substantial government funding have inherent advantages in responding to and implementing policy initiatives. Field investigations reveal that elementary schools in economically developed cities have explored mature models in constructing smart classrooms, developing AI curricula, introducing online educational resources, and organising students to participate in AI competitions. In contrast, rural elementary schools often engage in formalistic AI education. One rural parent stated:

> My child's school has a science class, but the teacher often doesn't know what to teach, occasionally sharing science stories. Worse still, the teacher sometimes assigns AI learning as homework, requiring children to study independently at home using smartphones. (P02)

We cannot attribute this formalism to teacher irresponsibility. The reason lies in the numerous difficulties faced by rural elementary schools in underdeveloped regions when implementing AI education policies. As the saying goes, "One cannot cook a meal without rice." The lack of infrastructure, funding, technical expertise, and insufficient school attention make it challenging for teachers to conduct meaningful AI education.

"Quality" and "equity" constitute the core goals of compulsory education development in China and frequently appear in contemporary educational policy documents. The absence of a connecting word between “quality” and “equity” underscores their equal importance. However, in local policy implementation, these two goals are often imbalanced. Spatially, educational inequality affects individuals, schools, and regions in various ways, particularly exacerbating the gap in high-quality educational resources between urban and rural areas (Duan et al. 2021). Within the same region, school reputation, as symbolic capital, is a key factor leading to differences in student enrolment, student quality, school development levels, and AI education investment. As one parent explained:

> Even within the same city, there are significant differences between schools. My child’s school has low status, poor development, limited funding, and a poor reputation. It focuses only on traditional textbook teaching, lacking programming, robotics, and other courses. Students are unfamiliar with AI and lack learning environments. (P05)

For parents, good schools provide children with more opportunities to access advanced AI education ecosystems. For example, media reports show that six Shanghai schools, chosen by the Chinese Ministry of Education (2024) as the first national AI education bases for primary and secondary schools, have set up robotics clubs, AI innovation labs, or AI observation stations. These schools create a learning environment where “everyone can learn, learn anywhere, and learn anytime” (Xu and Gong 2024). Thus, while AI education aims for equity, schools act as mechanisms that sort students, perpetuating inequality and sowing seeds of difference.

Policy-level school classification and selection exacerbate social stratification and institutional disparities. High-quality AI educational resources create differences from the outset of elementary school enrolment, altering students’ opportunities to access AI education environments. In this process, gaps accumulate as children grow older, leading to long-term inequality (DiPrete and Eirich 2006). Nationally, the stratified development of AI education in primary and secondary schools is very evident. A survey of AI education competitions in Chinese primary and secondary schools revealed three levels of development—rapid, moderate, and slow—across 31 provincial administrative regions (Gu, Li, and Li 2023).

In this stratum, primary and secondary schools in first-tier cities are actively promoting artificial intelligence curricula, leading educational trends. For example, schools in Shenzhen integrate AI education seamlessly into their courses, equipped with cutting-edge facilities and dedicated AI labs. Students have access to a variety of AI tools and resources, including robotics kits, programming platforms, virtual reality (VR) simulations, and hands-on learning experiences. This early exposure to cutting-edge AI technologies enables urban students to develop strong AI literacy and skills from a young age. As a student from School X1 in Shenzhen mentioned,

> We have a dedicated AI lab where we learn programming and robotics. Our teacher often takes us on field trips to tech companies, and we even participate in AI competitions. (S02)

In contrast, suburban primary and secondary schools are just beginning to implement AI education and face significant challenges. While they may have some basic computer facilities, the availability of advanced AI tools and resources is limited. Teachers often lack specialised AI training, leading to a superficial integration of AI concepts into the curriculum. A teacher from School X2 in Anqing noted,

> We have a computer lab, but it’s not equipped for AI education. We try to incorporate some AI basics into our IT [information technology] classes, but it’s not the same as having a dedicated AI curriculum. (T02)

