A Report on China's ICT in Education for Rural Schools

in Suichuan County of Jiangxi Province and Yulong Naxi Autonomous County of Yunnan Province

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1.1 Advancement of ICT application in global education

1.1.1 Information and communication technology (ICT) in education: a crucial means to tackle global educational challenges

Education is a vital force to advance human society's civilization and progress. It's also an important issue of common concern worldwide. According to the UN's Sustainable Development Goals (SDGs), access to quality education is the basis for improving people's lives and achieving sustainability. For countries, education is a fundamental right that means a lot to stop the intergenerational transmission of poverty and improve human capital quality. For individuals, education constitutes a crucial factor in getting rid of poverty, achieving upward mobility, and realizing personal value as it enables.

With the joint efforts of the whole society, significant achievements have been made in educational development, for instance, people's degree of education and education quality has been significantly upgraded, and the concept of sustainability has been deeply implemented in education. As far as the UN's SDGs proposed in 2015 is concerned, the fourth goal is to "ensure inclusive and equitable quality education and enlarge lifelong learning opportunities for all," indicating the grand purpose and blueprint of the international community for quality education worldwide. However, social inequality and a widening gap between the rich and the poor caused by the interwoven political, economic, cultural, and other factors have increasingly challenged education. According to the "Global Education Monitoring Report" released by UNESCO in 2020 that focuses on "inclusiveness and education," global educational opportunities are still not equally distributed, leading to extremely costly quality education for too many learners. Before the COVID-19 pandemic, one-fifth of the world's children and the youth had been completely deprived of educational opportunities.

Overwhelmed by the COVID-19 pandemic, a black swan event, global education faces unprecedented challenges because of intensified social inequality and vulnerability. The school system is fragile. Schools in most countries around the world have been affected and declared closed. As of April 2020, nearly 1.6 billion children and the youth worldwide had been deprived of education; what's more, the disadvantaged and marginalized groups are faced with more significant risks of education quality reduction and dropout alongside exacerbated social differentiation and a widening digital divide. In response to the unpredictable pandemic-related threats, all countries turn to online education and guarantee "continuous learning during class suspension" amid the pandemic as a result of the information technology, a key technical means. Online education enables students to study at home instead of in schools, so that they can still get access to domestic and even global quality educational resources and continue learning at home. In this regard, the impact of the pandemic on students' learning is minimized.

Generally speaking, the construction of ICT in education has become a crucial means for countries worldwide to tackle educational challenges for the sake of sustainability. The application of information technology in education is irreplaceable in sharing quality educational resources, improving education quality, and promoting

social equity. For a considerable number of world's educatees, ICT application in education can eliminate the spatial differences in resource allocation, facilitate the interactive sharing of quality resources, as well as improve the resource access environment in regions lacking resources, and establish a huge networked learning community to boost the exchange and communication in a diversified context. Besides, introducing ICT into the teaching practice of schools helps reallocate input educational elements. Training teachers to master and apply ICT can facilitate classroom teaching reform to achieve quality learning.

1.1.2 Development status of ICT application in global education

Developed countries have made useful explorations in promoting educational equity with ICT. The United Kingdom promulgated the information-based strategy of "Harnessing Technology: Transforming Learning and Children's Services" in 2008, proposing such promising measures as developing information-based infrastructure, providing educators with ICT training and services, and building an online learning platform for learners. Singapore released its development program for ICT in education at the fourth phase—"Master Plan 4 (2015-2020)" in 2015 to advance its ICT learning ecosystem. France has developed the strategic plan of "Digital Campus" and such projects as device and resource construction, information technology innovation, and hi-tech incubation since 2015. "A Guidebook for Success: Strategies for Implementing Individualized Learning in Rural Schools" was issued by the United States in 2017, and it advanced ICT in education for rural schools by combining technology with education. ICT explorations among developed countries are committed to getting every student access to quality education, helping them achieve success in learning, and reducing educational inequality caused by family background and other factors. Meanwhile, less developed countries have also made efforts to improve students' learning outcomes with ICT. Themed on "Strengthening Teacher Training to Narrow the Gap in Education Quality in Africa", UNESCO China-Funds-in-Trust (UNESCO-CFIT) helped ministries of education and key teacher training institutions develop their capacity for pre-and in-service teacher training from 2012 to 2016 with the help of ICT, through mobile learning, as well as knowledge output and sharing. They also helped African countries such as Congo and Cote d'Ivoire address ICT-based teaching challenges. Backed by UNESCO/Republic of Korea Funds-in-Trust (UNESCO-KFIT), African countries such as Mozambique, Rwanda, and Zimbabwe tried transforming their education with ICT, developing E-School mode, and piloting ICT-based innovative approaches in 2016-2019, to expand lifelong learning opportunities and improve learning quality. Therefore, the application of information technology in education pursued by developed and developing countries for their educational development constitutes a crucial means to upgrade education quality and enhance labor quality and competitiveness.

1.1.3 Overview: The advancement of China's ICT in education

As a country with a population of 1.4 billion and a big country in terms of education, China is confronted by ensuring the quality and equality of education. According to the "Educational Statistics in 2019" announced by the Ministry of Education (MOE), there were nearly 200 million students in China under compulsory education, exceeding the total population of most countries worldwide. Cities, towns, and villages are scattered in vast China. The huge differences between urban and rural areas in such aspects as economic growth and resources, as well as the inadequate and unbalanced development, also lead to a considerable number of rural students' inherent disadvantages in their learning. Factors like ill-informed situations, lack of resources, backward teachers, and low social and economic status block the way rural students enjoy the same quality educational resources. Luckily, the rapidly developed ICT is now an effective tool to bridge the gap between urban and rural educational outcomes and facilitate educational equity.

China began to implement the "Modern Distance Education Project" at the beginning of 1999 and underwent tremendous changes from scratch, focusing on top-level design in the two decades after the Millennium. According to the "2003-2007 Action Plan for Invigorating Education" approved by the State Council in March 2004, the "construction of ICT in education" was incorporated into the six big projects; the CPC Central Committee and the State Council issued the "Outline of the National Medium and Long-Term Program for Education Reform and Development (2010-2020)" in July 2010, making clear for the first time the revolutionary impact of information technology on educational development; the MOE issued the "Ten-year Development Plan for ICT in Education (2011-2020)" in March 2012, demonstrating basically formed strategies and general arrangement for China's ICT in education in the context of informatization; it further issued the "Action Plan 2.0 for ICT in Education" in April 2018, proposing to reach the goal of ICT in education, namely "e-teaching Apps covering all teachers, e-learning Apps covering all the school-age students and digital campus covering all schools, as well as generally improving the level of harnessing information-based tools, strengthening teachers and students' information-based competence and building an 'Internet plus education' platform". So far, China's construction of ICT in education has entered a new stage of substantive development.

During the "13th Five-Year Plan" period, the rate of access to the Internet of domestic primary and secondary schools (including extremely poor teaching venues in less developed regions) had increased from 69.3% in 2015 to 99.7%. The proportion of schools with an outlet bandwidth of 100M had jumped from 12.8% to 98.7%. All schools of 52 poverty-stricken counties had been connected to the Internet, and 99.7% of them had achieved 100M bandwidth. 95.2% of primary and secondary schools had multimedia classrooms, with devices uniformly provided for teachers and students reaching 10.6 million and 17.03 million, respectively. The project of full coverage of digital educational resources in poor rural teaching venues had been implemented to develop 6,948 class hours of digital resources in English, music, fine arts, and other subjects, as well as 50 million pieces of resources matching teaching materials of all subjects under compulsory education. By the end of April 2020, there had been 13.47 million, 6.5 million, 5.92 million, and 410,000 columns dedicated to teachers, students, parents, and schools respectively on the National Public Service Platform for Educational Resources. Teachers and students signed up for online learning with their real names, making columns dedicated to students and

teachers reaching 96.43 million and 7.54 million respectively. The MOE had continuously promoted MOOC and accelerated its platform construction and open sharing. MOOC had enabled quality resources to online teaching and backed collaborative teaching as a result of its 41,000 quality online courses represented by 1,291 national-level MOOCs and 401 national-level virtual simulated experimental teaching projects.

1.2 Development and challenges of China's ICT in education in rural areas

Compared with other countries in the world, China is a big agricultural country with a large population. Large rural areas, many people to be educated and huge differences in various regions, and insufficient quality resources in rural education lead to rural students and teachers flowing to cities and towns. Thus seriously obstructing sustainable rural education, further aggravating the gap between urban and rural education. This hindering from stepping "towards inclusive and equitable quality education and lifelong learning for all" proposed by the UNESCO in its "Education 2030 Framework for Action". Information technology is regarded as a crucial means to improve rural education quality and develop urban and rural education equally. In the past two decades, the Chinese government has implemented vital information-based construction projects in rural and remote areas and ensured their access to information-based education to improve the education quality in remote areas and advance the sharing of quality teaching resources. As a part of China's critical information-based construction projects in rural areas, "Modern Distance Education Project Dedicated to Rural Primary and Secondary Schools" and "Three Classrooms" reflect focuses in different stages and constitute the epitome of such construction.

1.2.1 "Modern Distance Education Project Dedicated to Rural Primary and SecondarySchools" —Infrastructure construction regarding ICT in education for rural schools

The "Modern Distance Education Project Dedicated to Rural Primary and Secondary Schools" (from now on referred to as "Rural Distance Education Project") is fundamental in the early stage of China's construction of ICT in education in rural areas. It focuses on the construction of information-based hardware facilities in rural schools to advance their ICT in education.

With The MOE, the National Development and Reform Commission and the Ministry of Finance jointly issued the "Notice on Implementing the Pilot and Demonstration Program regarding the Modern Distance Education Project" in May 2003, with the approval of the State Council, to initiate the "Pilot and Demonstration Program regarding the Modern Distance Education Project" (hereinafter referred to as "Pilot and Demonstration Program"). This Pilot and Demonstration Program involved three rooms to play teaching-oriented CDs, rooms to watch teaching-oriented satellite TVs, and computer rooms in central schools. A total of 20,977 rooms were built to play teaching-oriented CDs, 48,605 rooms were built to watch teaching-oriented satellite TVs, and 7,094 computer rooms were built in 12 provinces (autonomous regions and municipalities directly under the central government) in western China, 6 provinces in central China, Shandong Province, and Xinjiang Production and Construction Corps involved during the pilot phase. The "Overall Plan for Implementing Modern Distance Education Project Dedicated to Rural Primary and Secondary Schools" was formulated in November 2004 after taking into account the experience in piloting the "Rural Distance Education Project," marking a shift from pilot phase to all-sided implementation. The construction project covering all rural primary and secondary schools

finished by the end of 2007 thanks to 11 billion RMB invested by the central and local governments, contributing to an elementary rural ICT in education, a necessary distance education network benefiting rural primary and secondary schools nationwide and a resource system meeting the teaching needs of rural primary and secondary schools.

1.2.2 "Three Classrooms" Project—Promotion of the teaching mode regarding ICT in education for rural schools

"Three Classrooms" refer to "dedicated lessons," "master lessons," and "online classes of famed schools." Dedicated lessons offer enough and quality nationally prescribed courses to poor rural schools and teaching venues to advance educational equality and balanced development with dedicated online courses or synchronous classes, appropriate quality educational resources updated on the Internet, etc. Masters classes aim to maximize the demonstration effect of experienced teachers and their lectures by establishing, for example, an Internet-based research and study community to upgrade teaching skills of ordinary teachers by prominent ones, thus advancing the teaching quality of rural teachers. Anchored in quality schools, online classes of famed schools are to systematically and thoroughly facilitate regional or national sharing of quality educational resources to meet students' demand for personalized development and quality education through network schools, online courses, etc., thus narrowing the gap among regions, urban and rural areas, and schools. "Three Classrooms" project has significantly driven China's construction of ICT in education in rural areas. Based on the infrastructure construction regarding the "Rural Distance Education Project," the "Three Classrooms" project has expanded the coverage of educational resources, thus enabling the majority of rural schools to quality teaching resources and rural teachers to teaching practice with the help of the Internet. Online Master Class, remote online classes, and other forms have gotten rural students to access to the teaching of experienced teachers from famed schools, hence improving in their performance. Provinces like Jiangxi and Hunan have contributed substantial construction achievements and valuable construction experience to dedicated lessons and other online teaching resource sharing modes that have been orderly promoted in China.

Primary and secondary schools nationwide continued teaching during school closing amid the COVID-19 outbreak in 2020, marking a transformation from traditional teaching in the classroom to online teaching. However, the COVID-19 pandemic also helped reveal the shortcomings of China's current ICT in education, especially by poor hardware and software resources in rural schools, lack of IT professionals as well as teachers' and students' information-based incompetence, etc., hence being powerless to cope with large-scale online teaching. The overall development of ICT in education in rural areas is still severe. In light of the great challenges confronting China's information-based development despite significant achievements, realizing qualities and sustainable rural ICT in education and narrowing the "digital divide" of regional educational development in rural areas with poor infrastructure and short of quality resources is the focus of China's educational development.

ICT is used to promote high-quality curriculum resources and synchronous classes offered by prestigious off-site teachers through the internet. So that rural students can receive teaching remotely, overcome spatial barriers, enjoy high-quality education resources that were once limited to developed cities, and obtain quality primary

education and aesthetic education, which is an important program for the deep and comprehensive improvement of rural education quality.However, in practice, the provision of educational technology will not directly or instantly improve the quality.The practical implementation of "Three Classrooms" requires a major and comprehensive reform of "teaching" and "learning". In this process, the role and function of teachers, as well as the teacher-student relationship underwent fundamental changes, and new problems of teaching management and assessment followed. In the application of ICT in promoting rural education development represented by "Three Classrooms", the model of combining remote learning resources and on-site guidance separates the teaching content and learning activities, and brings tremendous changes to teaching method, teaching organization format, teachers' responsibility, learning method, division of responsibilities between exams and evaluation method, organization measures and assessment, which demand re-reconsideration. These pose a massive challenge to rural schools that less adaptable and less transformative than urban schools. Currently, with the steady progress, of the "Three Classrooms" and the online classroom practice of "closing schools without suspending learning" in rural areas during the pandemic, using ICT promoting rural education is more than preliminary advocacy, and integrating ICT with various elements of rural education will need more in-depth discussions.

Through field research on two counties of Suichuan, Jiangxi and Yulong, Yunnan, this report is designed to unveil the basic situation of rural ICT in education at home, analyze the value, focus, and challenges of ICT in education in advancing China's rural education reform and innovation, as well as summarize and spread the "Chinese experience" of rural ICT in education from a global perspective.

2.

CASE STUDIES

The research group conducted the case study on two counties of Suichuan, Jiangxi and Yulong, Yunnan. Located in the central and western China, respectively, the two counties represent the development status of rural ICT in education in these regions to a certain extent.

This field research subjects included heads of local education bureaus, school principals, teachers, and students. Interviews were conducted with these heads to grasp information-based construction arrangements, financial investment, infrastructure construction, and online teaching planning during the pandemic. Some school principals and teachers were also interviewed, to grasp the allocation of information-based facilities, teachers' information-based teaching, and the online teaching situation during the pandemic. A large number of teachers and students in the two counties filled in questionnaires on a 7-point Likert scale. The research group grasped the harnessing situation of information-based teaching methods and devices, as well as teachers and students' feelings towards ICT in education. Finally, the research group visited 10 rural schools in Suichuan County, interviewed 6 principals, 43 teachers, 6 leaders in charge of the Education Bureau there, and collected 476 questionnaires from teachers and 980 questionnaires from students. They also visited 8 schools in Yulong County, interviewed 8 principals, 29 teachers, and 5 leaders in charge of the Education Bureau there, and collected 848 questionnaires from teachers and 668 questionnaires from students.

