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Pathways and Strategies for Digital Technology to Empower High-Quality Development of County-Level Regular High Schools

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Abstract: Against the backdrop of China's ongoing county high school revitalization drive, digital upgrading is no longer a secondary technical task—it has become a core tool for narrowing the persistent urban-rural education gaps that have accumulated through decades of education system reform. This analysis draws on 12 months of on-the-ground fieldwork conducted between March 2024 and March 2025 across 16 county regular high schools spanning 8 prefecture-level cities in Shaanxi Province. Sites were selected to cover both the economically developed Guanzhong Plain and the lower-resource Qinba Mountain and Loess Plateau regions, to capture how implementation varies across different local economic and geographic contexts. Data collection included 42 semi-structured interviews with school principals, frontline teachers across nine core subjects, and county education bureau staff responsible for digital education rollout, alongside six student focus groups with 120 11th- and 12th-grade students. This interview data is paired with structured observation notes from 78 in-person class visits across 12 subjects, covering both college entrance exam review sessions and regular new content lessons. The paper explores how digital tools support quality improvement in under-resourced rural campuses, identifies persistent structural frictions that limit program impact even after billions in national infrastructure investment, and proposes context-specific implementation approaches tailored to the unique constraints of county high school settings. Field data show that while basic infrastructure access has reached near-universal levels following national investment campaigns, gaps in teachers' ability to apply tools in class, locally adapted learning content, and long-term operational support prevent technology from delivering expected benefits. Notably, 75% of sampled schools reported that smart classroom equipment was used in less than 20% of regular, non-inspection class periods. The study finds that meaningful digital support for county high schools requires moving beyond one-time equipment purchases to build integrated, locally rooted systems that prioritize teacher and student needs, rather than forcing schools to adopt uniform models designed for urban key school contexts. These findings carry practical implications for national and provincial education authorities designing digital education policy for rural areas, as well as for school leaders rolling out digital tools on their campuses.

Keywords: County high school; Digital technology; High-quality education development; Rural education revitalization; Educational equity; Digital transformation in secondary education

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1. Introduction

China's 2023 *Action Plan for County High School Quality Improvement* set binding, measurable targets for narrowing quality gaps between urban and rural secondary education by 2027, listing digital transformation as one of eight core implementation priorities alongside teacher recruitment, curriculum reform, student mental health support, and school management improvement [1]. The plan built on 10 years of sustained national investment in rural education infrastructure: official statistics confirm that as of 2025, high-speed fiber internet reaches 100% of primary and secondary schools nationwide, including campuses in the most remote mountainous regions of western China, with 98.3% of rural classrooms equipped with smart whiteboards or high-definition projection equipment, marking the formal completion of the first phase of national digital education infrastructure construction. But as our field research makes clear, hardware access alone does not translate to improved learning outcomes, and the gap between policy goals and on-the-ground implementation remains far larger than official reports often suggest. Across more than half the schools we visited, expensive smart classroom equipment sat locked in storage closets for most of the school year, or was powered on only during official inspection visits, while teachers continued to rely on the same lecture-based instruction methods they used 20 years prior, with almost no meaningful integration of digital tools into daily teaching practice.

This gap between infrastructure investment and actual effect is not unique to China: global research on educational technology in low-resource contexts has consistently found that hardware access alone rarely improves learning outcomes, without parallel investment in teacher training, content adaptation, and ongoing operational support [2]. But existing research on rural digital education in China tends to split into two opposing camps that fail to capture the specific realities of county high schools, leaving an important research gap. One body of work, often produced by edtech companies or policy advocacy groups, frames technology as a near-universal solution capable of instantly resolving decades of resource gaps, arguing that simply installing smart equipment will automatically close urban-rural score gaps without any additional investment or structural change. The other camp, largely consisting of critical education scholars, highlights deep structural obstacles that render most digital interventions ineffective in low-resource settings, pointing to issues like teacher resistance, mismatched content, and lack of maintenance as nearly insurmountable barriers, and often arguing that digital investment in rural schools wastes public funds. Neither perspective fully captures the messy, on-the-ground realities of implementation in county high schools, where understaffed departments, tight college entrance examination schedules that leave almost no time for pedagogical experimentation, and uneven teacher skill levels create unique constraints that differ sharply from both urban key schools and small rural primary schools.