The situation is even more dire in rural schools, such as those in Shangluo, where AI education is often non-existent or merely symbolic. These schools lack the necessary infrastructure, funding, and teacher training to implement meaningful AI curricula. Students have little to no exposure to AI technologies, and their understanding of AI is often limited to what they see in popular media. Two students from School X3 in Shangluo complained:

> Our school only has some old, faulty computers. In IT class, we crowd around one computer, making it difficult to click or view more content. Urban children enjoy spacious, well-equipped computer labs. Opportunities are far from equal. (S01)

> I feel that AI courses are as disconnected from my life as science classes. I know AI has great potential for future development, but currently, I cannot access AI courses or the latest knowledge. (S05)

The development of AI technology has raised expectations for its role in solving educational problems and improving academic performance, prompting a series of policies integrating AI into education. Educators, schools, and enterprises are increasingly promoting these initiatives. In China, the Ministry of Education has explicitly stated that AI education in primary and secondary schools should be basically universal by 2030. While this has narrowed the digital access gap in AI education, field investigations indicate that rural areas still lag behind urban areas in terms of artificial intelligence. Limited internet access, insufficient technical skills, and lower smart cognition prevent rural students from enjoying the “AI dividend” like their urban counterparts. Students from urban unemployed families, rural families, and left-behind children face greater risks of social exclusion.

Groups such as S01 and S05, excluded from smart technology, lack the knowledge and skills to effectively participate in AI education. These disadvantages stem from geographical concentration and multiple structural differences interacting with other factors. For marginalised groups in urban and rural areas, smart exclusion is not intentional but an unintended consequence of social processes or policy decisions. However, compared to urban elementary school students, this exclusion—whether intentional or unintentional—increases the risk of rural elementary school students “falling behind” and widens inequality gaps. Students excluded from AI education or unable to leverage AI lose increasing opportunities and resources in daily learning, further affecting their ability to benefit from or achieve success through AI. An IT teacher from Shenzhen's X1 school confirmed this, stating:

> AI education at X1 School has achieved remarkable results, with students mastering skills such as graphical programming, robot assembly, and AI game design. At the technology festival, students showcased self-developed smart waste-sorting assistants integrated with camera recognition and mechanical arm sorting, which ran successfully and attracted attention. After class, students visited Tencent and Huawei AI R&D centres and participated in competitions. (T04)

The impact of these regional disparities on students' AI literacy and skills is profound. Urban students, with their early exposure to AI technologies and resources, are better positioned to succeed in the digital age. They develop strong problem-solving abilities, critical thinking skills, and creativity, which are essential for future careers in AI and related fields. In contrast, rural students, who lack access to AI education, are at a significant disadvantage. They may struggle to keep up with their urban peers in terms of digital literacy and skills, limiting their future opportunities and potential.

Empirical evidence also shows that the level of AI education received by urban and rural elementary school students is significantly related to parents' occupations and educational levels. Children of parents with bachelor's degrees or higher, or those in executive or university professor roles, often receive earlier and more systematic AI education. Considering social class and status, parents' educational levels primarily manifest in their ability to directly promote their children's education, such as creating supportive family environments. A university professor in AI research (P03) mentioned in an interview that they not only frequently bring their child to the laboratory for observation and learning but also guide them in participating in multiple AI education competitions. This parent stated:

> Currently, school curricula focus mainly on fun, knowledge dissemination, and inspiration, aiming to outline the basic concepts of AI for children. If one hopes their child will stand out among peers, school learning alone is far from sufficient. This requires targeted extracurricular investments to gradually enhance the professionalism of learning. (P03)

These findings align with research by Zou and Ma (2019), confirming that family background (e.g., parents' educational levels and political status) is closely related to educational inequality. Family background indicators are key variables influencing children's educational inequality. In families with high cultural capital, parents can provide better guidance and more educational resources for their children. Thus, parents' cultural capital is inherited and sustained within the family, completing the process of cultural reproduction.