2.1 Research results of ICT in education in Suichuan County, Jiangxi Province

Located in the eastern foot of the southern Luoxiao Mountains, the southwest border of Jiangxi Province, and the southwest of Ji'an City, Suichuan County, with a total area of 3,144 square kilometers, is characterized by many mountains and few fields. It is the county with the largest area and the most population in Ji'an City of Jiangxi Province. Specifically, it had a total population of 622,200 dominated by Han nationality by the end of 2019, approximately 412,200 of which were rural. Suichuan County was no longer a poverty-stricken county until 2019 in light of its backward economic growth. At present, there are 261 schools of various types, with 129,500 students and 6,238 faculty members. Among them, more than 90,500 students are under compulsory education, and 5,319 faculty members are available for that. The gross enrollment rate of primary and junior secondary schools, there is 100%.

According to samples involved in the field research, teachers there are generally young with an average age of 33 (see Fig. 1 for the age distribution of teachers), and more than half of the teachers (53.78%) have been teaching less than 5 years. The first academic qualification of teachers is dominated by associate bachelor (37.82%) and undergraduate (53.36%); those whose highest educational qualification is an undergraduate account for the largest proportion (78.99%), which is also related to their young age. According to the Education Bureau, most newly recruited teachers hold bachelors' degrees or above in the past three years. More than half of teachers (57.56%) have spent less than five years learning and applying instructional technology, and about a quarter (25.63%) have spent more than 10 years in this regard.
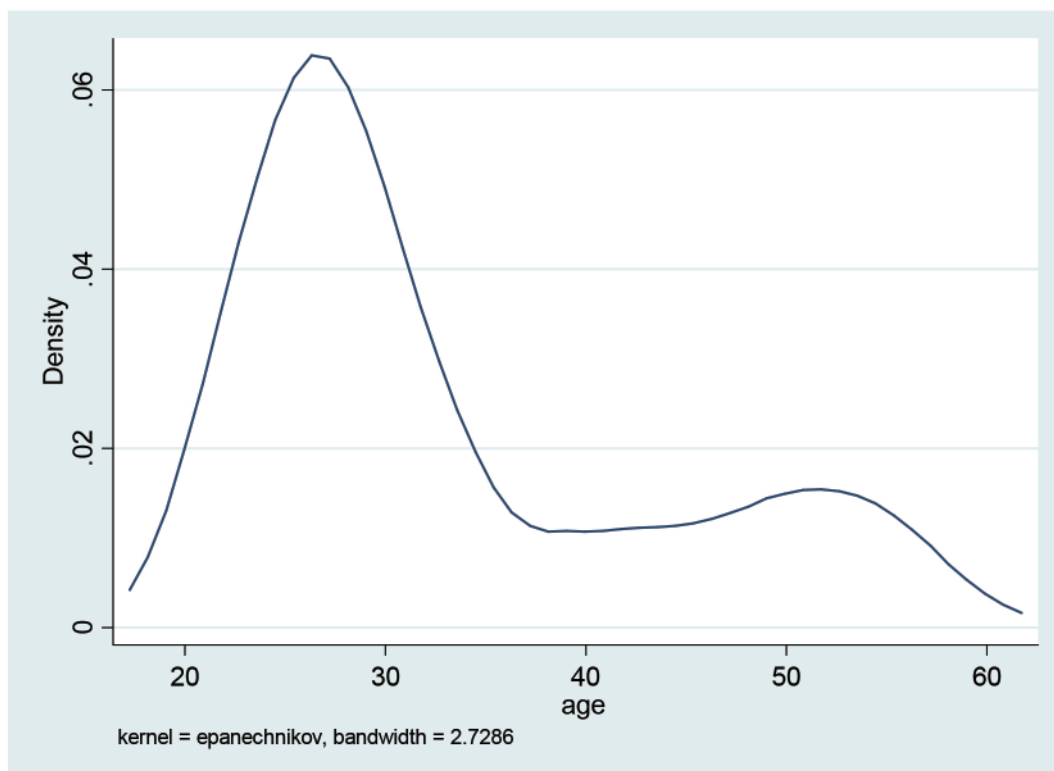

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Fig. 1 Age Distribution of Teachers in Suichuan County

Table 1 Basic Information of Teachers (N=476)

Variable	Amount	Percentage (%)	Variable	Amount	Percentage (%)
Gender			**Professional rank**		
Male	176	36.97	Internship	24	5.04
Female	300	63.03	2nd grade primary	62	13.03
Teaching stages			1st grade primary	7	1.47
Primary school	133	27.94	Senior primary	5	1.05
Secondary school	343	72.06	2nd grade secondary	113	23.74
Seniority			1st grade secondary	81	17.02
Less than 1 year	59	12.39	Senior secondary	75	15.76
1-5years	197	41.39	No-ranking	109	22.9
6-10years	72	15.13	**Time spent in learning and applying instructional technology**		
11-15years	18	3.78			
16-20years	28	5.88	1-2years	144	30.25
More than 20 years	102	21.43	3-5years	130	27.31
First academic qualification			5-10years	80	16.81
Graduate from secondary vocational schools (secondary normal schools, senior secondary schools)	31	6.51	More than 10 years	122	25.63
Associate bachelor	180	37.82	**The number of subjects**		
Undergraduate	254	53.36	At primary school		
Postgraduate	10	2.1	1	99	74.44
Doctor	1	0.21	2	19	14.29
Highest academic qualification			≥3	15	11.28
Graduate from secondary vocational schools (secondary normal schools, senior secondary schools)	1	0.21	At secondary school		
Associate bachelor	52	10.92	1	306	89.21
Undergraduate	376	78.99	2	31	9.04
Postgraduate	46	9.66	≥3	6	1.75
Doctor	1	0.21			
The way to obtain the highest academic qualification					
Formal schooling	330	69.33	Radio/TV university	9	1.89
Correspondence	93	19.54	Postgraduate classes	3	0.63
Online courses	11	2.31	Others	30	6.3

2.1.1 Development of ICT in education in Suichuan County

Suichuan County has relatively complete information-based devices. According to the feedback from heads of the local Education Bureau and the visit of the research group, 261 schools there are all been connected to the Internet, hence access to all kinds of online resources with computers in classrooms. 96.29% of classrooms are equipped with teaching-oriented multimedia display devices, such as projectors, electronic whiteboards, or touch-screen all-in-one machines. The latest touch-screen all-in-one machines can be connected to WIFI, Bluetooth, mobile phones, etc. Teachers can tap the screen to play courseware and videos easily, make interaction in class, tick or mark pictures, and courseware directly, among others. Though loved by teachers, these new devices are extremely limited.

Basically, each teacher has one dedicated device, and 15.24% of students use computers. The ratio of schools, teachers, and students' creating a sharing account online for teaching or learning are 100%, 97.61%, and 81.07%, respectively. Most schools visited are equipped with 1-2 computer classrooms to ensure that information technology courses are offered at least once a week, and each student can use a computer exclusively. According to the field research on 10 schools, the average annual investment in ICT in education is 141,200 RMB, with a maximum of 500,000 RMB and a minimum of 0 RMB, leading to a large gap. These investments are primarily from superior departments, followed by schools' self-financing and social sponsorship. 8 schools are making general short-term and medium and long-term plans for ICT education and building incentive and assessment systems for teachers' ICT-based teaching. 7 schools appoint staff to

Fig. 2 A Relatively Latest Device in the Classroom of CL Primary School

Fig. 3 The Latest Device in the Classroom of Suichuan TY Primary School (Teaching Venue)

Fig. 4 A Relatively Old Device in the Classroom of HX Primary School (Teaching Venue)

manage and maintain information-based devices, 4 of which appoint ones not specialized in information technology. The specific information-based software and hardware allocation of the schools visited is shown in Fig. 5.

	DJ Primary School	ZA Primary School	SC Primary School	DJ Primary School	CL Primary School	DJ Junior Secondary School	YH Junior Secondary School	ZA Junior Secondary School	SC Secondary School	YX Junior Secondary School
Satellite TV	■	■	■	■	■	■	■	■	■	■
Projector	■	■	■	■	□	□	■	■	■	■
Sound device	□	■	■	■	■	■	■	■	■	■
Video cassette recorder	■	□	■	□	□	□	□	□	□	□
Interactive whiteboard	■	■	■	■	■	■	■	■	■	■
Computer for teaching	■	■	■	■	■	■	□	■	■	■
All-in-one machine	■	■	■	■	■	■	■	■	■	■
Computer room	□	■	■	□	■	■	■	■	■	■
Tablet PC	□	□	□	□	□	□	□	■	■	□
Multimedia reading room	■	□	■	□	□	□	□	■	■	■
Computer for handling office work	■	■	■	■	■	■	■	■	■	■
Printer	■	■	■	■	■	■	■	■	■	■
Teaching plan library	■	■	■	□	■	■	■	□	■	□
Material library	■	■	■	□	□	■	■	□	■	□
Multimedia courseware database	■	■	□	□	□	■	■	□	■	□
Quality teaching case library	□	□	□	□	□	□	■	□	□	□
Question bank	□	□	□	□	□	□	■	□	□	□
Electronic lesson preparation system	□	□	□	□	□	□	□	□	□	□
Digital library	□	□	□	□	□	□	□	□	■	□
Online course platform	□	□	□	□	□	□	□	■	■	■
Personal learning space online	■	■	■	■	■	■	■	■	■	■

Fig. 5 Information-based Software and Hardware Allocation of Schools Visited in Suichuan County (green means equipped, white means unequipped)

All schools are equipped with all-in-one machines, computers, interactive whiteboards, and other hardware devices. About a half have multimedia classrooms; additionally, personal devices like tablet PCs are less seen in rural schools. There are fewer software devices than hardware ones. Basically, all schools have teaching plan libraries, material libraries, multimedia courseware database, and personal learning space online; however, they are short of such software devices as question banks, electronic lesson preparation systems, and digital libraries.
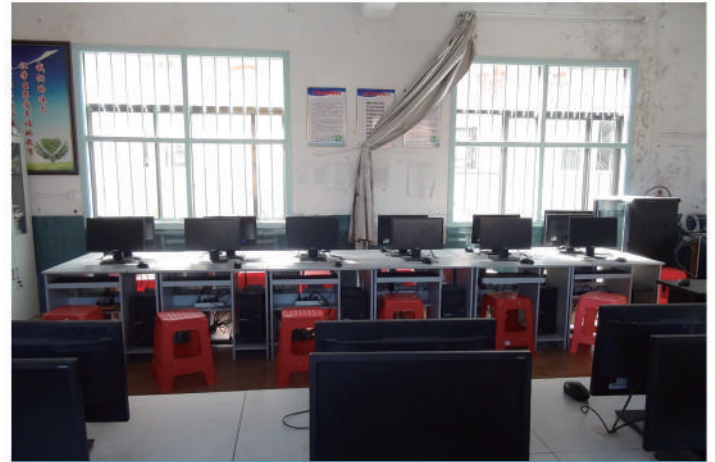
Fig. 6 Computer Room for Teaching of DJ Primary School

60% of teachers use all-in-one machines, computers for teaching, projectors, and computers for handling office work every day, as well as satellite TVs, printers, and other devices every week. Teachers seldom use multimedia reading rooms, computer rooms, and CD player rooms, and more than 10% of them never use such devices. This is shown in Fig. 7.
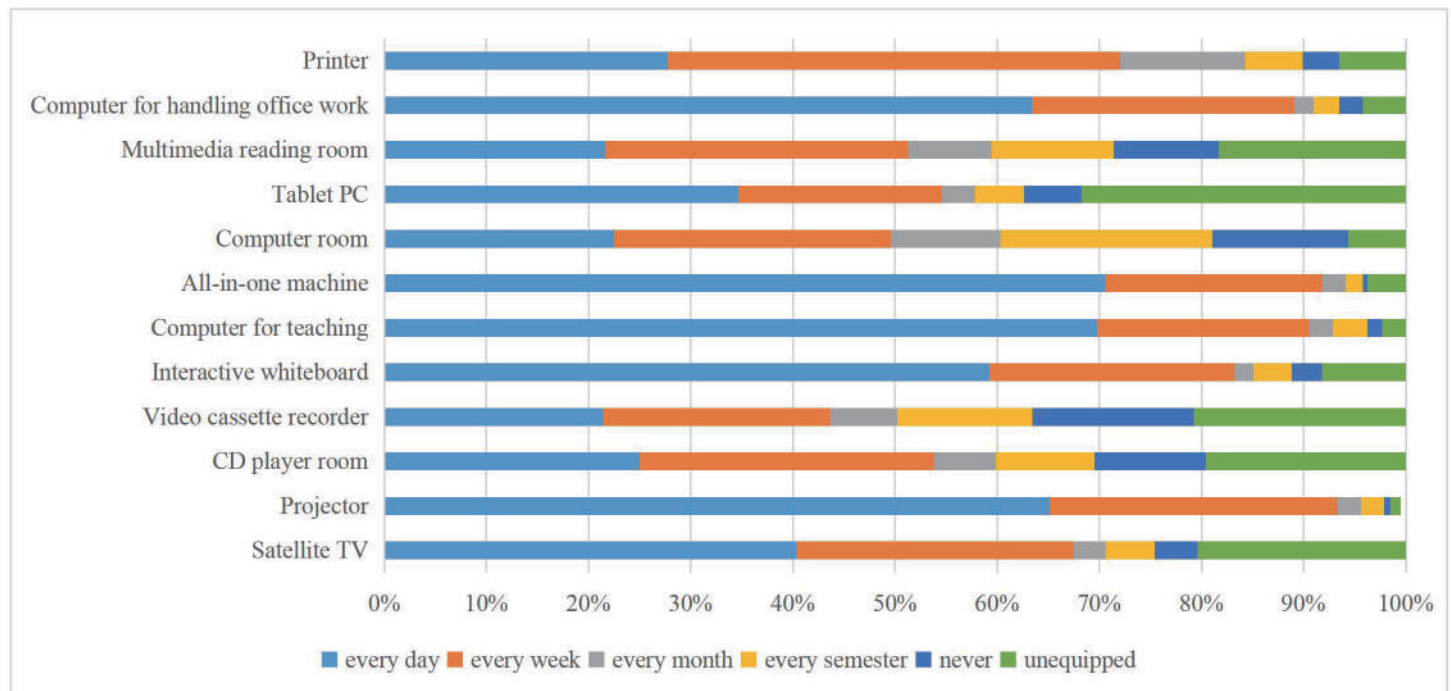
Fig. 7 Use Frequency of Various Information-based Devices for Teachers in Suichuan County
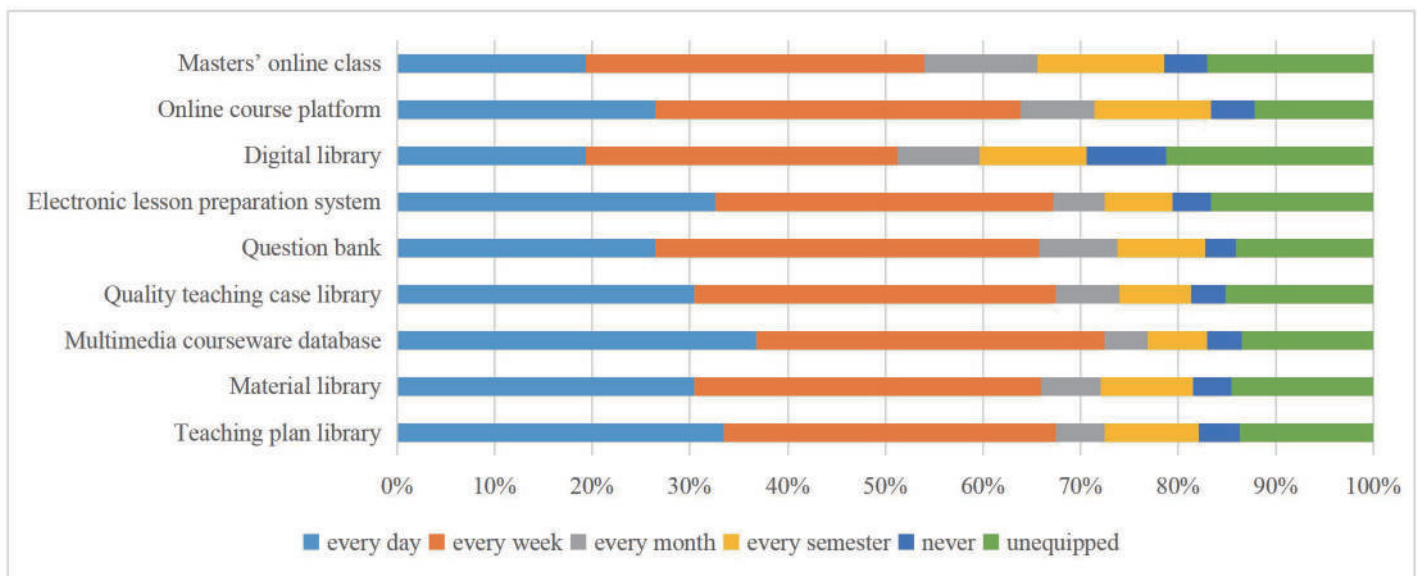
Fig. 8 Use Frequency of Information-based Resources in Suichuan County

As shown in Fig. 8, more than half of the teachers use various digital resources at least once a week. More than 30% of them use multimedia courseware database, teaching plan library, electronic lesson preparation system, material library, quality teaching case library, and other devices every day.