County high schools occupy a uniquely important and understudied space in China's education system: they serve more than 60% of rural students who go on to take the national college entrance exam, face enormous pressure to improve exam scores to help students access higher education, and have more financial and human resources than small rural primary schools but far less institutional capacity than urban key schools [3]. Yet most existing digital education research in China focuses either on urban schools or on rural primary education, leaving county high schools largely overlooked, despite their central role in rural social mobility. This study seeks to fill that gap by grounding analysis in direct, long-term observation of 16 schools across different economic contexts, rather than abstract theoretical models of technology adoption or one-off, large-scale survey data that cannot capture the nuances of daily implementation.

The research was guided by three core questions from the outset: first, through what specific, observable channels can digital tools support quality improvement in county high schools, when deployed appropriately to address local needs? Second, what are the most persistent, cross-cutting obstacles preventing meaningful integration of digital tools into daily teaching in these contexts, and how do these obstacles reinforce each other? Third, what context-appropriate policy and practice approaches can address these obstacles, without forcing schools to adopt models designed for very different urban school contexts? Unlike most existing studies, which rely on one-off visits to schools, the findings presented here are based on repeated visits to each school over the 12-month research period, allowing us to observe actual technology use in regular, unobserved classes rather than only performative use during official visits or researcher observations.

The paper proceeds as follows. Section 2 outlines the core value and operational mechanisms of digital technology for county high school quality improvement, drawing on observed successful cases from the four high-performing schools in the sample that achieved meaningful, sustained integration of digital tools into daily teaching. Section 3 analyzes key implementation obstacles, drawing on interview and observation data across all 16 schools, and presents comparative data on digital development gaps between urban and rural schools. Section 4 puts forward practical implementation approaches, grounded in successful practices observed in high-performing schools in the sample, rather than abstract theoretical recommendations. Section 5 concludes with specific policy implications, study limitations, and directions for future research.

2. Value implications and operational mechanisms of digital technology empowering high-quality development of county high schools

Digital tools do not automatically improve education quality, and we observed many cases where millions of yuan in equipment investment had no measurable impact at all on student outcomes or teacher practice. But when deployed thoughtfully to address specific, documented local pain points, we found that technology targets four core structural weaknesses that have held back county high school performance for decades, creating measurable improvements in both teaching quality and student outcomes over time [4,5]. These mechanisms are not theoretical; they were observed in practice in the four high-performing schools in our sample that had achieved meaningful, sustained integration of digital tools into daily teaching, with equipment use rates above 60% in regular classes. See **Figure 1**.

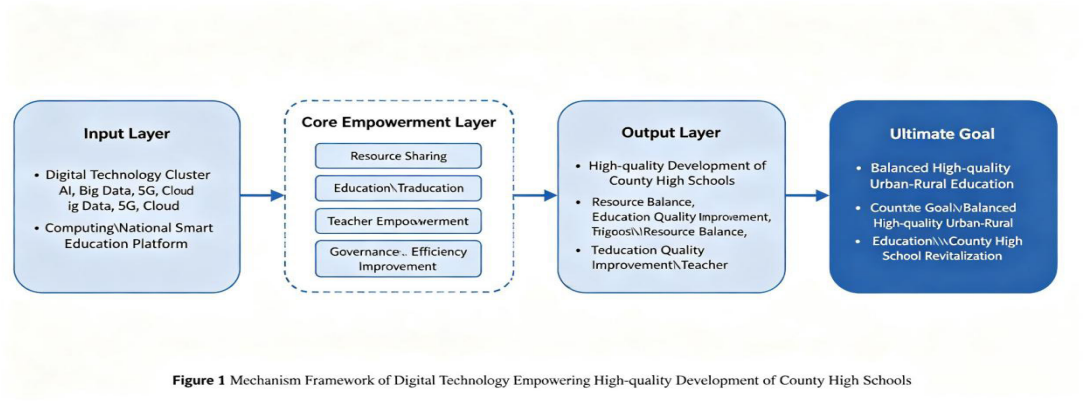

Figure 1 Mechanism Framework of Digital Technology Empowering High-quality Development of County High Schools

Figure 1. Framework of the mechanism through which digital technology empowers high-quality development of county-level regular high schools

2.1. Breaking temporal and spatial barriers: Restructuring high-quality educational resource supply

The most immediately visible effect of digital technology in the schools we visited was its ability to break down geographic barriers that have historically concentrated almost all high-quality teaching resources in large urban centers [6]. For decades, high-poverty rural counties have faced persistent "brain drain" of experienced teachers, who are recruited away to urban schools for higher salaries, better working conditions, and more professional development opportunities, leaving county high schools staffed largely by young, early-career teachers with little experience teaching college entrance exam content. During visits to schools in the Qinba mountain counties of southern Shaanxi, which sit 3–4 hours by car from the nearest prefecture-level city, we observed that live dual-teacher broadcasts let students in these remote locations access the same college entrance exam review sessions delivered by senior teachers with 20+ years of experience at provincial key high schools in Xi'an [7].