Field investigations reveal two mechanisms of intergenerational reproduction of cultural capital. First, the desire for "children to succeed" leads families with high cultural capital to have high educational expectations for their children and to invest heavily from an early age. For example, wealthy rural families send their children to county schools, while wealthy urban families purchase school district housing. Parental encouragement and investment sustain children's learning enthusiasm and academic performance. Second, the transformation of institutionalised cultural capital gives children from families with highly educated parents a natural advantage in AI education. Influenced by family culture and with parental resource support, these children can engage in deeper learning at an earlier age. Highly educated parents can also provide tutoring to help their children build learning advantages. These two mechanisms lead to intergenerational inequality in AI education, widening the gap in access to high-quality AI educational resources among children from different backgrounds.

Parents' economic resources have a greater impact on AI education inequality than educational levels. Specific parental resources most related to children's resources constitute the contemporary transmission of resources (Hällsten and Thaning 2018; Mastekaasa and Birkelund 2022). Wealth creates multi-generational advantages, such as purchasing AI courses, tools, and private tutors to support academic success. Families with accumulated wealth convert these advantages into opportunities for their children to access high-quality educational resources, achieving intergenerational transmission of inequality.

The family of S13 is a typical example. They migrated from rural areas to cities during China's reform and opening-up period. After two generations of effort, they benefited from the dividends of economic special zone development and became part of Shenzhen's middle class. S13's father used family wealth and resources to establish a technology company. Under his father's vision, S13 began AI education from the first day of enrolment, learning Python and robot design. To enhance his abilities, his father set up a "smart robotics laboratory" at home. This case illustrates that family income and wealth are prerequisites for educational investment. Higher per capita income enhances parents' ability to invest in their children's AI education, fostering interests, hobbies, and talents from an early age, reflecting China's "family background competition".

A study analysing seven years of admissions data from seven key Chinese universities found that attaining academic excellence is difficult for children from disadvantaged backgrounds, and educational inequality is expanding (Du 2018). These differences stem from unequal educational resources between urban and rural areas, disparities in socio-economic status, and differing educational perceptions among disadvantaged families. Urban and rural China exhibit significant cultural and value differences that influence attitudes towards education. Urban residents recognise the impact of education on careers and life, have high educational expectations, and invest substantial resources in their children's education. In contrast, rural residents, affected by fierce labour market competition, devaluation of educational credentials, and underdeveloped rural education, increasingly dismiss the value of schooling, leading to reduced educational expectations and investments.

Thus, the penetration of AI education in rural areas faces significant challenges. Rural parents, constrained by economic conditions and educational perceptions, pay insufficient attention to and invest less in AI education, failing to recognise its relevance to their children's future growth.

Vulnerable families exhibit "indifference" and "lack of attention" towards AI education. Affected by this, elementary school students from these families have lower self-expectations for AI education. They are exposed to AI later, feel unfamiliar and insecure, and lose interest in exploring it due to the lack of parental support, resources, and tools. In contrast, upper-middle-class families are more resolute in the academic progress of AI education. Some parents choose good elementary schools and invest more in their children's AI "shadow education" for systematic learning.

Our research shows that with the popularisation of the internet, the "access gap" between children in different regions is narrowing. However, a new "digital divide" is emerging due to differences in children's literacy, methods, and abilities in using information technology. This divide is not just about operational skills in smart technology but also about usage gaps, such as differences in usage time, frequency, and whether technology is used actively or creatively. Students revealed the following:

> To me, AI technology is like a superhero at home, capable of doing anything. It is like a talking magic box that satisfies my needs by presenting stories, songs, or answers. Every time I see a robot act on my commands, I feel like I also have superpowers; it's so cool! (S03)

> In my view, AI technology is like a mysterious planet in a distant galaxy. Whenever I hear urban friends talk about how they use smart learning devices and robots, I am especially envious. I look forward to the day when I can have the key to this mysterious planet and experience its charm. (S14)