According to the field research on teachers' satisfaction with their use of digital resources (as shown in Table 2), they are generally satisfied (the average value of each item exceeds 6 and the standard deviation is about 1.2). Suichuan County is authorized to use the local information-based resources—the "Ganjiaoyun" platform that integrates plenty of teaching resources, including teaching plans, courseware, videos of experienced teachers' teaching in class in Jiangxi Province, and electronic aided teaching tools. *"Some good teaching resources, PPTs and teaching plans are available on this platform, the primary source of free digital teaching resources for teachers in Jiangxi Province, which are very suitable for new teachers desiring to improve their teaching skills. "* (A teacher of CL Central Primary School)

	Average value	Standard deviation
Teaching plan library	6.08	1.25
Material library	6.08	1.23
Multimedia courseware database	6.10	1.26
Quality teaching case library	6.13	1.18
Question bank	6.10	1.24
Electronic lesson preparation system	6.16	1.18
Digital library	6.16	1.17
Online course platform	6.03	1.29
Masters' online class	6.11	1.19

Table 2 Satisfaction with the Use of Digital Resources

2.1.2 Information-based teaching

To better understand the situation of information-based education there, especially during the pandemic, the research group conducted a questionnaire survey on teachers and students and conducted profound interviews with principals and teachers of 10 schools.

2.1.2.1 Teachers basically understand ICT in education and are competent in and willing to try information-based teaching

71.43% of teachers involved in the field research believe that instructional technology is the application of information technology and related theories in education for the sake of serving to teach; 17.86% regard instructional technology as an aided means of teaching; 59.87% agree with the information-based teaching reform and innovation and call for its implementation; 26.26% uphold such reform and could take the initiative to improve themselves to meet the requirements, regardless of difficulties; 10.08% could do it as required but need a push as they are less active, and only 2.73% reject information-based teaching from competence and attitude perspectives. Generally speaking, teachers understand information-based teaching positively and accept it.

	Average value	Standard deviation
You can skillfully use all kinds of retrieval tools for targeted information retrieval	5.79	1.34
You can download resources with all kinds of software concerned, such as Thunder	5.94	1.25
You are proficient in basic operations of text input, editing, and typesetting	5.99	1.19
You are proficient in PPT preparation, etc.	5.98	1.21
You are proficient in simply processing images with Photoshop	5.20	1.72
You are proficient in recording and editing audios and videos with software concerned	5.24	1.67
You often exchange with other teachers the selection and production of teaching resources	5.76	1.35
You are familiar with resource acquisition platforms, such as public service platforms of educational resources, platform of fully covered teaching resources, etc.	5.68	1.39
You can choose the right resources for distance education and online educational	5.72	1.36
You will develop certain teaching resources according to your own needs	5.54	1.51
You will present the teaching items in video, audio, words, and other appropriate media means according to the teaching needs	5.78	1.36
You can innovate teaching items with the help of information-based and local resources	5.69	1.40

Table 3 Information-based Teaching Skills of Teachers in Suichuan County

As shown in Table 4, teachers' satisfaction with using information technology in teaching scores 5.85, indicating their high degree of satisfaction. Teachers generally agree that the application of information technology helps increase class interaction and stimulate students' motivation without significantly troubling teachers, thus making information-based teaching more effective than conventional teaching.

Table 3 Information-based Teaching Skills of Teachers in Suichuan County

	Average value	Standard deviation
I am very satisfied with the use of information technology in teaching	5.85	1.30
I think information-based teaching is more effective than conventional teaching	5.88	1.27
Information-based teaching did not trouble me much	5.84	1.32
There are more interactions between students and me thank information-based teaching	5.95	1.24
Information-based teaching enables students to learn more passionately	5.97	1.24
The school's maintenance and introduction of such devices facilitate my information-based teaching	5.84	1.33

These are also fully reflected in the interviews. School leaders and teachers think that information-based teaching is the general trend. *"Everyone can operate computers. We all know that this is the general trend. Technology is so developed now."* (A principal of ZA Junior Secondary School in Suichuan, Jiangxi Province) As far as teachers are concerned, information-based devices contribute to another interactive mode between teachers and students. *"Sometimes I asked students to present their homework in the front with the pro jector, and they found it interesting when they touched the screen."* (A teacher of YH Junior Secondary School in Suichuan, Jiangxi Province) The use of information-based devices to display pictures and videos also facilitates students' better understanding of teaching items. *"......Telling them that grassland is vast does not help. They can remember it longer by appreciating videos or photos concerning grassland probably because videos are rather effective than words in remembering things. They will understand that text more by combining words with videos or photos."* (A teacher of SC Primary School in Suichuan, Jiangxi Province)

2.1.2.2 Effect of dual-teacher mode

Suichuan County started to develop dedicated lessons in 2019. It planned to build another 59 teaching venues with dedicated lessons in 21 townships and towns in 2020 after its first batch of 22 primary schooling venues with dedicated lessons finished in 2019. The first group of experienced teachers giving lessons (primarily provincial and municipal special-grade teachers, subject leaders, and famous teachers in cities and counties) and 10 famed schools presenting online class were determined. Anchored in one classroom of the central primary school in town, dedicated lessons are remotely offered to the teaching venues affiliated to the central primary school as a result of "Class Accessible to ICT", as well as automatic inductive cameras and sound receivers that help capture teachers and students' behaviors. The lecturer can grasp the learning situation at the remote teaching venues from a dedicated screen beside him/her and interact with students there by video in real-time. Except for cameras that transmit the situation of remote teaching venues, there are also display screens, sound receivers, audio devices, etc., prepared for the lecturer to present his/her teaching.

Fig. 9 Facilities for Dedicated Lessons at the Anchored Classroom of Suichuan DJ Primary School

Fig. 10 Live Dedicated Lessons at Suichuan NP Primary School (Village Teaching Venue)

Fig. 11 VCR of Live Dedicated Lessons at Suichuan NP Primary School (Village Teaching Venue)

The administrative system and timetable concerning dedicated lessons on music, sports, and fine arts of central primary schools were found during the visit, as shown in the figure below.

As shown in questionnaires from teachers, the option "students can receive quality teaching in a planned way with the help of dedicated lessons" scores 6.01, revealing teachers' recognition of the teaching effect of dedicated lessons; what's more, local students can understand the teaching items of dedicated lessons. Dedicated lessons are interactive thanks to the cooperation of local and remote teachers, and the learning situation of students can also be timely transmitted to the lecturer. Meanwhile, "Three Classrooms" help improve local teachers'

Fig. 12 Facility Management System concerning Dedicated Lessons

professionalism from such perspectives as enriching the items taught, adding difficult knowledge and enhancing teaching skills via remote collaborative lesson preparation, thus gradually developing their quality teaching cases from the dual-teacher mode, etc.; what's more, the exchange between teachers thanks to such mode is more likely to bring forth teaching reflection, etc.
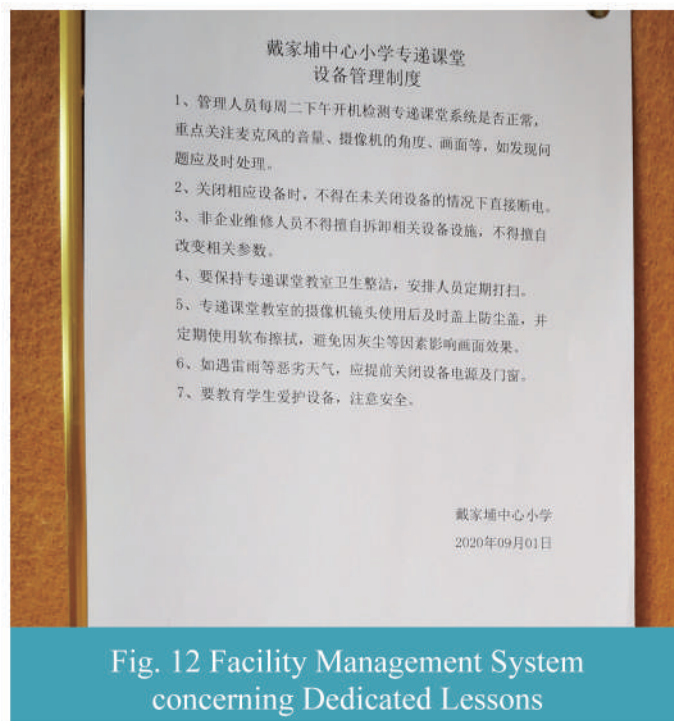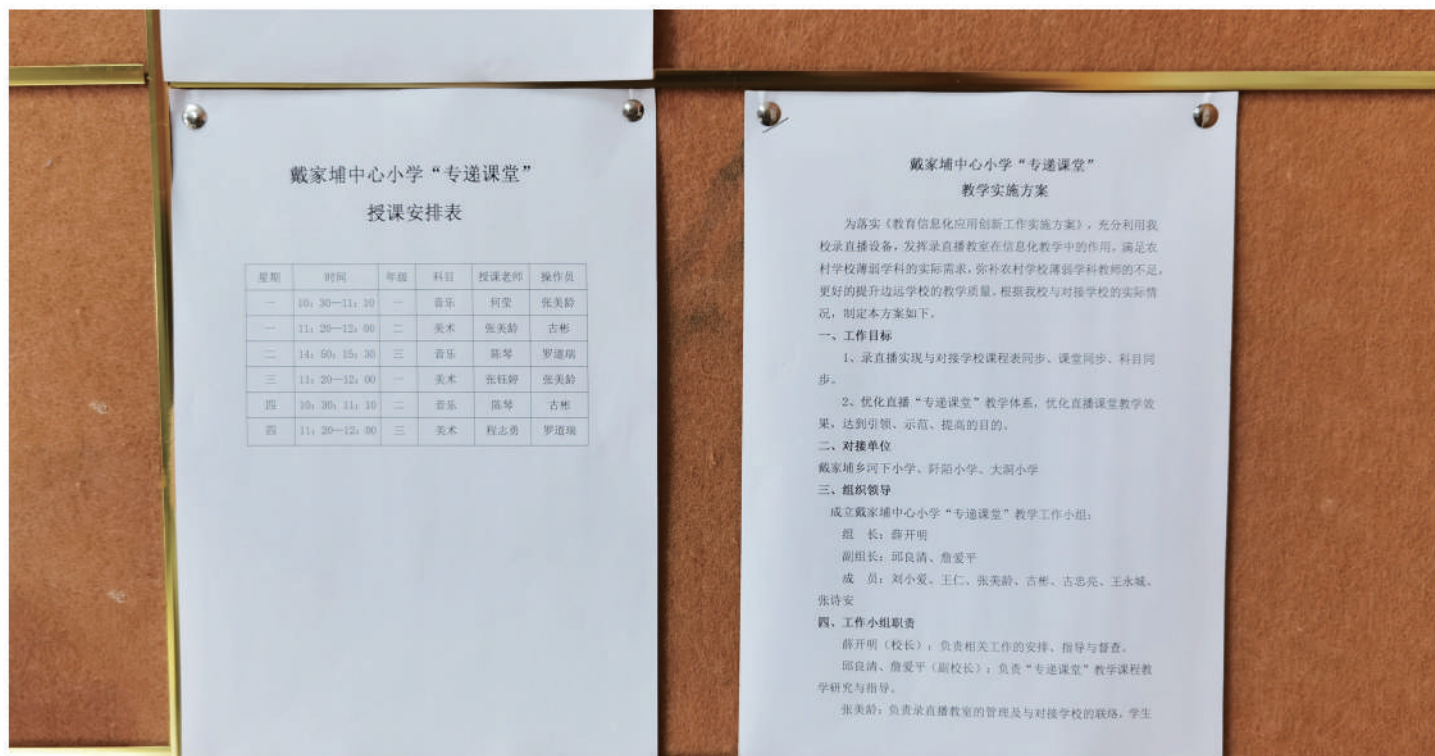

Fig. 13 Timetable concerning Dedicated Lessons

Table 5 Attitude towards Dual-teacher Mode

	Average value	Standard deviation
Students can receive quality teaching in a planned way with the help of dedicated lessons	6.01	1.23
Masters' lessons are conducive to improving my teaching skills	6.01	1.23
Local students can understand the teaching items of dedicated lessons	5.84	1.34
I often give lessons by playing CDs, that is, giving priority to teaching over CD playing	5.32	1.79
I often adopt Air Class mode, that is, explaining the knowledge mentioned in Air Class programs while watching them	5.31	1.81
I often enrich myself with resources online, that is, giving lessons online and preparing lessons via the Internet	5.71	1.46
I enrich the items taught and add difficult knowledge thanks to the dual-teacher mode	5.53	1.58
I timely check students' homework and feed it back to remote teachers thanks to the dual-teacher mode	5.49	1.64
I have a chance to prepare lessons collaboratively with teachers online thanks to the dual-teacher mode	5.49	1.63
I feel that I have lost the leading role in class due to the dual-teacher mode	5.01	1.91
I think students understand the knowledge taught in dual-teacher class better	5.53	1.54
I can give quality lessons independently with teaching cases developed in person thanks to the dual-teacher mode	5.59	1.51
Dual-teacher mode brings forth my reflection on teaching	5.72	1.43
All teachers involved in a dual-teacher class can grasp the situation of synchronous interactive class at any time	5.66	1.45
I am obliged to take care of students' learning jointly with remote teachers	5.64	1.50

Generally speaking, students perform better than usual thanks to the "dual-teacher mode" (the average value exceeds 5, and the standard deviation is about 1.5). They highly agree on having a chance to gain knowledge and know life outside the countryside via the "dual-teacher class" (average value of 5.76, which is also the maximum value). It can be seen that the "dual-teacher class" enables information outside to rural students to enrich their knowledge and life experience. There is less interaction between students and remote teachers in "dual-teacher class" in light of students' inactive question answering (average value of 5.04, which is also the minimum value).

