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Challenges of Online Mathematics Learning in Rural Elementary Schools in China

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Abstract: The challenges online mathematics education faces in rural primary schools in China are systematic. This article addresses five aspects of the challenge. Poor infrastructure, poor signal, and backward network configuration in rural areas have caused students' online access difficulties. Second, purchasing high-performance electronic equipment is a burden for many families due to poverty in rural areas. In addition, the learning facilitation in rural areas is weak; students need to cope with the rapid transition from traditional offline to online learning. When the drawing and tabulation required for learning mathematics are changed from manual to online, new operations and software must be learned, and both students and teachers need assistance. Finally, teacher-student interaction, assessment and feedback also present unique challenges for online mathematics education. These challenges include physical barriers brought by the external environment and psychological barriers that students need to overcome, which will widen the gap in mathematics achievement between urban and rural students, and some even affect all subjects. Therefore, eliminating these challenges or reducing their negative impact is an urgent task to narrow the urban-rural education gap.

Keywords: online education, mathematics, rural education, primary education, China

1. Introduction

China's education system has come a long way in recent decades, aiming to provide equal opportunities to students nationwide. During the COVID-19 pandemic, online teaching has made up for the interruption of education caused by social distance restrictions [1]. Whether in urban or rural areas, students and teachers can learn and impart knowledge through the Internet at home without going to the classroom [2].

However, online education faces systemic challenges. Through the research of a large number of literature, this paper expounds on five main existing challenges: Poor infrastructure, Hardware requirements for the device, Lacking learning facilitation, Weak interactions and challenges in assessment and feedback. These challenges have become vital barriers to the urban-rural education gap.

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2. Challenges Faced by Online Mathematics Education in Rural Primary Schools in China

2.1. Poor Infrastructure

Students must maintain stable, high-quality network connections when attending online classes. A weak or unstable network connection will cause the online meeting to freeze, cut off, or even fail to connect [3]. However, according to CNNIC statistics [4], during the COVID-19 pandemic, the Internet coverage rate in urban China was 86.4%, compared to 57.6% in rural areas, which explains substantially the achievement gap between urban and rural education. Low network coverage has become a key obstacle to rural online education, as evidenced in many previous studies. In Wan et al.'s study of the impact of COVID-19 on rural China [5], they found that an average of 70% of the students indicated that the internet signal was unstable.

Further, according to the research of Lin et al., China's urban and rural areas have a significant gap in network coverage and speed [6]. Due to insufficient construction of 5G base stations in rural areas, they are still stuck in the 4G or even 3G era, especially in China's poor western rural areas. The backwardness of telecommunications technology makes the internet speed in rural areas one-half slower than in cities on average [7,8]. In addition, although some rural locations can receive 5G signals, purchasing high-speed network packages has caused economic burdens to many rural families [9]. The low network speed will increase the stuttering phenomenon of multi-person video conferences. Xu et al. stated that due to the frequent traffic flow, online teaching platforms like DingTalk may experience network crashes [10].

2.2. Hardware Requirements for the Device

In addition to the challenges brought about by weak infrastructure, devices for online education need to meet specific hardware requirements, especially for learning mathematics. Cook and Sonnenberg demonstrated that equipment and technology should keep pace with the times, and the creativity of online learning requires the hardware support of mobile devices [11]. That is, computers or laptops, tablets, smartphones, and other devices powerful enough to load multiperson online meetings and run complex mathematical modelling software such as MATLAB. The capabilities of mobile devices determine how creative students can be, which is especially important in mathematics learning. Moreover, according to Sung et al., using devices with poor performance can reduce students' motivation to learn, affecting academic performance [12].

However, for students in rural areas, such devices are only usually affordable for some families. According to the National Bureau of Statistics of China, 8 million people in rural China live below the world poverty line, and these families cannot purchase internet services and high-performance Internet-connected devices [13]. Further, according to the '2017 China Rural Internet Application Report' released by China Economic Net the average ownership rate of computers in rural China is only 44.37% [14]. The above data shows that China's rural areas need high-performance networking devices as the critical medium of online education.