The metaphors of "superhero" and "mysterious planet" vividly express different perspectives on AI technology among elementary school students in different regions. In cities such as Shenzhen, students such as S03 and their peers have integrated AI into daily life, viewing it as an accessible and enjoyable tool. The "superhero" metaphor reflects their sense of control over AI, as they learn programming and command inputs to guide robots or smart devices. This mastery fosters confidence and pride, stimulating innovative thinking and problem-solving abilities. In contrast, students from less developed regions such as S14 from a fourth-tier city view AI as a distant "mysterious planet", symbolising curiosity and longing. For S14, AI remains an unexplored world, highlighting differences in familiarity and accessibility.

Analysing these metaphors reveals significant differences in perceptions of AI technology and its applications. Students from first-tier cities, supported by family backgrounds, parental resources, and advanced curricula, typically possess higher AI skills and engage in complex projects and innovations. In contrast, students from less developed regions lag behind, focusing more on traditional academic and examination skills while often neglecting the future importance of AI. This gap underscores the necessity of equitable access to AI education to cultivate innovation and problem-solving abilities in all regions.

Second, there are differences in “screen freedom” among elementary school students. Field observations show variations in daily smartphone usage time. According to guidelines from the World Health Organization and China, children should not use electronic devices for more than 15 minutes at a time or more than one hour per day. However, some elementary school students, particularly left-behind children, exceed these limits. As S06’s grandfather stated:

> The child wants to play on the phone as soon as he gets home. He uses it to find answers, quickly finish homework, and then continues gaming and watching videos for over three hours. We can’t do anything. As long as he completes his homework and doesn’t cause trouble, we let him do as he pleases. (S06)

This excessive “screen freedom” exacerbates the new digital divide in AI education among elementary school students. Children under parental control use smartphones with scientific time management, protecting their vision and effectively using AI applications for learning. In contrast, left-behind children, lacking supervision, often indulge in smartphone entertainment, neglecting learning and missing opportunities for AI education. This puts them at a disadvantage in adapting to the digital society and AI-related fields of the future, further widening the gap with their peers.

Discussion

This study critically reflects on the techno-optimistic narrative that AI naturally promotes educational democratisation, uncovering deep structural contradictions in the allocation of artificial intelligence education resources within China’s basic education sector. The findings indicate that the process of embedding AI technology into the education system is not a neutral technological diffusion but rather forms a multidimensional educational stratification system through three logics: policy resource allocation, cultural capital reproduction, and digital capital accumulation. This ultimately leads to a Matthew Effect in the social distribution of technological dividends.

National AI education policies exhibit significant spatial heterogeneity in implementation, creating a core-periphery resource allocation pattern. Key urban schools obtain excessive resource injection through policy labels such as demonstration schools or base schools, constructing a complete ecosystem comprising AI laboratories, professional teaching staff, and competition systems. In contrast, rural schools remain trapped in a vicious cycle of no computer labs, no AI equipment, and no programming courses. This resource allocation model validates the core mechanism of the theory of maximally maintained inequality: Although educational technologisation reforms have increased rural students' access opportunities in absolute terms, they have failed to change the relative proportion of resource distribution and instead widened the capability gap between urban and rural students through the establishment of technological thresholds. The demonstration effect in policy implementation further reinforces this stratification, causing high-quality resources to agglomerate in advantaged schools and forming a self-fulfilling prophecy cycle.

Family cultural capital achieves technological transformation through three dimensions: parents with higher educational backgrounds complete early socialisation of AI concepts through daily conversations; middle-class families convert economic capital into high-quality educational services such as private programming tutors; and professional families provide their children with privileged experiences such as AI enterprise visits through industry resources. The intergenerational transmission of cultural capital in the field of AI education is characterised by early technological enlightenment, channelised resource acquisition, and elitist capability development. Rural families, however, are constrained by technological cognition deficits, economic conversion bottlenecks, and social capital scarcity, leading their children to face dilemmas of lagging accumulation, fragmented learning, and functional disconnection in AI literacy development. This fully demonstrates the intergenerational transmissibility of cultural capital and its shaping role in educational opportunities.