In one 12th grade physics review class we observed at Hanbin High School, a senior teacher in Xi'an delivered a live lesson on difficult electromagnetism problems that consistently cause major point loss for rural students on the national exam, while the in-class teacher at Hanbin walked around the room helping students with individual questions and pausing the broadcast to re-explain concepts students found confusing, drawing on examples from local hydropower stations that students were familiar with. After class, a group of 12th grade students told us that before the dual-teacher system was introduced in 2022, they had never taken lessons from a teacher with experience grading national exam papers, and that the review sessions had helped them understand problem types they had previously been unable to solve even after repeated self-study. Unlike earlier resource-sharing models that relied on pre-recorded lectures teachers rarely used because they could not be adjusted to class pace, modern real-time interactive systems let rural students ask questions and receive live feedback during class, creating a learning experience far closer to in-person instruction than previous generations of edtech allowed.

It is important to note that this resource sharing does not replace local teachers; instead, it augments their capacity, giving them access to high-quality content they could not produce on their own, while allowing them to focus on in-class student support that external teachers cannot provide. In schools that used dual-teacher systems effectively, local teachers did not simply press play and sit at the back of class; they actively engaged with content, paused to explain difficult points, followed up with students after the lesson, and adapted content to local student levels, which was critical to the model's success. In contrast, schools that used dual-teacher broadcasts without active local teacher facilitation saw almost no improvement in student scores, as students could not keep up with the pace of urban lessons without in-class support.

2.2. Data-driven instruction: Shifting toward personalized student support

The second core mechanism is the ability of digital tools to support data-driven, personalized instruction, which is nearly impossible to implement manually in large county high school classes. Traditional county high school teaching relies on uniform whole-class instruction, with teachers delivering the same lesson to all students at the same pace, making it effectively impossible for teachers to identify individual knowledge gaps in classes of 50+ students, especially when most teachers teach 2–3 classes with a total of over 150 students, leaving almost no time for individual student tracking. At Zhashui High School, a mountain county school that adopted a smart homework grading system in 2024, teachers now receive automatic, granular analysis of student performance on every assignment: which questions were answered incorrectly by which students,

which knowledge points the whole class failed to master, and which students need targeted extra support before they fall behind.

We spoke to a 34-year-old math teacher at Zhashui who told us the system cut his weekly grading time by roughly 40%, from 15 hours per week to 9 hours, freeing him up to spend more time working directly with struggling students instead of spending weekends marking papers by hand. “Before, I would spend all Sunday grading 150 papers, and by the time I handed them back on Monday, students had already moved on to new content, so there was no time to re-teach what they missed,” he explained. “Now, I get the full performance analysis the second students submit their homework online, so I can spend 10 minutes at the start of the next class re-explaining the knowledge points that 70% of the class got wrong, and pull aside the 5–6 students who are really struggling for extra help during evening self-study time.” Early internal data from the school shows average math scores for 11th grade students rose 11 points in the first year of implementation, with the largest gains concentrated among the lowest-performing third of students, who had previously been left behind by the uniform pace of whole-class instruction.

This model is particularly impactful in county high schools, where teachers have extremely high teaching loads and almost no time to manually track individual student progress across hundreds of assignments. Digital systems do not replace teacher judgment, but they automate the time-consuming, repetitive work of grading and basic performance analysis, giving teachers more time to do the work that actually improves student outcomes: interacting directly with students and providing targeted, individual support.

2.3. Cross-regional teaching research collaboration: Closing county teacher professional development gaps

The third mechanism, which we found had the largest long-term impact on overall school quality, is the ability of digital systems to support ongoing cross-regional teaching research collaboration, addressing the single largest constraint on county high school quality: the near-total lack of structured, ongoing professional development for teachers. Most county schools have tiny subject departments, with only 2–3 teachers per grade level, meaning there are no senior colleagues on hand to observe lessons, give constructive feedback, or provide mentorship for early-career teachers who make up more than half the teaching staff in many rural schools. Before digital systems, teachers in these schools might have the opportunity to attend one 2–3-day training in the prefecture-level city per year, which was rarely enough to meaningfully improve their teaching, and they almost never had the chance to observe lessons taught by expert senior teachers on a regular basis.