2.3. Lacking in Learning Facilitation

Switching from traditional offline to online teaching requires adaptation to new software, operation systems, and learning styles. According to Ferri et al., children from low-income families lack digital skills, that is, the ability to use computers proficiently [15]. Due to the weak self-learning ability and exploration abilities of primary school students and junior high school students [16], this phenomenon is most evident in the primary education stage. As a result, in rural China, where poverty rates are higher than in urban areas, many students need more digital skills to deal with cumbersome online learning platforms, and their parents also need to gain such skills. Therefore, teachers and schools

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need to conduct workshops or spend time in class teaching students how to use web conferencing software or apps. Teacher assistance can reduce such difficulties for students. In urban areas of China, before online teaching starts, teachers will teach students how to participate in online courses through instant messages and pre-recorded videos [5]. After the lesson, teachers also provide recordings for students to review. In rural areas, however, teacher assistance's importance must be addressed due to the need for online teaching experience. This systematic disparity has further widened the level of education between urban and rural areas.

Online education presents challenges for the three main subjects of primary school education in China, Chinese, English, and mathematics. Ma et al. claimed that facing an electronic screen instead of a living body will cause passion burnout for teachers and students, which is not conducive to emotional expression in Chinese learning [17]. For English learning, the stuttering caused by unstable signals will prevent students from missing the teacher's pronunciation and falling behind the progress of the course [18]. The challenge faced by online mathematics education is the most different because it is not a language; it involves the drawing of charts and graphs, and when computers realise these operations, it will become more complicated as students have to be familiar with the software to be able to make the computers execute those operations for them. Compared with Chinese and English, mathematics' unique challenges require more teachers' facilitation. Wan et al. pointed out in their research that teacher assistance is critical to reducing the negative impact of online learning for students in rural schools [5]. The help of teachers can help alleviate the pressure on rural students in learning mathematics and is crucial in narrowing the gap in mathematics performance between urban and rural areas.

Another critical point to remember is that Bringula et al. put forward the notion of mathematics self-concept, interpreted as students' confidence in their mathematics level and interest in mathematics [19]. The author stated that teachers are improving and playing an essential role in maintaining the mathematical self-concept of online learners. Some students think drawing curves and graphs using a computer is less convenient than doing it manually so these students will develop resistance to online learning [20]. They will reduce their interest in mathematics. Therefore, to assist students, teachers first need to familiarise themselves with the operation of the online teaching platform and use digital tools effectively. Still, rural schools or the government must be aware of this and provide more teacher training.

2.4. Weak Interactions

Teacher-student interaction includes eye contact, speech, and movement communication. Interaction is a close behaviour between teachers and students, which enables students to keep up with the teacher's train of thought while promoting students' self-efficacy and intrinsic motivation [21], which is especially important in mathematics learning [22]. Furthermore, Nugent found a positive correlation between the degree of teacher-student interaction and student achievement and motivation [23]. The experiment of Yao et al. in Guiyang No.8 Middle School in China proves this in more detail [24]. The results show that compared with self-study-based recorded video teaching, live teaching with more teacher-student interaction improves student academic achievement.

Nevertheless, interactivity has yet to be challenged in online education. Due to the limitations of online teaching, teachers can only pay attention to some students. Tomei argues that online education's ideal class size is smaller than face-to-face teaching [25]. According to a comprehensive analysis of the research results of Taft and Iglesias-Pradas et al., the optimal number of online students is between 15 and 30 [26,27], while the traditional class size in rural China is between 50 and 60, far exceeding the ideal number. Therefore, when online users exceed 30, the lecturer's screen will display only some students' images. The teacher cannot make eye contact with each student, and the teacher's attention to each student is reduced. Also, the interaction is affected by network signals; Due to

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network delays, students' questions could not be transmitted to the teacher in time. As a result, students may need more timely responses.

Lacking face-to-face interaction and extracurricular activities can decrease interest and concentration. This also prevents online classroom discipline from being strictly followed in real classrooms, teachers cannot observe what each student is doing, and often more distracting things happen when studying at home. Dontre found that students' attention will be distracted by multimedia, such as playing games or browsing social media while video conferencing [28]. In addition, Cooper et al. reported that low-income families cannot provide students with private study space, and students are passively distracted by noise [29].