Table 6 Feelings about Dual-teacher Class of Students in Suichuan County

	Average value	Standard deviation
I like the "dual-teacher class"	5.47	1.54
I prefer "dual-teacher class" to traditional teaching	5.23	1.69
The "dual-teacher class" is conducive to boosting my learning enthusiasm	5.44	2.52
I study harder than before thanks to the "dual-teacher class"	5.26	2.82
I will prepare lessons before class thanks to the "dual-teacher class"	5.36	2.00
I will review lessons after class thanks to the "dual-teacher class"	5.41	1.55
I can understand the knowledge taught in the video	5.57	1.48
I understand the knowledge taught by local teachers better than teachers in the video	5.55	1.45
I get my school record improved thanks to the "dual-teacher class"	5.22	1.53
I can finish my homework on time thanks to the "dual-teacher class"	5.52	1.43
I often answer questions actively in the "dual-teacher class"	5.04	1.74
I often exchange with classmates in the "dual-teacher class"	5.22	1.60
I exchange more with local teachers thanks to the "dual-teacher class"	5.39	1.59
I have a chance to know the knowledge and life outside the countryside thanks to the "dual-teacher class"	5.76	1.45

2.1.3 Teachers' professional development

According to the field research results, basic knowledge accounts for the largest proportion to advanced study and training (77.10%), followed by teaching practice in class (75.63%), teaching theory (62.18%), and class management (51.68%). Teachers are generally more enthusiastic about attending advanced study and training, among which 76.26% (the largest proportion) are willing to learn from masters' lectures. When it comes to the most effective advanced study and training approaches to improve teaching skills, they rank learning from masters' lessons (76.47%), inter-school lesson appreciation (60.08%), inner-school lesson appreciation (56.30%), expert lectures on education and teaching (52.94%) and training by county instructors (31.93%) first, second, third, fourth and fifth respectively. Suichuan County of Jiangxi Province has rich teaching research activities inside and outside the school in various forms online and offline. "Junior-senior Pairing Project," teaching research "community", teacher training, and inter-school exchange contribute to teachers' rapid growth in all respects, for instance, teaching methods, teaching resources, teaching philosophy, and teaching means.

"Junior-senior Pairing Project": Experienced teachers paired with inexperienced ones impart all the teaching experience, skills, and resources to them and help them quickly know more about students in practice, get familiar with the class and improve skills via widespread mutual lesson appreciation, teaching plan optimization, courseware sharing, among others. "Junior-senior Pairing Project" also features the pairing of experienced with inexperienced teachers in line with actual conditions varying from school to school. Additionally, schools and the government have introduced the practice in different forms to motivate young teachers and help them get acquainted with teaching in a short time, gain valuable teaching experience, and develop professionalism.

"Basically, the most efficient Junior-senior Pairing Project has been launched in the whole county. The same is true to the pairing of experienced with inexperienced teachers." (A teacher of YX Junior Secondary School). *"There is a Junior-senior Pairing Project dedicated to young teachers. The experienced teachers are paired with inexperienced ones throughout three years of senior secondary school learning."* (A teacher of SC Secondary School)

Teaching research "community": Scattered student in Suichuan County due to its wide-area leads to diverse rural school types with Chinese characteristics, such as teaching venues, village primary schools, and central schools, hence the emergence of teaching research "community."

In light of short distances and other actual situations, many schools are combined into a "community" to make collaborative discussions via appreciating lessons by teachers of key schools and giving the same lesson by teachers of different schools.

"We share lessons with them and welcome them to our school for exchange as well. There were teachers sent there for exchange in one year. (What kind of teachers were they?) They were generally subject leaders and cadre teachers. (Did they give lessons as the teachers there do in one year over there?) Yes. And they also send teachers here for a one-year exchange. This is the most effective." (A teacher of YX Junior Secondary School)

"Currently, our school has been combined with several other schools into a "community" for exchange via school principals' lectures, giving lessons among teachers, attending activities in other schools, and appreciating lessons by other teachers." (A teacher of CL Primary School)

Additionally, teachers in a "community" will share resources frequently via the Internet in real-time, which is benefited by convenient information technology. Students' learning situation and teaching styles vary from school to school, open class and other forms are primarily for demonstration and exchange purposes. For practical teaching, obtaining teaching resources is instead favored than other "community" teaching research functions.

Inter-school exchanges: Thanks to the investment increase in teachers and the improvement of rural schools' teaching conditions, inter-school exchanges for broadening teachers' horizons by sending them to other schools constitute one way to improve teachers' professionalism. Teachers can profoundly understand the teaching

philosophy and teaching methods of other quality schools when they are sent there for exchange over some time and then come back with the progressive ideas and successful experience to be promoted in rural schools to improve the teaching quality.

"I was sent to a county school not long ago to learn from the classroom decoration. Besides that, I also attended inter-school exchanges and training, through which I benefited a lot." (A teacher of CL Primary School)

2.1.4 Information-based teaching during the pandemic—Centralized display of the level of ICT in education in Suichuan County

The Education Department of Jiangxi Province adopted a unified teaching model for primary and junior secondary schools throughout the province during the pandemic.That is to say, prominent teachers were organized to record video courses online to be played for students of each grade uniformly on the "Ganjiaoyun" platform. All the primary and secondary school students can watch it on networked cable TV, Jiangxi IPTV (China Telecom), and Jiangxi IPTV (China Mobile), as well as on computers, mobile phones, and tablet PCs via the "Ganjiaoyun" platform. Under the Education Bureau of Suichuan County's guidance, teachers of various schools organized students to watch live quality courses online on the "Ganjiaoyun" platform recommended by the provincial authority. According to the overall arrangement of schools, by virtue of Seewo, teachers gave lessons online to the third-year junior secondary school students, with a total of 192 live review lessons; additionally, the county government also informed teachers of safety affairs and trained them for information-based applications.

The "Ganjiaoyun" platform's adoption of teaching by prominent teachers throughout the province is conducive to improving teaching skills. Teachers in Suichuan are generally young. Many of them from different schools mentioned the chance to learn teaching skills while watching prominent teachers' video courses on various subjects together with students. *"You will learn instructional design from prominent teachers' video courses and further find your shortcomings. It's really beneficial. They are skilled in explaining a difficult knowledge in a simple way, which I am very envious of."* (A teacher of ZA Primary School)

You can find drawbacks of unified teaching in the field of research. For instance, courses on "Ganjiaoyun" prepared based on teachers' past experience do not fully match rural students' specific situation. As mentioned by many teachers, some subjects are too difficult to understand or taught far more efficiently without coherence, or the examples are less targeted.

"You can still understand most courses if you listen carefully, except for English. The reason is that speaking in English in the class all the way is beyond the ability of our students." (A teacher of YX Junior Secondary School)

"Personally speaking, learning online is lack of coherence due to the shift of teachers every day. It was found based on feedback from students and video course viewing that the next teacher did not go on with the unfinished lessons of the last class and seldom went over the homework. Students only mastered some new knowledge, but

failed in solving problems." (A teacher of YX Junior Secondary School)

Because of the problems found, teachers in Suichuan County of Jiangxi Province adopted personalized homework assignments and timely home visits during the pandemic, as well as tutoring at home at a later period, etc., to help students review knowledge. Besides frequently posting information, as well as collecting and checking homework via WeChat group, teachers actively explored another means to keep in close touch with students. Based on the functions of image sending and voice input, teachers urged students to watch live video courses by asking them to take photos, send audio reading, among others; they also tried other resources to collect and check homework, as well as follow students' attendance, such as WeChat mini-programs mentioned by many teachers represented by "Mini Check-in", "Homework Register", "Homework Manager".

"We collected and checked homework with a WeChat mini program via mobile phones, not computers at that time. So we enlarged the text size because of the small phone screen." (A teacher of CL Primary School)

In light of the times' trend, teachers performed well in shifting from leading to the assistant role and optimized the teaching mode during the pandemic. After the pandemic situation was under stable control, teachers there continued information-based teaching.

"As an English teacher, I required students to send their text reading in WeChat group before I corrected their pronunciation during the pandemic. I found it still quite practical after the resumption of classes and carried it on with a fixed sending time in consideration of not much knowledge learnt in school and the importance of review." (A teacher of CL Primary School)

The novel teaching methods developed in response to the pandemic situation have broadened teaching ideas, improved results testing efficiency, and refreshed the education and teaching in the post-pandemic era. The provincial unified "Ganjiaoyun" teaching platform ensures online teaching coverage so that students in remote mountainous areas can watch prominent teachers' video courses on TV, hence a true "continuous learning during class suspension". However, the less targeted unified teaching leads to quite different learning effect for students at different levels. Fortunately, students' learning effect was improved steadily during the pandemic thanks to the local teachers' assistance in Suichuan County, for example, adjusting the difficulty degree of homework and after-school tutoring. After the pandemic situation was under stable control, these teachers also summarized the online teaching methods used before and optimized the local rural education and teaching with information technology.

2.2 Research results of ICT in education in Yulong County, Yunnan Province

Located in the south foot of Hengduan Mountains and the northwest of Yunnan Province, Yulong Naxi Autonomous County (hereinafter referred to as "Yulong County"), the only Naxi autonomous county in China, covers a total area of 6,198 square kilometers, 96.53% of which are mountainous and semi-mountainous areas. Characterized by Naxi people being settled among each other, with ethnic minorities here and there, the county had a total population of 225,300 by the end of 2019, including 193,500 ethnic minorities and 125,100 Naxi people, accounting for 85.9% and 55.5% of the total population respectively. Yulong County, as a poverty-stricken county at a national level, was lifted out of poverty in 2018. It currently has 116 schools of various types, including 101 primary schools, 9 junior secondary schools, 1 senior secondary school, 2 six-year schools, 2 nine-year schools, and 1 high vocational school. Among them, 1 senior secondary school, 1 six-year school, 2 nine-year schools, and 1 high vocational school are located in Yulong County, and the rest 111 schools are scattered in 16 villages (towns). The net enrollment rate of primary schooling reaches 99.68%. The completion rate of nine-year compulsory education reaches 93.30%, and the gross enrollment rate of junior and senior secondary schooling reaches 106.36% and 80.10%, respectively.

According to the samples involved in the field research, teachers there are generally middle-aged, averaging 41 and 44% of the teachers have been teaching for more than 20 years. The first academic qualification of teachers is dominated by associate bachelor (37.82%) and undergraduate (53.36%); those whose highest academic qualification is an undergraduate account for the largest proportion (78.99%), most of which obtain such qualification through formal schooling (69.33%) and correspondence (14.54%). There are 80 senior teachers (16.81%), 88 1st-grade teachers (18.49%), 175 2nd-grade teachers (36.76%) and 109 teachers with no rank (22.90%). The ratio of senior and 1st-grade teachers in primary schools is smaller than that in secondary schools. Most teachers (44.81%) have spent more than 10 years in learning and applying instructional technology. Only a few (6.37%) have spent 1-2 years in this regard, indicating generally long learning and applying time. Teachers there are stable and even enjoy good benefits if they are permanent ones.
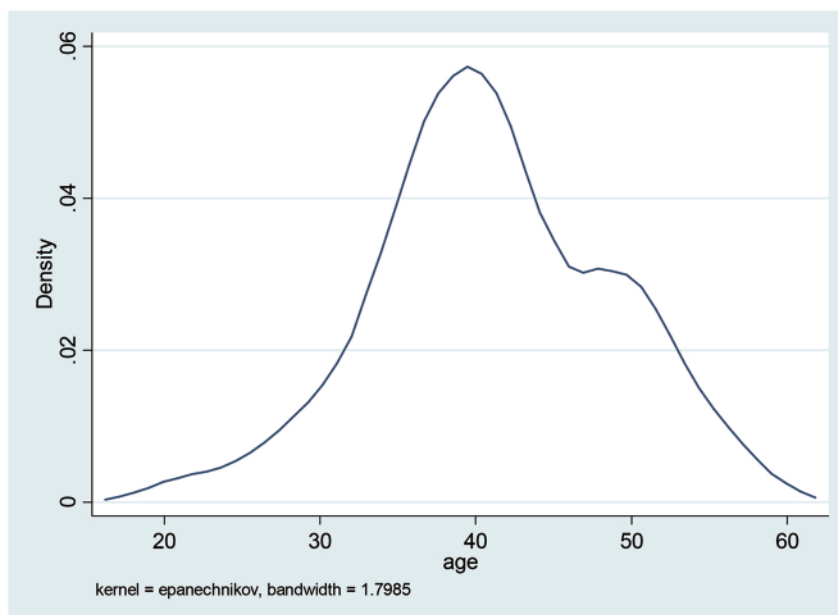

Fig. 14 Age Distribution of Teachers in Yulong County

Table 7 Basic Information of Teachers (N=848)

Variable	Amount	Percentage (%)	Variable	Amount	Percentage (%)
Gender			**Professional rank**		
Male	377	44.46	Internship	3	0.35
Female	471	55.54	2nd grade primary	133	15.68
Teaching stages			1st grade primary	240	28.3
Primary school	675	79.6	Senior primary	234	27.59
Secondary school	173	20.4	2nd grade secondary	55	6.49
Seniority			1st grade secondary	86	10.14
Less than 1 year	14	1.65	Senior secondary	74	8.73
1-5years	35	4.13	No-ranking	23	2.71
6-10years	68	8.02	**Time spent in learning and applying instructional technology**		
11-15years	124	14.62			
16-20years	228	26.89	1-2years	54	6.37
More than 20 years	379	44.69	3-5years	165	19.46
First academic qualification			5-10years	249	29.36
Graduate from secondary vocational schools (secondary normal schools, senior secondary schools)	436	51.42	More than 10 years	380	44.81
Associate bachelor	267	31.49	**The number of subjects**		
Undergraduate	143	16.86	At primary school		
Postgraduate	2	0.24	1	156	23.11
Doctor			2	208	30.81
Highest academic qualification	40	4.72	3	182	26.96
Graduate from secondary vocational schools (secondary normal schools, senior secondary schools)	257	30.31	4	96	14.22
Associate bachelor	547	64.5	≥5	33	4.89
Undergraduate	2	0.24	At secondary school		
Postgraduate	1	0.12	1	124	71.68
Others	1	0.12	2	46	26.59
			≥3	3	1.74
The way to obtain the highest academic qualification					
Formal schooling	205	24.17	Radio/TV university	23	2.71
Correspondence	536	63.21	Postgraduate classes	1	0.12
Online courses	1	0.12	Others	82	9.67

2.2.1 Development of ICT in education in Yulong County

The current construction of ICT in education there primarily relies on the "Rural Distance Education Project" launched in 2005 and the "Transformation Plan for Rural Schools Poor in Compulsory Education" (From now on referred to as the "Transformation Plan") launched in 2010. The "Rural Distance Education Project" gets schools their access to teaching-oriented CD player systems, satellite signals, and computer classrooms. However, only computer classrooms are in use due to the rapid update of information-based devices. There have been upgraded information-based facilities thanks to the Chinese government's total investment of more than 14.4 million RMB in the "Transformation Plan". Currently, Yulong County gets all primary and secondary schools, as well as teaching venues connected to the Internet at gigabit. Some classrooms are authorized to the dedicated Yunnan education network to ensure teaching activities. All schools involved in compulsory education are equipped with multimedia classrooms and electronic whiteboards can be seen in every classroom.

