

Difficulties and Breakthroughs in Remote-Site Teachers' Professional Development in the Data-Intelligent Era: Analysis Based on Chinese Practice Cases

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Abstract: Driven by data-intelligent technology, while remote live-streaming classrooms promote educational equity, they also bring systematic professional development difficulties for remote-site teachers. Based on the case of Chengdu No.7 High School's remote live-streaming classroom, this study identifies a triple crisis triggered by technological alienation: temporal-spatial domination, erosion of professional identity and pedagogical disembodiment. Theoretically, it points out that the essence of these dilemmas is the obscuring of educational authenticity by instrumental rationality. When technology escalates from an auxiliary means to a controlling force, remote-site teachers risk being reduced to "digital vassals." Accordingly, three breakthrough paths are proposed: in technology design, shifting from "efficiency-first" to "contextual adaptation"; in professional paradigms, moving from "technical appendage" to "reflective practitioner"; and in policy systems, transitioning from "techno-instrumentalism" to "agentive empowerment." This research not only expands the theoretical perspective of educational technology criticism but also provides important references for Global South countries and regions with uneven resources on how to protect teachers' professional autonomy while promoting digital education. It ultimately argues that the application of data-intelligent technology in education should establish a balance between instrumental and value rationality, reconstructing the educational ecology with teacher subjectivity at its core.

1. Introduction

In recent years, the application of data-intelligent technology in the global education field has become an irreversible trend. Against this backdrop, the remote live-streaming classroom model, as a significant practice for promoting educational equity through data-intelligent technology, has garnered widespread attention. However, existing international research primarily focuses on the impact of distance education on student learning outcomes, with less systematic exploration of how it reshapes teacher roles and triggers identity alienation issues in professional development, particularly lacking critical analysis from the perspective of teacher subjectivity. This paper aims to address this research gap.

In China, remote live-streaming classrooms, represented by the Sichuan Chengdu No.7 Middle School Oriental Wen Dao Online School, are promoted as a "new driving force" for promoting educational balance [1], emphasizing that remote-site teachers can achieve professional growth by "observing master teachers' classes in real-time" [2]. To date, over 300 high schools nationwide have participated in this type of simultaneous distance teaching practice. Nevertheless, behind the technological empowerment lie unexplored structural difficulties.

Educational technologist Neil Postman once pointed out that when technology escalates from a tool to an ideology, it deconstructs professional autonomy [3]. This observation is particularly salient in remote live-streaming classrooms: although remote-site teachers gain certain professional development resources, they may also fall into the crisis of "dissolution of subjectivity" and "deskilling," even becoming "digital vassals" of the technical system [4]. In educational settings, if data-intelligent technology is simply regarded as a tool for improving efficiency, it may overlook the intersubjectivity between teachers and students, as well as the complexity and creativity of educational activities. As John Goodlad emphasized, "the essence of education lies in human interaction, not information transmission" [5]. Therefore, reexamining the maintenance and enhancement of teachers' professional autonomy is crucial within the context of data-intelligent technology, as it concerns not only individual growth but also whether digital transformation can truly return education to its essential purpose: nurturing students.

2. Definition of Core Concepts

2.1 Data-Intelligent Technology

Data-intelligent technology is a relatively recent term and concept. It encompasses multiple meanings including data intelligence, digital and intelligent transformation, data-intelligent technology itself, and digital intelligence quotient (DQ). Together, these constitute the complete conceptual meaning of data-intelligence: it refers to the process where individuals possessing a DQ utilize data-intelligent technology to acquire and produce data intelligence, providing the evidential support necessary to achieve digital and intelligent transformation [6]. Compared to traditional information technology, its essential differences lie in: (1) A shift from "tool-assisted teaching" to "algorithm-dominated process transformation." For instance, AI-based classroom monitoring systems in live-streaming classrooms are no longer merely teaching aids; they reshape the normative logic of entire teaching behaviors through data quantification standards. (2) A shift in educational objectives. For example, China's "Education Informatization 2.0 Action Plan" positions it as an "institutional tool for promoting educational equity" [7], emphasizing the balanced distribution of high-quality resources through technological configuration, rather than mere technical demonstration. Heidegger, in his essay "The Question Concerning Technology," noted that "technology is not merely a means and tool; its essence is a mode of revealing. This revealing, while bringing convenience, may also conceal the true nature of things" [8]. This warns us that data-intelligent technology can be an excellent tool for enhancing educational quality, but it may also obscure the humanistic attributes of education through its algorithmic logic. Therefore, teacher professional development in the digital age must acknowledge this dual nature.