Cloud-based teaching research networks, like the system in use at Suide High School on the Loess Plateau, connect county school teachers directly with their peers in urban key schools for joint lesson planning, public lesson observation, and regular professional development workshops every week. One 31-year-old politics teacher at Suide, who had been teaching for 8 years after graduating from a local normal university, noted in an interview that before joining the cloud network in 2023, she had never observed a single lesson taught by a provincial-level senior teacher in her entire career; now she joins two joint lesson planning sessions every week with teachers from top Xi’an high schools, and observes 2–3 public lessons taught by expert teachers every month. “When I first started teaching, I had to figure everything out on my own, because there was no one else in the politics department who had more experience than me,” she

said. “I would design lessons based on what I remembered from my own high school classes, and I had no idea if I was teaching content the right way for the exam. Now, I can ask other teachers for advice when I’m struggling with a lesson, and I can see how expert teachers structure their classes and explain difficult concepts, which has completely changed how I teach.” Student evaluations of her classes improved 28% in the first year after joining the network, and her students’ average politics scores rose 8 points on the 2024 final exam.

This ongoing, embedded, collaborative professional development is far more effective than one-off training sessions because it is integrated into teachers’ daily work and allows them to build long-term professional relationships with teachers in other schools, rather than attending disconnected lectures that have no connection to their actual teaching. Over time, this model builds the long-term capacity of local county teachers, rather than relying on external experts to deliver one-off training that has no sustained impact.

2.4. End-to-end data integration: Improving precision in school governance

The fourth mechanism, which is less visible than classroom technology use but creates system-wide improvements, is improved school governance through end-to-end data integration across school departments [8]. Most county high schools have long relied on manual, experience-based management, with little systematic data tracking for student attendance, academic performance, or teacher workload. Principals often made decisions based on anecdote or personal experience rather than hard data, because collecting and analyzing data manually across hundreds of students and dozens of teachers was too time-consuming for administrative staff. Digital management systems integrate data across teaching, student affairs, and logistics, allowing principals to identify problems early and allocate resources more effectively to address gaps.

For instance, one school we visited in Weibei cross-referenced digital attendance records and end-of-term grade data to find that students who skipped morning self-study even once per week were three times more likely to fail end-of-term exams, and that 70% of these students were dealing with unaddressed mental health issues or long commutes of over an hour each way to school. This allowed the school to implement targeted early check-ins with these students, including adjusted start times for students with long commutes and regular counseling check-ins for students showing signs of mental health stress, which reduced overall course failure rates by 18% in one semester. Another school used digital workload tracking data to identify that science teachers were spending 30% more time on administrative tasks like form filling and inspection preparation than Chinese and math teachers, allowing the principal to reallocate part-time administrative support to the science department to reduce their burden, which reduced teacher turnover in the science department by 22% in one year. While this mechanism does not directly change classroom teaching, it creates systemic improvements in school functioning that benefit all students and teachers over time, reducing unnecessary teacher burden and allowing schools to identify student problems before they become insurmountable.

3. Practical barriers and root causes in digital empowerment of county high schools

Despite the clear potential outlined above, our fieldwork found that 12 out of 16 schools in our sample had not achieved meaningful, sustained integration of digital tools into daily teaching, with most schools reporting that smart equipment was used in less than 20% of regular, non-inspection class periods. These

schools were held back by four interlocking barriers that reinforced each other, creating a cycle of low use, low impact, and low teacher buy-in that was difficult to break without targeted intervention. See **Table 1**.

Table 1. Comparison of core indicators for digital development in counties

Metric	National/average urban level	County-level/rural area standards	Data sources
Internet access rate in primary and secondary schools	100%	100%	Ministry of Education, 2025
Percentage of teachers capable of independently designing AI-integrated lesson plans	15%	<10% (average in county schools)	China Academy of Educational Sciences, 2025
Proportion of minors with digital literacy at the primary level or above	70.94%	53.11%	National Internet Information Office, 2024
Proportion of minors with advanced digital literacy	15.90%	6.33%	National Internet Information Office, 2024
Smart Equipment Availability Rate at County-level Schools in Shaanxi Province	-	68%	Shaanxi Provincial Department of Education, 2025

3.1. Resource side: Platform silos and locally misaligned content

The first barrier, encountered in every single school we visited, was fragmented, siloed digital platforms and learning content that was not adapted to county school students' learning levels [9]. Nearly every school had purchased access to 3 or more separate digital education platforms, procured through uncoordinated projects at national, provincial, and county levels, with no integration or data sharing between them. Teachers told us they had to remember 4-5 separate account passwords to access different resources for different subjects, and student performance data could not be transferred between platforms, meaning they had to manually enter grades into multiple systems at the end of every term, creating a huge additional administrative burden that discouraged teachers from using the platforms at all. One IT teacher responsible for managing platforms at a Guanzhong plain school estimated that he spent 10 hours per week manually transferring data between systems, time he could have spent supporting teachers with classroom technology use.