According to the field research on 8 schools, the average annual investment in ICT in education is 87,000 RMB, with a maximum of 250,000 RMB and a minimum of 0 RMB, leading to a large gap. These investments are primarily from superior departments.8 schools are making general short-term and medium and long-term plans for ICT in education and

Fig. 16 Having Lessons at HD Primary School, Yulong County

Fig. 17 Having Lessons at BG Primary School, Yulong County

Fig. 18 Having Lessons at YL2 Junior Secondary School

Fig. 15 Built-in Functions of the Electronic Whiteboard in HD Primary School, Yulong County

Fig. 19 Having Lessons at YL1 Senior Secondary School

building incentive and assessment systems for teachers' ICT-based teaching. Surprisingly, all teachers in these 8 schools receive training in information-based skills. 6 schools appoint staff to manage and maintain information-based devices, 4 of which appoint ones not specialized in information technology. The specific information-based software and hardware allocation of the schools visited is shown in Fig. 20.

	BS Primary School	HD Primary School	BG Primary School	JH Primary School	WB School	YL1 Senior Secondary School	YL2 Junior Secondary School	JH Junior Secondary School
Satellite TV								
Projector	■	■	■	■	■	■	■	■
Sound device	■	■	■	■	■	■	■	■
Video cassette recorder			■			■	■	■
Interactive whiteboard	■	■	■	■	■	■	■	■
Computer for teaching	■	■	■	■	■	■	■	■
All-in-one machine	■	■		■			■	■
Computer room	■	■			■	■	■	■
Tablet PC	■	■		■	■		■	
Multimedia reading room		■			■			
Computer for handling office work	■	■	■		■	■	■	■
Printer	■	■	■	■	■	■	■	■
Teaching plan library						■		
Material library	■	■	■	■	■	■	■	■
Multimedia courseware database	■	■	■	■	■	■	■	■
Quality teaching case library	■	■	■	■	■		■	■
Question bank	■	■	■	■	■	■	■	■
Electronic lesson preparation system					■			
Digital library								
Online course platform						■	■	■
Personal learning space online	■							

Fig. 20 Information-based Software and Hardware Allocation of Schools Visited in Yulong County
(green means equipped, white means unequipped)

All schools are equipped with complete hardware devices, such as projectors, interactive whiteboards, and computers, except for multimedia reading rooms; additionally, personal devices like tablet PCs are less seen in rural schools. As for software devices, almost all schools have a material library, multimedia courseware database, quality teaching case library, and question bank (secondary schools are basically equipped with an electronic lesson preparation system); however, they are short of the libraries, online personal learning spaces, etc.

The most frequently used electronic devices every day are interactive whiteboards (48.47%), all-in-one machines (35.14%), computers for teaching (34.91%) and projectors (34.79%), which are also rather frequently used weekly; moreover, the weekly use frequency of printers and computers for handling office work exceeds 60%. More than half of teachers unveil no multimedia reading rooms (54.36%), tablet PCs (51.65%), or other relatively advanced information-based teaching devices equipped. However, the information-based devices introduced in the first "Rural Distance Education Project," such as video cassette recorders, CD player rooms, satellite TVs, are used less frequently, and 30%-40% of teachers unveil no more such devices equipped further. According to Yulong County, schools have fully applied information-based devices to teaching and ensured their regular running. As for the old devices failing to be replaced in time by the state or county Party committee, schools will get them running again with the state's public fund.

Fig. 21 Smart Classroom of Yulong WB School (a nine-year school)

Fig. 22 Use Frequency of Various Information-based Devices for Teachers in Yulong County
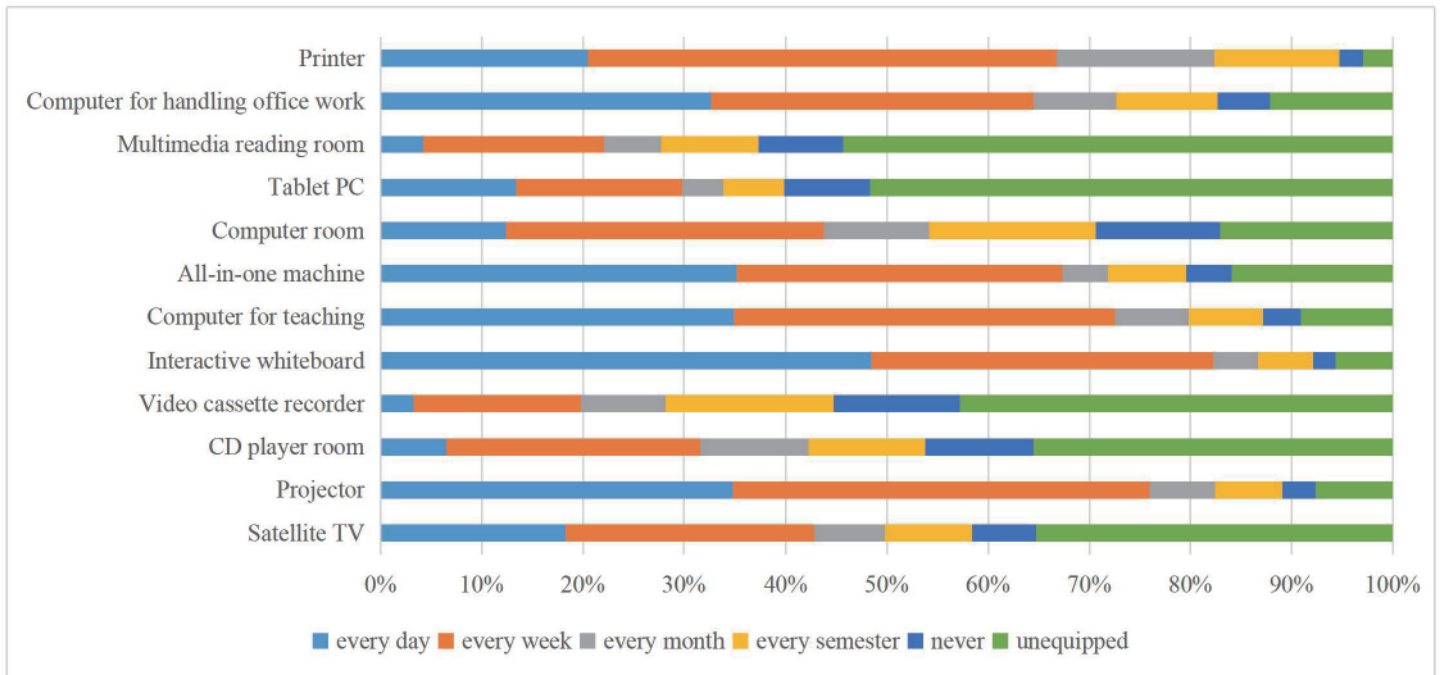
In terms of digital resources online, teachers using multimedia courseware database (22.17%), teaching plan library (16.04%), and electronic lesson preparation system (15.21%) every day account for the largest proportion, and more than half of them use the above resources every week. In contrast, digital libraries, masters' online classes and question banks are less frequently used, with less than 10% of teachers using them every day. Additionally, 55.78% of teachers unveil no digital library equipped, and 30% unveil no such resources as electronic lesson preparation system, material library, and teaching plan library equipped. Masters' online classes and online course platforms are largely equipped in light of promoting the Hope Project driven dual-teacher experimental schools dedicated to ethnic minorities, with only about 20% of teachers not using such resources. Generally speaking, information-based hardware and software devices are frequently used there, which is also proved via interviews with teachers. According to many teachers, especially the teachers in dual-teacher experimental schools, *"Actually, I use them almost every day as long as there is electricity."* (A teacher of BS primary school) ."*So do our teachers. They use them every day unless they are broken."* (A principal of BG primary school) *"Teachers play courseware, PPT, listening comprehension, etc. three-fourths of a class."* (A teacher of YL2 Junior Secondary School)

Fig. 23 Use Frequency of Information-based Resources in Yulong County
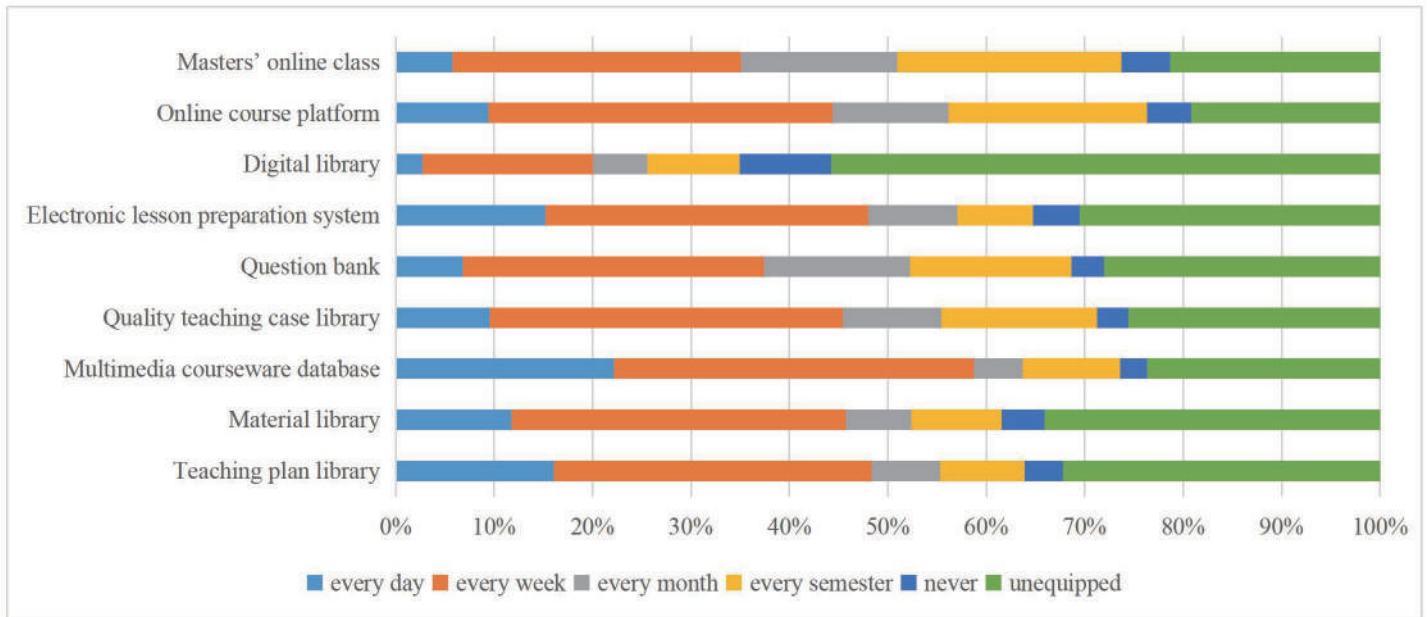
According to the field research on teachers' satisfaction with their use of digital resources, they are generally satisfied (the average value of each item exceeds 5.20 ,and the standard deviation is about 1.4). Schools also purchase teaching resource databases with self-raised funds, such as subject databases and resource databases for the National College Entrance Examination, to facilitate teachers' information-based teaching.

	Average value	Standard deviation
Teaching plan library	5.33	1.38
Material library	5.25	1.42
Multimedia courseware database	5.30	1.39
Quality teaching case library	5.29	1.38
Question bank	5.24	1.37
Electronic lesson preparation system	5.32	1.41
Digital library	5.51	1.45
Online course platform	5.20	1.42
Masters' online class	5.25	1.39

Table 8 Satisfaction with the Use of Digital Resources of Yulong County

Generally speaking, Yulong County has completed mechanisms towards its construction of ICT in education, as well as fully prepared hardware facilities and online resources, which is conducive to the promotion and implementation of information-based teaching.

2.2.2 Information-based teaching

In order to understand the situation of information-based teaching there, especially during the pandemic, the research group conducted a questionnaire survey on teachers and students and conducted profound interviews with principals and teachers of 8 schools.

2.2.2.1 Need to improve ICT-based skills and highlight dedicated lessons

75.35% of teachers involved in the field research believe that instructional technology is the application of information technology and related theories in education for the sake of serving to teach; 19.22 % regard instructional technology as an aided means of instruction; 47.17% agree with the information-based teaching reform and innovation and call for its implementation; 39.86% uphold such reform and could take the initiative to improve themselves to meet the requirements, regardless of difficulties; 9.79% could do it as required but need a push as they are less active; and only 2.48% reject information-based teaching from competence and attitude perspectives. Generally speaking, teachers understand information-based teaching positively and accept it.

As shown in Table 9, teachers can do information-based teaching. Detailedly, they can basically do text input, editing and typesetting (average value of 4.93), know well various software for downloading resources (average value of 4.80) and do well in PPT preparation (average value of 4.80); relatively speaking, they are unskilled in

	Average value	Standard deviation
You can skillfully use all kinds of retrieval tools for targeted information retrieval	4.77	1.68
You can download resources with all kinds of the software concerned, such as Thunder	4.80	1.71
You are proficient in basic operations of text input, editing and typesetting	4.93	1.67
You are proficient in PPT preparation, etc.	4.80	1.69
You are proficient in simply processing images with Photoshop	3.92	1.78
You are proficient in recording and editing audios and videos with software concerned	3.75	1.84
You often exchange with other teachers the selection and production of teaching resources	4.78	1.64
You are familiar with resource acquisition platforms, such as public service platforms of educational resources and platforms of fully covered teaching resources,	4.42	1.67
You can choose the right resources for distance education and online educational	4.55	1.64
You will develop certain teaching resources according to your own needs	4.19	1.78
You will present the teaching items in video, audio, words and other appropriate media means according to the teaching needs	4.39	1.75
You can innovate teaching items with the help of information-based and local resources	4.35	1.66

Table 9 Information-based Teaching Skills of Teachers in Yulong County

recording and editing audios and videos with software concerned (average value of 3.75), nor are they skilled in simply processing images with Photoshop (average value of 3.92). It can be seen that teachers there can meet the basic requirements of courseware preparation but need to strengthen their information-based skills overall.

Consistent with the results of the questionnaire survey, most teachers interviewed express their master of such basic operations as text input, editing and PPT preparation; however, some relatively complex information-based skills like teaching-oriented animation making vary from teacher to teacher.
"(Do you make animation?) We all can make it." (A teacher of BS primary school)

"Teachers including those aged about 55 master basic skills ...They can operate this device now ...Making animation and adding effect, videos, and texts, etc. may be challenging as for courseware preparation; however, it is all right to operate that device." (Principal and teachers of YL1 Senior Secondary School)

"Young teachers know operations concerned at least, regardless of well or not." (A teacher of BG primary school)

As shown in Table 10, teachers generally accept information-based teaching (the average value of each item exceeds 5, and the standard deviation is small). Most of them agree with a better information-based teaching effect than conventional education (average value of 5.18). They fairly agree with school's maintenance and introduction of such devices facilitating their information-based teaching (average value of 4.89), no trouble arising from information-based teaching (average value of 4.66), more interactions thanks to information-based teaching (average value of 5.12), and students' more passionate learning due to information-based teaching (average value of 5.24). Information-based means make teaching more interesting and interactive. According to teachers, electronic whiteboards and matched teaching resources to contribute to diverse teaching methods and a relaxed teaching atmosphere, hence a positive effect on both teachers and students.