The current education informatisation process has evolved into a cognitive competition centred on digital capital, comprising three progressive layers: operational level (hardware usage proficiency), application level (educational transformation capability of AI tools), and innovative level (technological critical thinking and ethical awareness). Urban students, guided by parents, form an advanced pathway of exploratory learning, project-based practice, and innovation output, while rural students mostly remain at the shallow contact stage of recreational use, passive acceptance, and functional cognition. This difference holds special significance in the AI era, as digital capital has become a key literacy influencing future social mobility. While rural students are still adapting to basic operations, urban students have established technological identity through AI competitions and open-source projects. This cognitive time lag will translate into lasting capability gaps.

Existing AI education policies face deep contradictions between central policy uniformity and local implementation heterogeneity. National planning documents emphasise goals of universalisation and equalisation, but local education departments follow a tournament logic in resource allocation, favouring demonstration schools with limited resources. This policy distortion manifests as symbolic compliance in rural areas: Schools obtain financial allocations by being designated as AI education pilot sites but actually store equipment unused, merely coping with inspections through activities such as watching AI documentaries or completing online questionnaires. More alarmingly, left-behind children, lacking family supervision, fall into the electronic pacifier dilemma: Although they spend long hours on screens, their effective learning input is insufficient, creating a dual predicament of digital addiction and technological disconnection.

Conclusion

This study reveals that achieving equity in AI education cannot stop at technical access but requires constructing a systematic solution integrating policy reorientation, teacher training, curriculum innovation, and family support. Future policy design should break through the "one-size-fits-all" technocratic mindset and establish differentiated implementation pathways based on local economic levels, cultural characteristics, and resource endowments. Meanwhile, integrating AI literacy into the teacher professional development system and dismantling the "urban-centrism" in knowledge production are essential to fulfil the original aspiration of technology-empowered education. The findings underscore the urgent need to move beyond simplistic techno-optimism and adopt equity-centred reforms in AI education policy and practice. Specifically, we advocate for the following actionable policy recommendations:

1. Funding Allocation and Resource Distribution: Establish a dedicated central grant programme for AI education infrastructure in rural and under-resourced schools, with a minimum of 60% of funds specifically allocated to rural education departments to ensure they receive adequate financial support for AI curriculum implementation. An oversight committee comprising representatives from the Ministry of Education, local education bureaus, and independent educational experts should be set up to monitor fund usage and ensure transparency through quarterly financial disclosures and project progress reports.

2. Teacher Training and Support: Design a standardised 40-hour AI teacher-training programme tailored to primary school educators, covering fundamental AI concepts, basic programming skills, and practical teaching methods. This programme should be delivered through a combination of online courses and in-person workshops, with the online platform providing continuous access to teaching resources and a community for educators to share experiences and best practices. A certification system should be established, offering incentives such as salary increments or career advancement opportunities for teachers who complete the training and demonstrate proficiency in AI education, with annual assessments to evaluate teachers' AI teaching competence and the learning outcomes of their students.

3. Family and Community Engagement: Develop community AI learning centres, particularly in rural and suburban areas, where parents and students can access AI resources and receive guidance. These centres can offer weekend and holiday workshops, providing parents with the knowledge and tools to support their children's

AI learning at home. Schools should also be encouraged to organise regular AI parent-teacher association meetings to strengthen home-school partnerships and provide parents with updates on AI education initiatives and their child's progress in this field.

4. Policy Reorientation: Policies should be designed that prioritise equity over efficiency, with mechanisms to monitor and address disparities in AI education implementation. This includes creating incentives for schools to collaborate and share resources, as well as establishing accountability frameworks to ensure equitable access to AI education.