Worse, nearly all learning content on these commercial platforms was designed for urban key school students, with difficulty levels far above what most county high school students could manage, and reading examples tied to urban life experiences that rural students could not relate to at all. One 40-year-old Chinese teacher at a mountain county school put it bluntly in an interview: "These platform lessons are written for kids in Xi'an, not for our students who grew up in the mountains helping their parents farm. Half the reading passages talk about subway rides, museum visits, and overseas family trips that none of our kids have ever experienced, so they can't connect with the content at all. The practice problems are all designed for students who score 100 points higher on exams than ours do, so if I assign them, students just get frustrated and give up because they can't do any of them." We observed multiple instances where teachers tried to use platform content for open classes, only to find that it was too difficult for their students, and they had no way to edit or adapt it to lower difficulty levels, so they stopped using the platforms entirely for regular classes.

None of the platforms we observed allowed for easy local content creation or resource sharing between county schools, meaning teachers could not upload their own content adapted to their students' levels, and could not share adapted resources with teachers in other county schools facing exactly the same student challenges. This top-down, one-size-fits-all content model is one of the largest barriers to meaningful use, as

it forces teachers to either use inappropriate, mismatched content or not use the platforms at all.

3.2. Application side: Superficial integration of technology and teaching

The second barrier was superficial, performative use of technology that did not change core teaching practices at all. In the majority of regular, non-inspection classes we observed across the 12 low-performing schools, technology was used only as a direct replacement for blackboards: teachers projected pre-made PowerPoint slides, but otherwise followed exactly the same lecture-based routine they used before smart equipment was installed, with no interactive activities, no personalized feedback, and no meaningful change to their teaching methods. Very few teachers used digital tools for interactive quizzes, student collaboration, personalized feedback, or adaptive practice, because they had not been trained to do so, and because the intense pressure to cover college entrance exam content left almost no time to experiment with new teaching methods.

The most common pattern we observed was what school staff openly referred to as "performance use": teachers would design highly interactive, tech-heavy lessons for open classes or official inspection visits, spending weeks preparing special lessons that used every feature of the smart classroom, then immediately return to traditional lecture-based teaching for regular daily lessons once the inspectors left. One principal admitted to us in an off-the-record conversation, "We have to use all the equipment features when leaders come to visit, because that's what they check for during evaluations, but it takes 3-4 hours to prepare one of those interactive lessons, and it doesn't help students score higher on the exam, so we don't use it for regular classes. It's just for show." This superficial, performative use of technology means millions in public equipment investment delivers almost no actual improvement to teaching quality, and creates the false impression that digital transformation is progressing well when in reality, core teaching practices have not changed at all.

We also found that most teachers viewed technology as an additional administrative burden rather than a tool to make their work easier, because platforms required them to do extra work like entering data and preparing special lessons, without reducing their workload in other areas. Without clear, tangible benefits to teachers in the form of reduced grading time or improved student scores, there was little incentive for them to invest their limited personal time in learning to use new tools effectively.

3.3. Subject side: Persistent urban-rural gaps in digital literacy

The third barrier was significant, multi-level gaps in digital literacy among both teachers and students, which prevented effective use of even well-designed, appropriate tools. National survey data shows only 10% of county high school teachers can independently design AI-integrated lesson plans, compared to 15% of urban teachers, and the gap is far larger for advanced digital skills like adaptive content design and data-driven instruction [10]. Many older teachers in county schools, who made up 40% of the teaching staff in our sample schools, reported clear anxiety around using digital tools, worrying they would break expensive equipment or fail to operate it correctly in front of students, which would cause them to lose face. One 52-year-old chemistry teacher with 28 years of teaching experience told us, "I'm close to retirement, and I never learned to use these computer systems well. I tried using the smart whiteboard once last year, and I accidentally deleted all my slides in the middle of class, which was very embarrassing in front of the students. Now I just use the blackboard, because I know it works, and I don't have to worry about making mistakes."

Even younger teachers, who were more comfortable with basic technology use like making PowerPoint slides, rarely had the pedagogical skills to design integrated, technology-supported lessons that actually improved learning, as most training they received focused only on basic equipment operation rather than how to integrate tools into teaching to improve outcomes. Student digital literacy gaps are even starker: national data shows only 6.33% of rural minors have advanced digital literacy for learning, compared to 15.9% of urban peers, meaning many students lack the skills to use digital learning tools effectively outside of guided class time [11]. Most rural students we spoke to only used digital devices for entertainment like short videos and games, not for learning, and did not know how to use digital tools to find learning resources, complete online assignments, or do self-directed review.