2.2 Teacher Professional Development in the Digital Age

Teacher professional development in the traditional teaching era focused on cultivating comprehensive abilities, subject teaching capabilities, and professional ethics. Entering the data-intelligent era, the connotation of teacher professional development has also undergone new changes, primarily in two aspects: firstly, data-intelligent technology empowers teacher professional

development; secondly, teacher professional development now extends to include requirements for technology integration skills. Current research predominantly focuses on the second aspect: exploring pathways to enhance teachers' digital literacy, i.e., how to master the operation and application of intelligent tools. Some scholars have noted the value-added empowering potential of technology, evident in contemporary characteristics such as the cross-industry integration of digital technology, cross-regional sharing of digital resources, cross-spatiotemporal interaction through digital communication, and cross-disciplinary fusion of digital awareness. However, other research cautions that digital value clarification and regulation remain necessary, with the former awakening teachers' professional ethical responsibilities and the latter calling for the return of professional ethics [9]. These theoretical discussions present an even more complex picture in practical models. When data-intelligent technology intervenes in the teaching environment via live-streaming systems, the professional development difficulties faced by remote-site teachers, as frontline subjects of technology application, precisely reflect the dual nature of empowerment and alienation inherent in data-intelligent technology.

2.3 Remote Live-Streaming Classroom Model: The Case of Chengdu No.7 Middle School

2.3.1 Remote Live-Streaming Classroom Model

Remote live-streaming teaching is a form of online education based on digital and communication technologies. Its core characteristics include the quasi-permanent separation of teachers and students in space, the systematic provision of learning materials and support services by educational institutions, the use of technological media as carriers of course content and communication channels, and an emphasis on two-way communication and personalized learning [10].

From an international perspective, several countries have developed mature distance education systems. For example, the United States widely uses two-way interactive video and recorded courses, regulating distance education through legislation; the United Kingdom relies on the JANET network to establish a distance teaching system covering basic through higher education; Japan incorporates distance education into its lifelong learning system, with the government promoting related services via communication satellites since 1999; South Korea's Open University achieves large-scale real-time two-way teaching through dedicated channels and video conferencing systems. Although these models vary in form, they generally embody the common principles of being "learner-centered, technology-mediated, and interaction-focused."

In China, the remote live-streaming classrooms represented by the Chengdu No.7 Middle School Oriental Wen Dao Online School are typical practices of data-intelligent technology supporting educational equity. This model belongs to synchronous two-way distance teaching. The live classroom feed from the front-end school (usually located in educationally developed regions) is synchronously transmitted via the network to remote-site schools (often located in educationally under-resourced regions). Remote-site students, assisted by their local teachers, participate in real-time interactions in the front-end classroom, forming a cross-regional "dual-teacher collaborative" teaching scenario [11]. Compared to international practices, this model embodies the fundamental attributes of distance education-breaking spatiotemporal constraints and promoting resource sharing-while also reflecting China's localized exploration of technology empowerment and teacher collaboration paths in advancing educational equity.