Due to hardware limitations, teachers neglect to observe students, student's attention is distracted for active or passive reasons, and teacher-student interaction is systematically challenged, affecting rural students' enthusiasm and interest in mathematics. Consequently, students' grades are affected.

2.5. Assessment and Feedback

Online exam is an integral part of online education, and online exams are more accessible to cheat than offline exams. Adzima believes this is due to the relatively relaxed examination environment and the lack of invigilators [30]. Plus, math tests are easier to cheat on. Whether primary school, junior high school or high school, Chinese mathematics test questions include multiple-choice, fill-in-the-blank, and calculation questions. The common feature of these questions is that there are standard and unified answers, which makes it easier for students to pass answers to each other. Furthermore, cheating cannot be identified by repetition rates. Hill et al. state that institutions can use commercial third-party services to proctor exams, such as artificial intelligence and other digital tools, to monitor students while taking exams [31].

Nevertheless, many students and families will feel that their fundamental rights have been violated regarding data protection and privacy legislation. Most importantly, such services would consume substantial economic costs, impractical in poor rural areas of China. As a result, cheating is more common in rural areas than in cities.

Many factors influence students' cheating behaviour. Adzima, through interviews, found that younger students in the early stages of learning are more likely to cheat because elementary school students have difficulty maintaining self-control during online exams [30]. Moreover, Zhang and Yin supplemented the influencing factors of cheating, arguing that family relationships, only child status, living area (i.e. urban and rural areas) and socioeconomic status will all affect students' cheating behaviour [32]. Specifically, China's economic reforms have pushed many rural populations to cities over the past two decades. Many of these people are already parents. Their children live alone in the countryside and are not well off. Today, left-behind children have become a common phenomenon in rural China. Cadsby et al. stated that rural left-behind children would show more cheating behaviours in the third to fifth grades than urban children due to the factors of their original families [33]. In summary, rural primary school students are prone to cheating because of their young age, defects in their native families, and poor economic conditions.

The primary school stage is critical for shaping learning habits and character. Based on the interview results of Strom and Strom, 91% of parents claimed that honesty is an essential quality of students, while only 55% of parents said that their children were honest [34]. The huge gap of 36 percentage points shows that many children show cheating behaviour. Due to the above-mentioned particular situation of students in rural areas, and the fact that online examinations have created a breeding ground for students' dishonesty, once this bad habit is developed, it will hurt students' future study and life and the gap between urban and rural education will further widen.

In addition, the particularity of mathematics is also reflected in the exam. Complex diagrams or hand-drawn figures can be challenging to present and answer in an online format effectively. Cazzola

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demonstrated in the article that mathematics transforms and applies multimodal, including texts, formulas, schemas, diagrams, geometric figures, and graphs [35]. After the outbreak of COVID-19, people had to use distance education. Whether it was teachers or students, it was challenging to adapt to the transformation of digitalisation quickly. More people prefer to use traditional paper and pen to express mathematical ideas. This rapid change from paper-and-pencil responses to digitalisation has added challenges to online exams. Therefore, additional time for students to familiarise themselves with the exam interface, enter math symbols, and manipulate diagrams is necessary. This may affect the total time to answer questions and may require adjustments to the exam duration.

Second, in traditional exams, students can ask the teacher for clarification if they are unsure about exam questions or other things on the test paper. While willingness to answer depends on the exam rules, this feedback is timely. In an online environment, teachers may need more time to give timely feedback due to network delays or reduced attention, leading to possible misunderstandings during exams.

3. Conclusions

This article provides a literature review on the challenges faced by online primary school mathematics education in rural China.

First, due to the backward infrastructure in China's rural areas, network delays and low network speeds have caused problems which affect students' acceptance of online education. Additionally, due to the poverty of most rural families, they need help to afford high-speed network services and high-performance hardware facilities.

Second, students and teachers were forced to rapidly shift from traditional offline to online education. Students and teachers must adapt to new software, operating systems and learning styles, especially the unique requirements of online math learning.

Besides, due to the limitations of distance education, teacher-student interaction is weakened.

Finally, in terms of Assessment and Feedback, due to the lack of supervision, students are prone to cheating, which is more likely to be manifested in poor rural left-behind children. Moreover, the teacher's feedback may need to be more timely due to network delay or reduced attention.

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