3.4. Institutional side: Missing long-term operational guarantee mechanisms

The fourth, and most fundamental, barrier was the complete absence of long-term operational guarantee mechanisms to sustain digital tools after initial installation [12]. Virtually all digital investment in county schools comes from one-time project grants, with no recurring, annual funding allocated for equipment maintenance, software updates, or ongoing teacher training after the project ends. Our school survey found only 68% of smart equipment in Shaanxi county high schools is in full working order, with many devices breaking within 2–3 years of installation due to lack of dedicated maintenance staff and repair budget. When equipment broke, schools had no dedicated budget to repair it, so it sat unused until the next project grant provided entirely new equipment, creating a wasteful cycle of installation, breakage, and replacement that wasted millions in public funds every year.

There are also no full-time digital education staff in 90% of the county high schools we visited; the teacher assigned to manage digital equipment is almost always an IT teacher who already carries a full 12–16-hour-per-week teaching load, with no extra time, specialized training, or additional compensation for system upkeep and teacher support. When teachers had problems with equipment or platforms during class, there was no one on staff available to help them immediately, so they often had to abandon the lesson and switch back to blackboard teaching, which discouraged them from trying to use technology in future classes. Without dedicated staff, ongoing dedicated funding, and clear accountability for digital education outcomes, even well-designed interventions will eventually stop working after initial project funding ends, as equipment breaks and teachers return to old practices.

4. Practical pathways for digital technology empowering high-quality development of county high schools

Addressing these interlocking obstacles requires a systemic approach that moves beyond one-time equipment purchase to build sustainable, context-appropriate digital ecosystems for county high schools, learning directly from the successful practices we observed in the 4 high-performing schools in our sample. These high-performing schools did not spend more money on equipment than other schools; in fact, two of them had lower per-student digital budgets than the average school in the sample. Instead, they focused on addressing the four obstacles outlined above, creating systems that supported ongoing, meaningful use of digital tools rather than focusing only on equipment installation. See **Figure 2**.

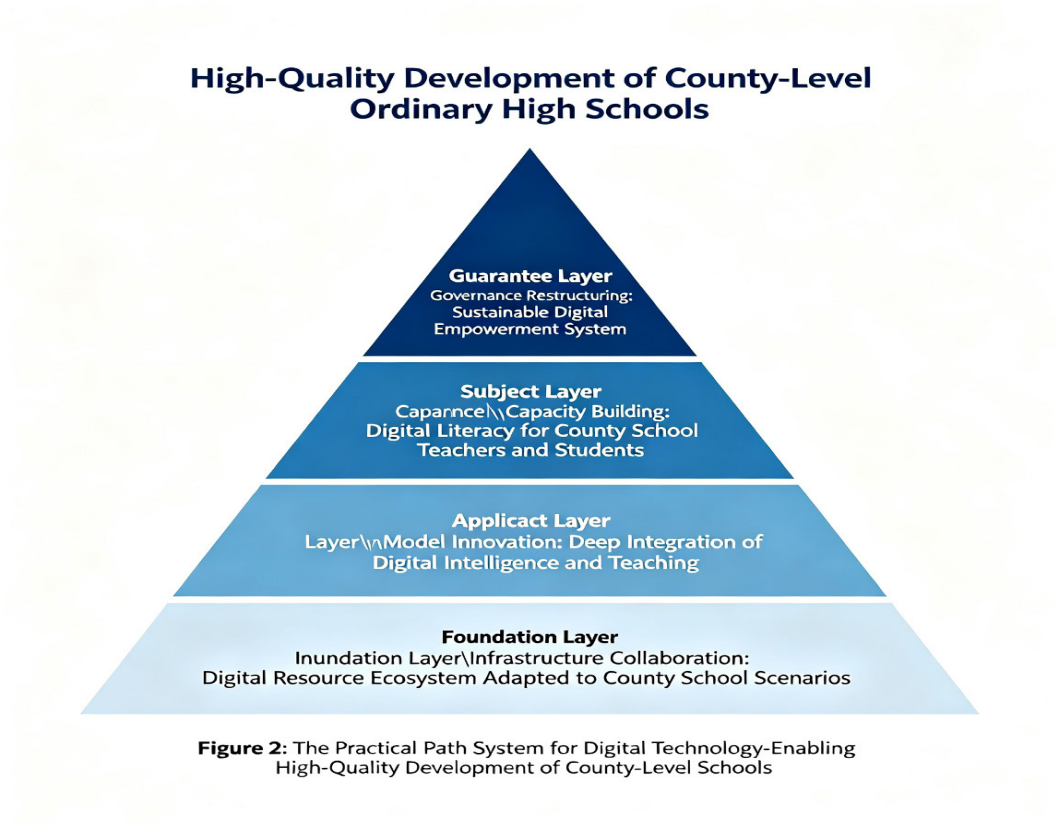

Figure 2. The practical path system for digital technology-enabling high-quality development of county-level schools