	Average value	Standard deviation
I am very satisfied with the use of information technology in teaching	4.79	1.62
I think information-based teaching is more effective than conventional teaching	5.18	1.49
The school's maintenance and introduction of such devices facilitate my information-based teaching	4.89	1.62
Information-based teaching did not trouble me much	4.66	1.63
There are more interactions between students and me thanks to information-based teaching	5.12	1.52
Information-based teaching enables students to learn more passionately	5.24	1.48

Table 10 Feelings and Attitude towards Information-based Teaching Mode in Yulong County

"Information-based teaching benefits both teachers and students in the class. Sometimes students rushed to answer questions presented in animation. There are extensive readings, videos, and temporary videos also presented in animation. What I show you today is a temporary video and exercise of such type. Students can do exercises presented in animation with a pen. (Live interaction is available, isn' t it?) Sure. Besides, it' s excellent. Especially in Chinese class, students read first, followed by teachers and me, with three parts. It couldn't be better." (A teacher of BS primary school)

2.2.2.2 Effect of dual-teacher mode

According to interviews with the local Education Bureau staff, Yulong County has taken the lead in piloting dual-teacher mode since 2016 based on the Hope Project in Yunnan dedicated to minorities. By virtue of quality educational resources online in Huanggang, Hubei Province and combined with local teachers' offline teaching, teachers are thus interacted with each other to embrace better teaching effect. By September 2019, the dual-teacher class covered all subjects in all primary and secondary schools, benefiting nearly 6,000 students. The Education Bureau further advanced "Three Classrooms" throughout the county. In light of the resource sharing philosophy of "Three Classrooms", Yulong County developed the "1+N" interactive teaching mode according to the actual situation to enable qualified teachers to more students.

As shown in questionnaires from teachers, students can receive quality teaching with the help of dedicated lessons (average value of 5.31), masters' lessons are conducive to improving teaching skills (average value of 5.38), local students can understand the teaching items of dedicated lessons (average value of 4.76) and teachers often enrich themselves with resources online (average value of 4.45). Giving lessons by playing remote teachers' video courses stored in CDs (average value of 3.96) and the Air Class mode (average value of 3.82) are less adopted, indicating teachers and students' desire for more opportunities and initiative to be taken, as well as teachers' pursuit of professionalism and novel teaching mode via substantial exchanges with remote teachers, instead of the acquisition of learning resources, a primary purpose of rural education in the past. Teachers fairly agree with enriching the items taught and adding difficult knowledge thanks to the dual-teacher mode, having a chance to prepare lessons collaboratively with teachers online thanks

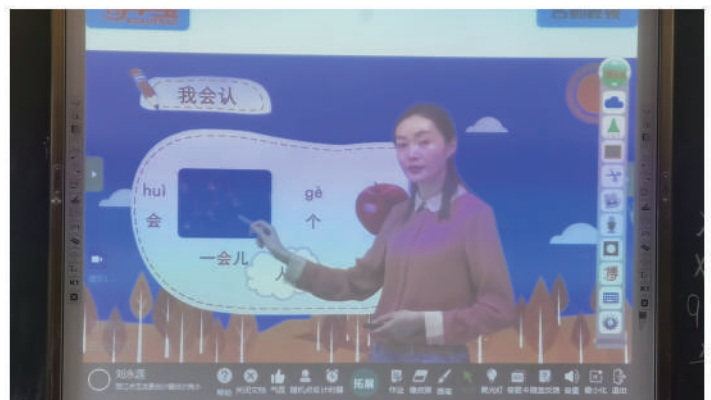Fig. 24 Dual-teacher Class of BS Primary School of Yulong County

Fig. 25 Live Dual-teacher Class of BS Primary School

all teachers' grasp of the situation of synchronous interactive class at any time thanks to dual-teacher class and obligation to take care of students' learning jointly with remote teachers.

	Average value	Standard deviation
Students can receive quality teaching with the help of dedicated lessons	5.31	1.47
Masters' lessons are conducive to improving my teaching skills	5.38	1.44
Local students can understand the teaching items of dedicated lessons	4.76	1.61
I often give lessons by playing CDs, that is, giving priority to teaching over CD playing	3.96	1.89
I often adopt Air Class mode, that is, explaining the knowledge mentioned in Air Class programs while watching them	3.82	1.92
I often enrich myself with resources online, that is, giving lessons online and preparing lessons via the Internet	4.45	1.74
I enrich the items taught and add difficult knowledge thanks to the dual-teacher mode	4.30	1.73
I timely check students' homework and feed it back to remote teachers thanks to the dual-teacher mode	3.85	1.88
I have a chance to prepare lessons collaboratively with teachers online thanks to the dual-teacher mode	4.13	1.90
I feel that I have lost the leading role in class due to the dual-teacher mode	3.68	1.87
I think students understand the knowledge taught in dual-teacher class better	4.39	1.73
I can give quality lessons independently with teaching cases developed in person thanks to the dual-teacher mode	4.42	1.69
Dual-teacher mode brings forth my reflection on teaching	4.84	1.68
All teachers involved in the dual-teacher class can grasp the situation of synchronous interactive class at any time	4.54	1.73

Table 11 Attitude towards Dual-teacher Mode in Yulong County

It is further understood in interviews the impact of information-based means on teaching. First of all, digital resources online benefited from the information-based teaching help enrich items to be taught. Teachers get their teaching facilitated thanks to Boxuezhiyun App with rich resources uniformly applied by the local Education Bureau to the Hope Project in Yunnan dedicated to minorities.

Fig. 26 A Screenshot of Yulong County's Boxuezhiyun App

According to teachers in BS Primary School, there are plenty of teaching resources to be chosen from in class: *"Dual-teacher class is the focus, plus matched teaching CD-ROMs by the People's Education Press. In the beginning, we liked CD-ROMs due to excellent resources in them. Now, our math teachers prefer CD-ROMs most in particular, while Chinese teachers prefer Boxuezhiyun App. In other words, it varies from subject to subject."* (A teacher of BS primary school)

Quality digital teaching resources online can also effectively make up for the teachers' problems and deficiencies in their teaching. Some ethnic minorities, influenced by dialects, find it hard to avoid speaking with an accent. In dual-teacher Chinese classes at primary schools, online teachers' standard text reading acts as a good example for students.

"It works for text or Chinese character reading. It is better to read after teachers online than those of ethnic minorities like me in light of our poor Mandarin." (A teacher of WB School)

Teachers give lessons in combination with short and concise knowledge explanations in fragments available thanks to "dual-teacher mode," thus helping students work out key and challenging questions. "Dual teachers" complement each other as teachers online classify and explain knowledge and teachers offline analyze and guide students through key and difficult points. For example, a teacher of a primary school pointed out:

	Average value	Standard deviation
I like the "dual-teacher class"	4.62	1.76
I prefer the "dual-teacher class" than traditional teaching	4.52	1.68
The "dual-teacher class" is conducive to boosting my learning enthusiasm	4.83	1.54
I study harder than before thanks to the "dual-teacher class"	4.69	1.59
I will prepare lessons before class thanks to the "dual-teacher class"	4.68	2.25
I will review lessons after class thanks to the "dual-teacher class"	4.62	1.61
I can understand the knowledge taught in the video	4.90	1.54
I understand the knowledge taught by local teachers better than teachers in the video	4.87	1.55
I get my school record improved thanks to the "dual-teacher class"	4.61	1.55
I can finish my homework on time thanks to the "dual-teacher class"	4.79	1.57
I often answer questions actively in the "dual-teacher class"	4.38	1.63
I often exchange with classmates in the "dual-teacher class"	4.65	1.59
I exchange more with local teachers thanks to the "dual-teacher class"	4.73	1.53
I have a chance to know knowledge and life outside the countryside thanks to the "dual-teacher class"	5.22	1.51

Table 12 Feelings about Dual-teacher Class of Students in Yulong County

"Students got confused by equivalent relation in their preview and then figured it out thanks to the explanation by teachers on Boxuezhiyun App who made clear the logic through extracting the useful information and sorting relations out." (A teacher of BS primary school)

Students generally accept the "dual-teacher mode" (the average value exceeds 4.4 ,and the standard deviation is about 1.6). Most students like it and very much agree with the chance to know knowledge and life outside the countryside thanks to the "dual-teacher class" (average value of 5.22, which is also the maximum value). This mode helps enhance students' interaction with local teachers and learning enthusiasm, as well as their initiative of preview and review. Students who would like to answer questions actively in "dual-teacher class" account for the smallest proportion (average value of 4.38, which is also the minimum value).

2.2.3 Teachers' professional development

According to the field research results, teaching practice in class accounts for the largest proportion of advanced study and training (83.73%), followed by basic knowledge (74.76%), teaching theory (70.87%), and class management (58.84%). Teachers are generally more enthusiastic about attending advanced study and training, among which 85.97% (the largest proportion) are willing to learn from masters' lectures. When it comes to the most effective advanced study and training approaches to improve teaching skills, they rank learning from masters' lessons (86.44%), expert lectures on education and teaching (61.20%), inter-school lesson appreciation (53.54%), inner-school lesson appreciation (45.64%) and training by county instructors (29.83%) first, second, third, fourth and fifth respectively. Yulong County of Yunnan Province has developed diverse activities dedicated to teachers' improvement in professionalism in all respects, such as school-based teaching research, teacher training, and inter-school exchange, thus contributing to teachers' professional growth information-based teaching competence.

School-based teaching research is the most basic of teaching research activities. Teachers of the same subject team up to prepare lessons and address challenges collectively, which is also conducive to unifying teaching schedules and arranging teaching plans. The research, characterized by face-to-face interaction, is also the most convenient one. Teachers can share their ideas in the teaching research group immediately and test research outcomes quickly in practice via appreciating lessons, giving the same lesson by different teachers, preparing courseware together, etc. Almost every school develops a school-based teaching research mode centered on a "teaching research group".

"We often prepare lessons together and exchange with each other because teachers of the same subject are arranged in one office. What' s more, teaching research activities are held weekly, during which we discuss questions together." (A teacher of YL2 Junior Secondary School)

Teacher training constitutes another important means to advance professionalism. Yulong County has currently developed a reasonably perfect teacher training system, enabling teachers to attend projects at the county level, state level, and even world level. Part of the exchange and discussion mechanisms has long been stable to

advance teachers' long-term professional growth.

"A lot of such training activities are held in the county every year for the sake of teachers' growth, and the teachers of our school also attend them. For example, our teachers attended seminars on exercises and Chinese reading in Lijiang City a week ago." (A teacher of WB School)

Additionally, Yulong County promotes inter-school exchanges in various forms, including competition, job rotation, "Master Studio", exchange with countryside teachers, etc. Through which teachers' horizons are broadened, teaching experience is shared in mutual discussion, and professionalism is improved. The inter-school exchange has been gradually extended with the increasing attention to the professional growth of rural teachers. Many schools are pairing with schools in other provinces and cities for long-term exchange via quality platforms.

Attention has been gradually paid to training teachers' information-based skills amid ICT advancement in education for rural schools. At present, Yulong County, focusing on improving information-based competence, still trains their teachers in basic operations of such information-based devices as office software represented by Word and electronic whiteboards. Teachers can meet the basic needs after training. In general, Yulong County of Yunnan Province has rich teaching research activities in line with the teaching reality, such as mutual discussion and resource sharing via the Internet; it also has teacher training at all levels that value using information-based means in teaching. In this regard, teachers can operate basic information-based devices and office software and frequently use them in teaching to achieve good results.

2.2.4 Information-based teaching during the pandemic—Centralized display of the level of ICT in education in Yulong County

The local Education Bureau (hereinafter referred to as the "Education Bureau") issued such implementation plans as "Notice on the Ninth-grade Teaching Work during the Pandemic Prevention and Control" on February 26, 2020, making clear measures to guarantee online learning for the sake of "continuous learning during class suspension".

First of all, the Education Bureau backed standard teaching during the pandemic with the help of network operators. China Telecom Lijiang Branch and China Mobile Lijiang Branch took active actions to build cloud classes and Wuxianbao free of charge for the sake of online teaching. The two network operators also arranged professionals to install and debug equipment in time and trained teachers in using the software concerned to ensure regular online teaching. Schools can choose the appropriate online teaching platform according to their own needs.

"First was ViLin provided by China Mobile. It is like Netmeeting dedicated to videoconferencing. Later was Wuxianbao developed based on online courses, hence a must to charge money at the beginning. However, according to the documents by the state and the government, we used it free of charge at that time." (A teacher of YL1 Secondary School)

Fig. 27 Facilities for Live Class of YL1
Senior Secondary School during the Pandemic

Major network operators charged nothing for traffic and discounted telephone charges to ensure students' online learning conditions and back regular online teaching.

"Contact China Mobile and see if students can get free traffic, telephone charges, or something like that after the school' s active coordination. Spare no effort to meet students' needs as much as possible." (A principal of YL1 Senior Secondary School)

Secondly, schools' leadership and teachers all made crucial contributions to online teaching during the pandemic. Teachers spent similar hours in live teaching to offline teaching. The review class dominated at the beginning to help students review knowledge taught before. More time was spent in instructional design regarding preparing lessons, collecting online resources, designing online interaction and correcting homework than teaching offline to ensure students' quality online learning. Meanwhile, teachers' information-based skills got improved to a certain extent. After the resumption of classes, some teachers still adopt the combination of online and offline teaching via online teaching platforms, hence the emergence of a new teaching mode with advantages of both forms.

"It was an inspiring time. School teachers of all grades, especially those of the third grade, turned to live to teach and then checked homework. Students were very concentrated and hoped not to miss any live class on DingTalk during the pandemic ,though. Parents' meeting was also held online later. The created DingTalk group is still in use sometimes on weekends." (A teacher of YL1 Secondary School)

In the specific implementation, some primary schools arranged prominent teachers of respective subjects to give lessons on the cloud class to ensure the learning of low-grade students' learning in nearby areas during the pandemic. *"Since the pandemic started, our school especially got all six-grade students and students of other grades in the township access to live courses given by a good local teacher, which achieved good results."* (A principal of BG Primary School)

It is worth mentioning that premised on meeting pandemic prevention requirements, teachers in the county, motivated by getting each student with a textbook, sent textbooks in person to students' home to maximize their quality online learning in the difficult environment in light of class suspension due to increasingly severe pandemic situations. Unfortunately, some students, subject to economic conditions, couldn't watch online courses at home due to the lack of devices. In response to this, teachers, in the call of school leadership, teachers gave lessons at the village activity center to ensure that no one missed the courses or fell behind.

"So, teachers, out of teacher-student love, drove to the student's home (even 150 kilometers away) in each township and village one after another with packed textbooks to be used at the next semester. Those were really difficult days. Personally speaking, students felt schools and teachers' hard work." (A teacher of YL1 Secondary School)

Generally speaking, the rapid response made by the county during the pandemic is worth learning and reference. The government's overall arrangements, social forces' assistance, school leadership's quick response ,and teachers' changes and efforts made for online teaching all contributed to students' online learning to a certain extent. However, teaching quality was thus affected by such aspects as the particularity of the sudden burst pandemic and the separation between teachers, and students. Luckily, these problems reveal the information-based construction and teachers' information-based skills that need to be improved according to local conditions.

2.3 Experience in developing ICT in education for rural schools in Yulong County and Suichuan County

Field research results on the two counties represent the epitome of China's ICT application in advancing its rural education quality and demonstrate the changes of China's rural education brought about by its measures towards ICT in education in rural areas since the beginning of this century. It is found in the research the remarkable results achieved in China's ICT application in rural schools, contributing to gradually typical application of information technology in teaching and information-based teaching upgrading of some rural central schools. ICT in education for rural schools is now challenged by quality software development and qualified teachers, instead of lack of devices. Compared with cities, rural areas have their ICT in education shifted from absolute backwardness to structural backwardness, hence a little bridged digital gap. There are higher requirements on integrated resource databases online. Based on the research results, the aspects below concluded are supposed to advance China's rural education primarily.