As AI continues to reshape the future of education, it is imperative to ensure that its benefits are shared equitably across all regions and socio-economic backgrounds. This requires shifting from seeing AI as a fix-all solution for educational challenges to acknowledging it as a tool that must be carefully used within a broader social justice and equity framework. By tackling the structural barriers found in this study, policymakers and educators can move towards creating a more inclusive and equitable AI education ecosystem.

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References

Benjamin, R. 2019. *Race after Technology. Abolitionist Tools for the New Jim Code*. Medford: Polity Press.

Bourdieu, P. 1986. "The Forms of Capital". In *Handbook of Theory and Research for the Sociology of Education*, edited by J. G. Richardson, 241–258. New York: Greenwood Press.

Charmaz, K. C. 2006. *Constructing Grounded Theory: A Practical Guide through Qualitative Analysis*. London: Sage Publications. https://doi.org/10.3402/qhw.v1i3.4932.

Chen, L., L. Wang, and L. Liao. 2021. "Research on the Resource Allocation of Compulsory Education from the Perspective of Efficiency Evaluation: Taking Three Province-Governed Counties in Jiangsu Province as Examples". [In Chinese.] *Journal of University of Electronic Science and Technology of China* 23 (2): 86–98.

Dai, Y. 2023. "Negotiation of Epistemological Understandings and Teaching Practices between Primary Teachers and Scientists about Artificial Intelligence in Professional Development". *Research in Science Education* 53: 577–591. https://doi.org/10.1007/s11165-022-10072-8.

Du, Q. 2018. "Whose Children Are More Likely to Enter '985 Project' Universities? A Longitudinal Research on the Distribution of High Quality Education Opportunity". [In Chinese.] *Review of Higher Education* 6 (5): 54–65.

Duan, H., H. Yan, Y. He, and X. Li. 2021. "Spatiotemporal Analysis of the Achievement of Equitable Quality Basic Education in Gansu Province, Northwest China". *Sustainability,* 13 (11): 5862. https://doi.org/10.3390/su13115862.

DiPrete, T. A., and G. M. Eirich. 2006. "Cumulative Advantage as a Mechanism for Inequality: A Review of Theoretical and Empirical Developments". *Annual Review of Sociology* 32: 271–297. https://doi.org/10.1146/annurev.soc.32.061604.123127.

Galliano, D., and P. Roux. 2008. "Organisational Motives and Spatial Effects in Internet Adoption and Intensity of Use: Evidence from French Industrial Firms". *The Annals of Regional Science* 42: 425–448. https://doi.org/10.1007/s00168-007-0157-z.

Gu, X., R. Li, and S. Li. 2023. "What Is the State of Artificial Intelligence Education? Evidence Response to the Results of AI Education Competition for Primary and Secondary Schools". [In Chinese.] *Open Education Research* 29 (6): 82–91. https://doi.org/10.13966/j.cnki.kfjyyj.2023.06.009.

Hällsten, M., and M. Thaning. 2018. "Multiple Dimensions of Social Background and Horizontal Educational Attainment in Sweden". *Research in Social Stratification and Mobility* 56: 40–52. https://doi.org/10.1016/j.rssm.2018.06.005.

Holstein, K., and S. Doroudi. 2021. "Equity and Artificial Intelligence in Education: Will 'AIEd' Amplify or Alleviate Inequities in Education?" Preprint, *ArXiv*, April 27. https://doi.org/10.48550/arXiv.2104.12920.

Luo, J., and X. Wang. 2022. "Household Registration Status, Social Integration, and Equitable Distribution: Evidence from Field Experiments with Primary School Students". [In Chinese.] *World Economic Papers* 8 (4): 39–56.

Mastekaasa, A., and G. E. Birkelund. 2023. "The Intergenerational Transmission of Social Advantage and Disadvantage: Comprehensive Evidence on the Association of Parents' and Children's Educational Attainments, Class, Earnings, and Status". *European Societies* 25 (1): 1–21. https://doi.org/10.1080/14616696.2022.2059542.