4.1. Infrastructure coordination: Building a digital resource ecosystem adapted to county school contexts

First, provincial and county education authorities should take steps to integrate fragmented digital platforms currently in use across schools, creating a single unified portal with single-sign-on access to all resources and fully interoperable data systems, to drastically reduce administrative burden on teachers. Instead of procuring multiple unconnected platforms through separate departmental projects, authorities should adopt a single integrated system that meets all school needs, with open data standards that allow student performance data to move between functions without manual entry by teachers. This single platform should also include a dedicated feedback channel for teachers to report problems and request content adaptations, to ensure the platform evolves to meet local needs over time.

Second, content development must involve county school teachers directly in curation and adaptation, rather than only using content designed by urban experts who have never taught in rural schools. Platforms should include dedicated, separate sections for county school content, adapted to match actual learning levels of rural students and incorporating local context and examples that resonate with rural students' lived experiences, rather than relying solely on urban-focused content. Instead of forcing county schools to use content designed for urban campuses, platforms should support easy local content creation and teacher-to-teacher resource sharing between county schools, allowing teachers to upload and share their own adapted materials with peers facing similar student populations. The high-performing schools in our sample all created their own shared county-level resource banks for teachers, which were used far more often than

commercial provincial platform content, because they were specifically tailored to local student learning levels.

Third, future infrastructure investment should prioritize reliable, easy-to-use tools that directly address documented teacher pain points, rather than purchasing expensive, complex equipment that teachers do not need and will not use. For example, the simple smart homework system used in Zhashui High School was adopted because it directly reduced teacher grading time, while more expensive virtual reality systems purchased by other schools as "showcase" projects were almost never used because they did not address any core teaching need and took too much time to set up for regular classes.

4.2. Deep integration: Exploring new models of technology-supported classroom teaching

Schools should move beyond superficial, performative technology use to develop context-appropriate teaching models that leverage digital tools to solve specific, documented pain points in county high school teaching, rather than mandating a single uniform model across all schools regardless of context. The successful models we observed all addressed specific local needs: the dual-teacher college exam review model at Hanbin High School addressed the lack of experienced senior teachers for review classes, the smart homework system at Zhashui addressed the challenge of tracking individual student progress in large classes, and the cloud teaching research model at Suide addressed the lack of ongoing professional development for isolated rural teachers.

Education authorities should encourage schools to experiment with small-scale, low-cost pilots of different models, rather than requiring all schools to adopt the same top-down model, and create formal mechanisms to share successful, context-appropriate models between county schools, with support for adaptation to local contexts. It is particularly important to avoid forcing schools to copy urban teaching models that do not fit county school realities: for example, flipped classroom models that require students to have high-speed internet access at home do not work in rural areas where 30% of students do not have reliable home internet, but dual-teacher models that use technology during scheduled class time work very well in these contexts. Successful integration requires starting with actual teacher and student needs, rather than starting with technology and looking for problems to solve.

Schools should also adjust their internal performance evaluation systems to reward meaningful technology integration that improves student outcomes, rather than rewarding performative use during inspections or counting the number of technology-integrated lessons as an evaluation metric, to encourage teachers to use tools in regular classes rather than only for show.

4.3. Capacity building: Systematically improving digital literacy of county school teachers and students

Teacher professional development for digital skills should be completely restructured to move beyond ineffective one-off, lecture-based training sessions that have no long-term impact, to ongoing, school-based coaching that meets teachers at their current skill level. Training should be differentiated for teachers at different skill levels: starting with basic operational skills and confidence-building for older or less tech-savvy teachers, before moving to advanced pedagogical integration for teachers who have already mastered basic use, rather than providing the same one-size-fits-all training to all teachers regardless of skill level. Critically, training should be led by frontline teachers who already have successful experience using digital

tools in county high schools, rather than external edtech experts who have never taught in rural settings, because these local teacher leaders understand the specific constraints and needs of county school contexts and can provide practical, relevant advice. The high-performing schools in our sample all selected "teacher leaders" in each subject who had already successfully used digital tools in their own classes, and gave them a 30% reduced teaching load to provide ongoing coaching and support to other teachers in their department, which was far more effective than external training delivered by outside experts.