2.3.1 County-level education department's formulation and implementation of overall plans for ICT in education according to local conditions

According to the research results, county level education departments have attached great importance to ICT in education. They have prepared overall ICT-based plans according to local conditions with the resources and investments thanks to the national "Transformation Plan" and "Three Classrooms" after considering their education development level and status. Schools plan for advancing ICT in education year by year and ensure its implementation and information-based teaching effect through reforming teaching mode and the system of

implementation and information-based teaching effect through reforming teaching mode and the system of professionalism-induced teacher training and assessment.

For example, the local government of Suichuan County actively cooperated with the state arrangements to build a government-led mechanism for developing ICT in education with many departments involved. Suichuan County formulated and issued the "Implementation Plan for Accelerating ICT in Education in Suichuan County" in 2017 to accelerate its ICT application joined by all parties concerned. The county government also developed a long-term mechanism for investing in teaching-oriented audio-visual facilities with 30% of the central and provincial project funds (primarily "Transformation Project" funds), 30% of the county's education-related surcharges, and a certain proportion of the public funds per student. It has invested 50.0642 million RMB in ICT in education in recent three years (including 9.1426 million RMB in 2018, 22.8153 million RMB in 2019, and 19.4817 million RMB in 2020), with 70% in hardware, 13.5% in software, and 16.5% in personnel training approximately. Moreover, an assessment mechanism dedicated to ICT application was introduced to integrate the ICT application in teaching into teaching planning and the assessment on quantitative management objectives. The regular assessment was thus conducted, hence a good work orientation. 8 of the schools visited have basic plans for acquiring ICT-based hardware, gaining educational resources, building teaching platforms and management platforms, as well as improving teachers and students' information-based competence; and 1 school has a detailed plan to ensure the implementation of all work.

Yulong County of Yunnan Province developed its ICT in education into a cooperative mechanism with the state, local government, schools and society. First of all, the state projects and financial policies are the fundamental guarantees of the county's ICT construction.While implementing the state policies and advancing the state projects, the local government accelerated the ICT construction of the county, including supervising and tracking project implementation, cooperating with the financial allocation, allocating the resources within the county, etc. The Party committee of Yulong County cooperated in allocating funds in light of schools' actual conditions in its jurisdiction. For example, it invested more than 10 million in the ICT construction of a new school to build an information-based teaching platform.The local Education Bureau made overall arrangements for allocating and updating information-based facilities, with priority given to junior secondary schools, followed by primary and senior secondary schools.The planning is around ICT application in teaching thanks to well-constructed information-based infrastructure in the county. In this regard, efforts were made to give quality lessons of all subjects in line with the philosophy of "Quality Lessons + Project Promotion" and pursue normal ICT application to achieve quality teaching. All visited schools formulated plans for developing ICT in education. Under the guidance of such plans, schools, on the one hand, tracked the project implementation now and then and maximized resources by, for example, giving synchronous music, sports, or fine arts lessons by professional teachers to students in central school and village primary schools with the help of information-based devices; on the other hand, they called for improving teachers' information-based skills and guaranteed their master of information-based devices via in-school training, thus achieving the goal of ICT construction.

2.3.2 Educational resource sharing between urban and rural areas propelled by developing "Three Classrooms" teaching mode

The emergence and popularization of "dedicated lessons" can effectively make up for the structural shortage of teachers in the region, thus benefiting directly full curriculum with large coverage as required by compulsory education, and curriculum meeting compulsory education requirements as well as equal and balanced educational development in urban and rural areas indirectly. In Suichuan County, Jiangxi Province, some township central primary schools have given "dedicated lessons" on music, sports ,and fine arts to students in remote teaching venues. Yulong County also piloted a "1+N" interactive English class where students in dominated classroom and subordinate classroom learn fine arts with national characteristics jointly. Students can appreciate lessons carefully prepared by teachers from afar on the online platform and interact with teachers on the screen in real-time.

"Masters' lessons" are peculiar for China to address rural teachers' unsatisfactory teaching quality and low professionalism. Currently, both Yunnan and Jiangxi have built a "community" composed of teachers for advanced study and training online to conduct teaching research activities and teaching experience sharing among cadre teachers via such network platforms as QQ group and WeChat groups. In Suichuan County, teachers in a "community" will share resources and discuss teaching frequently via the Internet. Convenient information-based means have greatly accelerated resource sharing in real time.

"We will share courseware with them as long as they need it. The same is true to unit exercises, for example." (A teacher of YX Junior Secondary School)

"Teachers of different subjects involved in the county teaching research also created a group to discuss any difficult questions encountered in their teaching ,and those of the same grade teaching the same subject can express their personal opinions." (A teacher of YH Secondary School)

Yulong County's "masters' lessons" contribute to the interconnection between regions, hence learning and progress together among famous teachers and other ones. Yulong County has currently built a "community" composed of more than 10 famous teachers for advanced study and training online. Online teaching research boosts the relationship between instructors, famous teachers ,and ordinary ones, not to mention the platform to express their opinions. Accordingly, the teachers' traditional situation receiving information passively in teaching research activities is changed, hence teachers' continuous progress after exchange and discussion.

"By virtue of corresponding information technology like Seewo electronic whiteboard, we conducted live teaching research activities available to other school teachers." (A principal of WB School)

"Information technology teachers in charge of the examination concerned in the county created a group available for question discussion and resource sharing once needed." (A teacher of YL2 Junior Secondary School)

Anchored in quality schools, "online classes of famed schools" are to get students of rural schools to access to lessons given by famous teachers of key urban schools simultaneously via the Internet and electronic whiteboard; while rural teachers are there to assist in organizing activities in class, answering questions, checking homework and tracking learning effect. Students in some pilot schools in Yunnan have broadened their horizons and improved their performance by studying from the prominent Chengdu No. 7 High School. In addition to meeting students' needs for personalized development and quality education, "online classes of famed schools" help solve uneven educational resources distribution.

2.3.3 Attaching importance to training and improving rural teachers' information-based teaching skills

In addition to national and provincial training towards in-service teachers, the two counties have also explored diverse teacher training activities, such as "urban-rural teaching research community," "exchange with countryside teachers," "job rotation," "online training and school-based training," "workshop training." "training held in schools," "diagnostic training" and "Junior-senior Pairing Project," thus contributing to more training opportunities and improved teaching skills.

"There are more and more opportunities. Now, a teacher is required to attend at least 48 class hours of training at or above the county level in one academic year." (A teacher of HD primary school)

"It works in at least two aspects. First, hours and credits are necessary for registering the Teacher Certification every five years. You will get them once you finish your training; second, you will get your teaching skills improved accordingly." (A teacher of WB School)

Besides significantly boosting the interaction between teachers, the face-to-face training at the provincial level with famous teachers makes teachers trained to know more about the teaching atmosphere and methods of famous teachers directly. "I once attended a provincial training held in Nanchang involved with teachers of different schools. We sat very close and had discussions together. Lecturers also came from different places. That is why I prefer face-to-face training." (A teacher of ZA primary school)

Some specific localized measures towards teachers' professional growth are also found in the two counties in the field research. For example, a school in Suichuan, Jiangxi Province implemented the "Junior-Senior Pairing Project" to make inexperienced teachers adapt to teaching quickly and improve their professionalism.

"The so-called Junior-senior Pairing Project is to pair experienced teachers with inexperienced ones since many problems are troubling newcomers, for example, managing students, keeping the class under control, assigning homework and giving lessons." (A teacher of DJ junior secondary school)

2.3.4 Developing diversified partnerships

Multi-parties should collaboratively develop an effective mechanism to expand the coverage of quality educational resources by information-based means and build a diversified cooperative system for ICT construction in rural areas. Efforts should also be made to advance professional growth, get investments from enterprises and social public service organizations, as well as develop stable cooperative relations with colleges, universities, and professional organizations, thus facilitating ICT in education.

The Education Bureau of Suichuan County, Jiangxi Province has actively cooperated with multi-parties, for example, China Unicom and China Mobile to ensure normal network communication, as well as Shanghai Adream Foundation in sharing online courses. It has seized opportunities to realize pairing assistance and enlarge investments in ICT application in rural schools by effectively using social funds and other resources.

The county government and schools at all levels have also teamed up with other social forces. In response to the appeal by the Volunteer Association there and Shenzhen One Foundation, nearly 2 million RMB had been donated to Suichuan County to build 18 music classrooms in rural areas, make decoration and enrich digital equipment, music instruments, etc. as of 2019; Suichuan County cooperated with Shanghai Adream Foundation in 2020 in advancing the dreamy classroom project of 4 primary schools with invested 100,000 RMB by both sides, in which the Foundation helped build a "Dream Center" and a distinctive classroom integrating network, multimedia, books and class taking, and also provided training services; DJ Primary School, in conjunction with Jack Ma Foundation, built a Jack Ma Children's Palace equipped with a total of 40 Tmall Magic Screens, iPads and VR glasses, as well as toys like LEGO, thus enabling students to interact with remote teachers via VR amid daily learning. Information technology is also applied to activities of rural schools, besides teaching. Some schools contacted social public service organizations via the Internet to collectively hold themed activities like "protection of environmental water education" and "sex education"; DJ Primary School has a "Call Mom and Dad" corner to strengthen the

Fig. 28 Music Classroom of Suichuan CL Primary School Donated by the One Foundation

Fig. 29 Donated iPads and Other Devices of Jack Ma Children's Palace Affiliated to DJ Primary School

parent-child relationship because students can get in touch with their parents working outside at any time; teachers actively shared all kinds of resources online to get students frequently access to them, for example, all kinds of videos uploaded by overseas students in response to the organized activity called "See the World on the Window," to broaden rural students' horizons. They also actively attended teaching experience sharing activities at the county level initiated by colleges and universities, such as the "Experience Sharing Meeting on Online Teaching at Primary and Secondary Schools" dedicated to "online teaching stories" nationwide jointly organized by the Faculty of Education, Beijing Normal University and UNESCO International Research and Training Centre for Rural Education (UNESCO INRULED).

Inhabited by ethnic minorities in western China, Yulong County faces fairly backward economic growth and social progress, hence assistance and attention from all walks of life. Yulong County of Yunnan Province has made great efforts to boost the Shanghai-Yunnan Pairing Assistance Project, through which two smart classrooms were built for the schools there in 2019; it has reached an assistance plan with the Hope Project dedicated to Yunnan ethnic minorities to accelerate the allocation of information-based devices like teaching-oriented laptops and obtain "Boxuezhiyun" resource package for the sake of getting teachers access to online

Fig. 30 Projection Screen of Jack Ma Children's Palace Affiliated to DJ Primary School

resource library for their information-based teaching and backing "dual-teacher class." Technology companies of Yunnan invested in building a 1+N synchronous class base in the county, to address the shortage of music, sports ,and fine arts teachers. China Telecom and other network operators also contributed to remote and online teaching during the pandemic with its "Wuxianbao." In 2020, Yulong County of Yunnan Province and Beijing Normal University reached a pairing anti-poverty agreement involving financial support, training for teachers of management, consumption-based poverty alleviation, and school pairing assistance, to get Yulong County out of poverty by education; at the same time, Beijing Normal University built another education and teaching practice base in Yulong for fostering a quality rural teaching team.

The established multi-cooperative system broadens the sources of funds for ICT in education for rural schools, hence more investments in its ICT construction; all parties have contributed to rural students' growth and introducing software and hardware towards information-based teaching with their respective advantages, indicating their social responsibility and concerns of education.
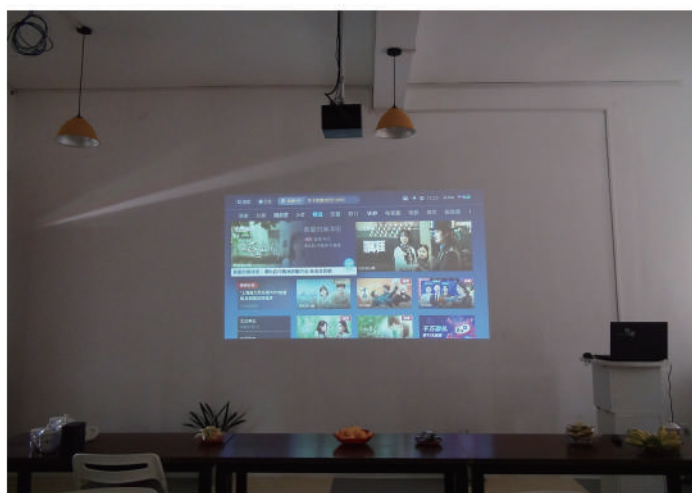
2.4 Challenges in the development of the two counties

Despite significant progress in the construction of ICT in education in rural areas, teachers' greatly improved information-based skills, and the upcoming deeply integrated ICT application in education found in the field research, the rural education system is challenged by the aspects below amid steady advancement of ICT application:

2.4.1 Challenges of sustainable ICT in education

Continuous investments greatly challenge information-based teaching in rural areas in light of such features of information-based facilities as high risk of damage, fast updating, and aging, remote rural teaching venues, and costly maintenance.

According to the Education Bureau of Suichuan County, Jiangxi Province visited, *"Failure to replace old and aging facilities due to seriously insufficient funds for their upgrading challenge the current ICT in education most. Such facilities cannot be used at all despite the Internet-connected to the county and village schools, thus restricting the advancement of ICT in education in rural areas".* Suichuan County is primarily confronted with old and aging facilities and slow updating in its ICT in education. Most of the "Class Accessible to ICT" installed between 2012 and 2016 are seriously aging. A YX Junior Secondary School teacher in the county mentioned the low brightness, fuzzy display, and frequent breakdowns of the projector in the interview. *"Personally speaking, the projector equipped is less bright and breaks down frequently."* What's more, few information technology professionals in some rural schools far from the county are available to repair the aging facilities, thus increasingly troubling the teaching.

"I called technicians in the county in case of multimedia facility breakdowns. Then they walked a long way to our teaching venue in particular, which is rather troublesome. We report breakdowns to the central primary school first, and then the central primary school sends technicians for maintenance." (A teacher of DJ Primary School)

"……Sometimes it is beyond our capacity. So we turn to technicians. But it takes time for them to arrive here. A device is supposed to be replaced, in five years in principle. All-in-one machines prevail and work better than projectors now because screens of projectors are easily broken due to low engine power." (A teacher of CL Primary School)

The sustainable ICT in education in Yulong County still faces a series of challenges. First of all, the county and schools couldn't afford constant software and hardware upgrading as required by fast developed information-based devices. According to local Education Bureau leaders, the information-based devices introduced at the beginning of the "Transformation Plan" in 2010 are seriously aging, hence a need to get them replaced.