Ministry of Education of the People's Republic of China. 2018. "Education Informatization 2.0 Action Plan". [In Chinese.] Official Website of the Ministry of Education of the People's Republic of China, April 18. http://www.moe.gov.cn/srcsite/A16/s3342/201804/t20180425_334188.html.

Ministry of Education of the People's Republic of China. 2024. "List of Artificial Intelligence Education Bases for Primary and Secondary Schools". [In Chinese.] Official Website of the Ministry of Education of the People's Republic of China, February 20. http://www.moe.gov.cn/srcsite/A06/s3321/202402/t20240223_1116386.html.

Nemorin, S., A. Vlachidis, H. M. Ayerakwa., and P. Andriotis. 2023. “AI Hyped? A Horizon Scan of Discourse on Artificial Intelligence in Education (AIED) and Development”. *Learning, Media and Technology* 48 (1): 38–51. https://doi.org/10.1080/17439884.2022.2095568.

OECD.AI. 2022. “The OECD Artificial Intelligence Policy Observatory”. Accessed October 13, 2024. https://oecd.ai/en/countries-and-initiatives.

Opesemowo, O. A., and V. Adekomaya. 2024. “Harnessing Artificial Intelligence for Advancing Sustainable Development Goals in South Africa’s Higher Education System: A Qualitative Study”. *International Journal of Learning, Teaching and Educational Research* 23 (4): 67–86. https://doi.org/10.26803/ijlter.23.3.4.

Schiff, D. 2022. “Education for AI, *Not* AI for Education: The Role of Education and Ethics in National AI Policy Strategies”. *International Journal of Artificial Intelligence in Education* 32 (3): 527–563. https://doi.org/10.1007/s40593-021-00270-2.

State Council of China. 2017. “Development Plan for New-Generation Artificial Intelligence”. Official Website of the Central Government of the People’s Republic of China, July 8. https://www.gov.cn/zhengce/zhengceku/2017-07/20/content_5211996.htm.

Tang, J. 2016. “Lost at the Starting Line: A Reconsideration of Educational Inequality in China (1978–2008)”. *The Journal of Chinese Sociology* 3: 1–18. https://doi.org/10.1186/s40711-016-0028-z.

Van Deursen, A. J. A. M., and E. J. Helsper. 2015. “The Third-Level Digital Divide: Who Benefits Most from Being Online?” In *Communication and Information Technologies Annual*, Studies in Media and Communications, Vol. 10, edited by L. Robinson., S. R. Cotten., J. Schulz., T. M. Hale, and A. Williams, 29–52. Leeds: Emerald Group Publishing. https://doi.org/10.1108/S2050-206020150000010002.

Wang, C., S. C. Boerman, A. C. Kroon, J. Möller, and C. de Vreese. 2024. “The Artificial Intelligence Divide: Who Is the Most Vulnerable?” *New Media and Society* 27 (7): 3867–3889. https://journals.sagepub.com/doi/10.1177/14614448241232345.

Wu, X., and D. J. Treiman. 2004. “The Household Registration System and Social Stratification in China: 1955–1996”. *Demography* 41 (2): 363–384. https://doi.org/10.1353/dem.2004.0010.

Xu, Q., and J. Gong. 2024. “AI Courses Integrated into Schedules, Campuses Create Intelligent Learning Spaces: These Schools Empower Student Growth with Comprehensive AI Capabilities”. [In Chinese.] *Shanghai Observer*, September 22. https://web.shobserver.com/wx/detail.do?id=799177.

Zou, W., and Z. H. Ma. 2019. “Family Background, Intergenerational Transmission and Educational Inequality”. [In Chinese.] *China Industrial Economics* 2: 80–89. https://doi.org/10.19581/j.cnki.ciejournal.2019.02.012.