For students, digital literacy education should be integrated into regular subject teaching, rather than being taught as a separate standalone course that focuses only on basic computer skills like typing, to ensure students develop practical skills for using digital tools for learning, not just for entertainment. This includes teaching students to use digital resources for self-directed exam review, evaluate the credibility of online information, and use digital tools to complete assignments and collaborate with peers, which are critical skills for both exam success and future higher education.

4.4. Institutional guarantees: Building a sustainable digital empowerment governance system

Finally, governments at provincial and county levels must establish long-term, sustainable institutional guarantees to support digital education, rather than relying on short-term one-time project grants that end after equipment is installed. First, education authorities should establish recurring, annual funding mechanisms for digital education, allocating a fixed 5–8% of annual school education budgets to equipment maintenance, software updates, and ongoing teacher training, to ensure that tools remain functional and supported after initial installation. This avoids the wasteful cycle of installation, breakage, and replacement that characterizes much current digital investment in rural schools.

Second, every county high school should have at least one dedicated part-time digital education coordinator, with a 30–40% reduced teaching load and appropriate additional compensation to manage systems, provide immediate technical support to teachers during class, coordinate training, and gather feedback from teachers about platform needs. This position does not require advanced technical skills; it only requires a staff member with dedicated time to troubleshoot small problems, coordinate repairs, and support teachers, which addresses one of the most common complaints from teachers: that there is no one to help them when something goes wrong during class.

Third, evaluation systems for digital education should be completely reformed to move beyond counting equipment numbers, internet speed, or the number of "technology-integrated lessons" to measuring actual impact on teaching and learning, including how often equipment is used in regular unobserved classes, teacher satisfaction, and changes in student outcomes over time. This eliminates incentives for performative technology use and encourages schools to focus on meaningful integration rather than putting on shows for visiting inspectors.

5. Conclusion and outlook

Digital tools hold clear, practical promise for supporting county high school revitalization and closing persistent gaps between urban and rural education outcomes, but this promise will never be realized if implementation remains fixated on equipment purchases rather than the actual day-to-day needs of county school teachers and students. For years, rural digital education policy across China has operated on the

untested assumption that building infrastructure alone will drive change: billions have been spent on devices, with almost no parallel investment in locally adapted content, ongoing teacher support, long-term upkeep, or institutional systems to sustain use. The field evidence from Shaanxi laid out in this paper makes the failure of this hardware-first approach unambiguous: equipment on its own does not shift teaching practice, and without supporting systems, most high-cost digital tools end up locked away in storage rooms, providing no tangible benefit to students.

The successful schools in our sample demonstrate a different path. When digital tools are adjusted to fit local contexts, backed by regular training and stable funding, and built to solve specific, on-the-ground pain points rather than check boxes for top-down inspections, they can bring real, measurable gains to teaching quality and student outcomes—even in schools with limited resources. None of these successful schools operated with bigger budgets or fancier equipment than their peers; what set them apart was a focus on weaving technology into regular daily practice, building local teacher capacity over time, and designing systems to sustain use long-term, rather than investing in one-off showcase projects built only for inspection visits.

This study has clear limitations that future work should address. First, our sample draws only on 16 schools in a single western province; future research should test whether these patterns hold in other regions with different levels of economic development, education investment, and student demographics, including sites in eastern and central China. Second, our analysis centers on implementation processes and short-term outcome shifts; future longitudinal work should track the long-term effects of digital integration on student exam performance, college admission rates, and post-graduation life outcomes over 3–5 year windows, to measure whether impacts are sustained over time. Third, this study was finalized before generative AI tools, including large language models, saw widespread adoption in rural campuses; future research should examine both the opportunities and risks these new tools present for county high school teaching and learning, an issue that will grow in importance as these tools become more accessible across rural areas.

County high schools serve the majority of China's rural secondary students and act as the primary channel for rural social mobility via access to higher education. For this reason, meaningful digital change on these campuses will be essential to meeting the national goal of equitable, high-quality education for all students. The findings here suggest this goal is within reach, but it will require a fundamental shift in policy priorities: away from counting how much equipment is purchased, and toward measuring how well technology is used, putting the day-to-day needs and practical expertise of the frontline teachers and students who use these tools every day at the center of policy design.

Disclosure statement

The author declares no conflict of interest.

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