"More electronic whiteboards are equipped to primary schools; additionally, YL1 Senior Secondary School upgraded their electronic whiteboards and computer classrooms. Devices in YL1 Senior Secondary School and

Yulong Minzu Secondary School in the county are rather aging because they were used in the first batch in 2010. YL1 Senior Secondary School has the most aging devices." (A head of the Education Bureau of Yulong County)

Daily maintenance of information-based devices trouble schools largely, and their breakdowns affect teaching activities and sap teachers' enthusiasm in using information-based devices to a certain extent. The aging electronic whiteboards that are commonly equipped often stop working due to breakdowns, and technicians excuse themselves for not repairing them by long-distance, frequent maintenance, among others. Most teachers in charge of maintaining information-based devices are non-professionals with limited capacity, leading to inefficient use of such devices in actual teaching. The limited self-raised funds also disappoint rural schools in updating and maintaining information-based devices. According to some teachers:

I still use (information-based devices) a lot, including broken or aging ones or those that take time to start up. That's why I make Plan B for each class in advance. However, several devices are broken probably because of aging, instead of the wrong operation. That's what technicians said. Those aging devices need to be repaired frequently, thus affecting teaching sometimes. So we want new devices. But they cost a lot of money. (A teacher of YL 2 Secondary School)

Devices failing to be repaired in time and accelerated depreciation lead to teachers' declining enthusiasm for using them, hence reducing use efficiency. In addition to frequent maintenance, aging devices can't load the latest digital teaching resources, hindering teachers from enriching their teaching with information-based devices further because of inconvenient operation.

According to the interviews with teachers, an unstable campus network also affects daily information-based teaching. In particular, dedicated lessons that require synchronization in different regions are inseparable from the high-speed campus networks. However, dedicated lessons are given by fits and starts in some remote areas under the existing network speed, hence failing to make sure effective participation.

According to primary and junior secondary schools teachers, there is no other paid software library to be used. YX Junior Secondary School in the county once mentioned the need for more teaching resources.

"What we particularly need now is resources because downloading courseware and resources on the Internet costs money. Our school used to buy resources. Teachers are very troubled by sorting resources out after downloading them." (A teacher of YX Junior Secondary School)

Only Suichuan Senior Secondary School in the county bought richer test resources on its own.

"Our school also purchased the services of several websites like https://www.zqy.com/, https://www.zxxk.com/, and https://www.ks5u.com/index.shtml. Such services include the intelligent test paper composition systems, courseware, and video downloading, etc. Teachers set questions via the intelligent test paper composition system and get answers automatically. They also download the courseware and modify it on their own." (A teacher of SC Senior Secondary School)

2.4.2 Challenges of continuous improvement of teachers' information-based teaching skills

According to the field research, teachers in the two counties are basically qualified to use information-based devices in teaching and courseware preparation. In particular, Suichuan County has recruited many young teachers due to the "Special Post Program" in recent years, hence an edge over information-based skills. But, there is insufficient information technology to back students' independent study.

Teachers' prominent problems in the two counties are the unskilled operation of online platforms, tools and techniques, lack of the Internet and hardware, a few teaching materials, and unstable teaching platform. Teachers primarily solve problems by asking colleagues for help, looking up data, and discussing with other teachers involved in the teaching research. Only about 20% of teachers solve problems utilizing advanced study and training activities or county-level teaching research activities, and about 10% give them up due to lack of channels. According to teachers interviewed, some teachers, limited by their familiarity with the software operation, would give it up and turn to the traditional teaching model to spend less time in knowledge explanation.

It is also found that teacher training in the two counties, though fairly complete, is dominated by pedagogical knowledge, subject knowledge ,and class management instead of information-based teaching. Some schools hope for more practical training. *"I chose information technology as an elective. Unfortunately, I learnt nothing seemingly probably because it is far more theoretical than practical. That is to say, practice is unavailable on any platform."* (A Teacher of CL Primary School)

The situation in which teachers in the two counties teach multiple subjects is very prominent. It happens to primary and secondary schools in Suichuan County, especially primary schools. 14.29% of primary school teachers teach two subjects, 11.28% teach three or more subjects; 10.79% of secondary school teachers teach multiple subjects. Additionally, in response to the states' call for more teachers majoring in music, sports ,and fine arts in rural areas, these newly recruited teachers need to teach Chinese, mathematics, English ,and other key subjects because of no significant increase in teachers of key subjects. In Yulong County of Yunnan Province, it is very common for a primary school teacher to teach multiple subjects. Only 23.11% of teachers there teach one subject, and the remaining teachers teach at least two subjects, of which 26.96% teach three or more subjects. It seldom happens to a secondary school teacher, with only 28.32% teaching multiple subjects. The uneven allocation of teachers leads to teachers' shortage in some subjects and the need for one teacher teaching multiple subjects temporally. Schools' desire for giving lessons by specialized teachers is barely to be fulfilled currently in rural schools.

"Some teachers have to teach multiple subjects. For example, math teachers teach physics and biology, or Chinese teachers teach virtue and law." (The principal of WB School)

Young teachers in Suichuan County that are mostly recruited thanks to the "Special Post Program", etc. can teach at county and city schools as long as they pass the examination after teaching at rural schools for 3 to 5 years.

Rural young teachers are generally not fixed in one place. A school principal jokingly called his junior secondary school a "training base" where new teachers leave after five years of training. Teachers who have been teaching for three years are called "experienced teachers" and even teachers with three years of teaching experience hold teaching research positions like lesson preparation leader. The high mobility of teachers challenges the teaching quality, management ,and development of rural schools.

2.4.3 Challenges of digital divide

The digital divide is an important issue of ICT in education worldwide. Amid economic growth and social progress, the digital divide has gradually represented the gap between information-based skills rather than equipped information-based devices, thus constituting a crucial factor to the increasingly differentiated educational outcomes between urban and rural students. According to field research, there is still a certain gap in allocating information-based devices for students in Suichuan County and Yulong County. Most students in the two counties have only one kind of online learning device (the mobile phone that belongs to their parents) and cannot study online unless their parents are at home. Additionally, students there primarily connect to the Internet with traffic due to low WIFI coverage rate. Only about 6% of students connect to WIFI, not to mention a few students have no access to the Internet; moreover, some teachers mention that the grandparents of stay-at-home children fail to pay the phone bill in time.

In the questionnaire survey towards students in Suichuan County, Jiangxi Province, most students (59.18%) have one kind of online learning devices, some students (34.97%) have two kinds, and less than 6% have three or more kinds; students preferring mobile phones and tablet PCs in their online learning account for the largest proportion (80%), followed by those preferring TVs (38.37%), as well as preferring desktops and laptops. According to the students' evaluation of the Internet situation during their online learning, most students (82.96%) choose better and a small proportion (8.78%) choose worse; about one-fifth of the total students (20.31%) get access to the Internet with traffic, some students (6.43%) with WIFI and 16 students (1.63%) with nothing. Most students (63.66%) say that teachers give lessons with the computer or TV almost every day, and only a few students (4.78%) mention teachers' little use of such devices in class.

A total of 668 valid questionnaires towards students in Yulong County, Yunnan Province were collected, including 351 from male students (52.54%) and 317 from female students (47.46%). These questionnaires were filled in by senior primary school students, junior secondary school students and part of senior secondary school students (from the fifth grade of primary schools to the second grade of senior secondary schools), with a few primary school students of Grade 5 and senior secondary school students of Grade 2 accounting for about 6.5% and students of other grades accounting for about 15% respectively. Most students (66.82%) have one kind of online learning devices, some students (23.57%) have two kinds, and less than 10% have three or more kinds; students preferring mobile phones and tablet PCs in their online learning account for the largest proportion (83.38%), while those preferring TVs account for the smallest proportion (9.73%). According to the students' evaluation of the Internet situation during their online learning, most students (74.25%) choose better and a small proportion (7.63%) choose worse; about one-third of the total students (33.53%) get access to the Internet with

traffic, some students (5.84%) with WIFI and 18 students (2.69%) with nothing. About a half of students (47.14%) say that teachers give lessons with the computer or TV almost every day, and only a few students (8.28%) mention teachers' little use of such devices in class.

Simple resource sharing is not conducive to reducing the digital divide because rural schools differ from urban ones in infrastructures, geographical environment, behavior habits, etc. In Suichuan County, for example, during the pandemic, the courses on "Ganjiaoyun" prepared based on teachers' past experience did not fully match rural students' specific situation. As mentioned by many rural teachers, some subjects were too difficult to understand without coherence. According to teachers in Yulong County, Yunnan Province, the "dedicated lessons" were too difficult to understand. They were divorced from the living practice of rural students in terms of discourse system, hence a failure to adapt to the general learning situation of rural students. The specific and special resource needs of rural teachers and students call for more attention; what's more, quantity and quality should be taken into account in urban and rural resource sharing, to match students at all levels appropriate electronic resources. Teachers mention limited access to resources, the mismatch between resources and rural reality, among others. To conduct targeted information-based teaching in rural schools, rural teachers made localized electronic teaching resources in line with the cognitive characteristics of rural students or reorganized and polished the existing quality resources according to the actual situation.

3.

ANALYSIS OF
POLICY IMPLICATIONS

Improving rural education quality means a lot to "ensure inclusive and equitable quality education and enlarge lifelong learning opportunities for all", the fourth one of the UNESCO' s SDGs. It is also a significant measure taken by the Chinese government to win a victory over poverty alleviation and improve the quality of Chinese people. Fortunately, the application of information technology facilitates the access to and sharing of quality resources in rural areas, as well as the improvement of rural teachers' teaching skills. ICT in education in rural areas worldwide can be advanced from the aspects below in light of the current ICT application situation in rural schools in central and Western China concluded in the field research and the law of ICT-based educational development in rural areas.

4 QUALITY EDUCATION

3.1 A sound rural educational management system

As complex systematic engineering is composed of many factors like infrastructures, software, educational applications, and talent fostering, ICT in education has focuses vary from stage to stage. A sound rural education system is needed to ensure the construction ,and advancement of ICT in education because huge differences in economy, culture, population, and other aspects in different rural areas lead to a failure to copy a certain development mode concerned simply.

(1) Strengthen the human capital in rural education to ensure the professionalism of the leadership in charge of ICT in education at county level and improve the information-based skills of school principals (vice principals) in charge of ICT in education, as well as their leadership in this regard.

(2) Develop independent management tools for schools in planning ICT in education, conducting information-based teaching, evaluating the performance of ICT in education, etc.

(3) Guide and back the management of the novel online and offline integrated teaching form, and polish the mechanism for protecting teachers and students' personal learning data and privacy.

3.2 An efficient investment and construction system

ICT in education requires ceaseless investments. Unfortunately, many rural schools face insufficient construction investments. Therefore, rural areas attach great importance to the scientific investment in ICT in education, to maximize such investments. Investments help realize "educational" functions and goals, rather than obtaining newer and more complete "technical" devices.

(1) Arrange information-based construction and develop investment schemes in light of the overall educational development plan. Focus on the investments in technical proposals conducive to facilitating learners' access to more quality resources and more exchange opportunities.

(2) Increase the investment in software resources and learning platforms, create an information-based learning environment that is more conducive to learners' independent study and personalized learning, and expand the application mode of existing hardware devices.

(3) Increase the investment in technical maintenance and management, reduce the abnormal losses of existing technical devices, and maximize the existing technical devices.

3.3 Pay attention to classroom teaching and teachers' professional development

Teaching in class is the focus of ICT in education for rural schools and teachers are the key elements to maximize information-based teaching. Teaching quality and teaching skills complement each other, hence attention is paid to two core elements of the innovation in teaching mode and teachers' professional growth as far as ICT in education is concerned.

(1) Promote teaching modes conducive to sharing quality educational resources, such as "dedicated lessons," "masters' lessons," "online classes of famed schools," and other projects promoted by the Chinese government.

(2) Provide digital resources developed independently by schools that match rural curricula, as well as tools to assess the developmental and formative nature of the students' learning process.

(3) Apply technology to build a semi-structured teaching methods, enrich subjects and make up for rural teachers' deficiency in their teaching methods, so that teachers can guide students in a more quality and personalized manner.

(4) Pay attention to teachers' career development and enable teaching training and tools matching their professional growth stages and needs to teachers of different ages and seniority.

3.4 Establishing partnerships with stakeholders

Urban and rural stakeholders inside and outside the education system should be taken into account as for making educational policies and implementing them in rural areas, to attract and encourage them to improve rural education quality more actively.

(1) The government should make policies to attract and encourage investments by enterprises and public service organizations in rural education, hence supplemented funds for continuously constructing and updating ICT in education.

(2) Guide and encourage digital courses, software, applications ,and AI-based teaching services for rural schools to back students' and teachers' growth.

(3) Encourage local normal universities or educational research institutions to deeply cooperate with rural education departments and schools, thus enabling intellectual resources to rural schools and maximizing the rural education system.

(4) Encourage local normal universities or educational research institutions to deeply cooperate with rural education departments and schools, thus enabling rural schools' intellectual resources and maximizing the rural education system.

3.5 Creating an equitable, inclusive technology learning environment

Efforts should be made to narrow the digital divide between urban and rural areas by virtue of technology, rather than further enlarging it. To this end, there is a need to improve the infrastructure construction in rural areas to get the Internet-connected to all people conveniently in a planned way and guarantee learners of different ages and genders the technical support they need.

(1) Improve the information-based infrastructure construction in rural areas to guarantee every school fundamental ICT in education.

(2) Pay attention to developing online environment, including providing intelligent terminal devices for rural schools and learners as far as possible to achieve learning anytime and anywhere.

(3) Provided dedicatedly developed resources and technology for disabled children, young children ,and female learners.

(4) Educate learners on necessary information security and information ethics.

Education inclusion and equity are at the heart of UNESCO's 'Education 2030' agenda. In recent years, the Chinese government has actively implemented the 2030 Agenda for Sustainable Development of the United Nations and prioritized education in socio-economic development. With access to education largely facilitated, the quality of education at all education stages significantly improved. The modernization of education governance system and capacity notably promoted, education-for-all has been basically achieved.

China has a large population of over 1.4 billion, with 550 million rural population, making it a difficult task to

ensure the quality and equity of education. The rapid development of ICT provides a tool with many possibilities to bridge the gap between urban and rural education and promote educational equity. The cases of Yulong County and Suichuan County demonstrate the efforts to provide quality education that is equal and inclusive for all students with new technologies and multiple parties' united efforts. How to use new technologies and bring together multiple forces in China to provide a quality education that is equal and inclusive for all students.

While economically advantaged cities have fully integrated new information technologies, such as Internet and artificial intelligence, to accelerate the development of education, education equity is still not achieved in terms of ICT application as rural schools now have complete hardware facilities but their ICT application in education is still at the initial stage.

Due to the lack of economic, social, and cultural resources in rural areas, simply providing devices, technological access, and shared resources have yet made ICT successfully integrated into the rural education ecology and be fully utilized in actual practice. This research attempts to evaluate and demonstrate the integration of ICT in rural education, especially the new forms, challenges and programs brought to rural schools by developing remote classrooms. In our research, the two schools' practice were paused after students returned to schools during the pandemic. Although some rural schools have made further attempts to regularize "dual-teacher teaching" with sufficient social support and to develop teaching management around the practice, new educational technology is still an element excluded from most schools' education system rather than an indispensable and necessary part of education. Regularization is a prerequisite for ensuring equal opportunities. In the future, the main direction for ICT4E (ICT for Education) development should be incorporating ICT into the regular system of rural schools and relying on new technologies to re-plan and build a high-quality rural education system, so that high-quality educational resources can benefit more people, especially those in the least developed countries and regions. This will need further consideration and practices.

4. EPILOGUE

Education inclusion and equity are at the heart of UNESCO's 'Education 2030' agenda. In recent years, the Chinese government has actively implemented the 2030 Agenda for Sustainable Development of the United Nations and prioritized education in socio-economic development. With access to education largely facilitated, the quality of education at all education stages significantly improved. The modernization of education governance system and capacity notably promoted, education-for-all has been basically achieved.

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5. ACKNOWLEDGMENT

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