2.3.2 Remote-Site Teachers

Remote-site teachers specifically refer to the group of teachers in remote live-streaming teaching who are responsible for local teaching adaptation, student management, and technical coordination,

forming a "dual-teacher education" division of labor with the front-end instructors. Their professional requirements include: proficiency in modern educational technology tools and solid classroom organization and teaching implementation abilities. Specific duties encompass: leading local classroom management, answering some student questions, grading homework and exams, and participating in joint lesson preparation between both ends, but they do not lead the overall classroom teaching activities [12]. It is noteworthy that although the professional role of remote-site teachers is alienated into "executive subordinates" within the technical system, they still demonstrate irreplaceable creative value in the "re-contextualization" of front-end knowledge.

3. The Triple Crisis in Teacher Professional Development Exacerbated by Data-Intelligent Technology

Despite joint advocacy by policymakers and technology vendors for technological promises centered on "equitable resource sharing," "demonstration of teaching practices," and "process standardization to reduce burden," this instrumental rationality-oriented application of technology—i.e., a technological mindset emphasizing efficiency, control, and standardization—has resulted in a significant efficacy gap in the real-world context of educational practice. Although remote-site teachers nominally gain opportunities to "observe master teachers' classes," they often devolve into passive executors maintaining the stable operation of the technical system. The fundamental contradiction lies in the fact that the techno-instrumental perspective overlooks the inherent situated, emergent, and intersubjective nature of educational activities, thereby reducing the complex teaching process to a mechanically reproducible information transmission process, stripping teachers of the autonomy to flexibly adjust teaching based on the immediate context. When the logic of technology supersedes the principles of education, it systematically triggers the following triple development crisis: temporal-spatial domination, erosion of professional identity, and pedagogical disembodiment.

3.1 Theoretical Framework Construction: A Model of Alienation and Breakthrough in Teacher Professional Development

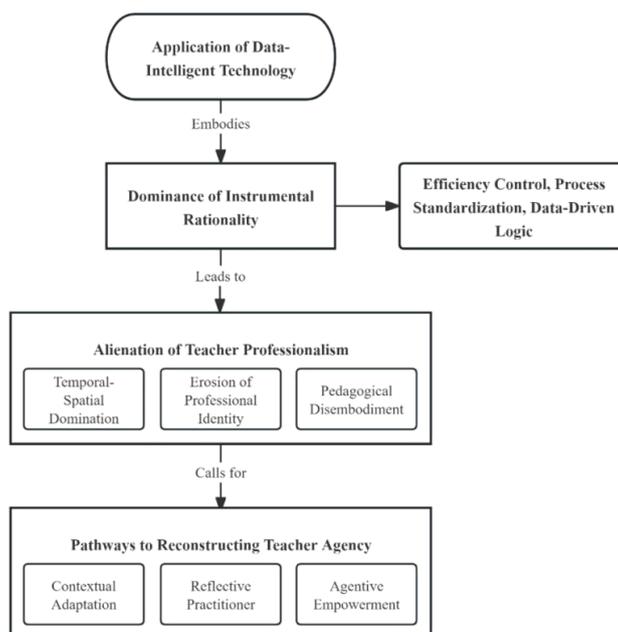


Figure 1: The Theoretical Framework of Teacher Alienation and Empowerment in Data-Intelligent Education

To systematically analyze the aforementioned crises, this study constructs a theoretical analytical framework of "technology application - alienation - breakthrough" (Figure 1). This framework aims to reveal that the deep application of data-intelligent technology in distance education is not value-neutral; its embedded logic of instrumental rationality-manifested in the extreme pursuit of efficiency, control, and data-becomes the core mechanism driving the alienation of teachers' professional practice.

Based on this analytical model, the following sections will delve into the triple crisis in teacher professional development exacerbated by data-intelligent technology.

3.2 Temporal-Spatial Domination: Rhythmic Synchronization Pressure and Constrained Teaching Autonomy

The "dual-teacher teaching" model often evolves in practice into a unidirectional control structure dominated by the front-end and executed by the remote-site. Due to a lack of systematic training and the right to know about instructional design, remote-site teachers often regress into mere maintainers of classroom discipline [13]. For instance, classroom observations at Wenxian No.1 Middle School in Gansu Province, China, showed that 90% of remote-site teachers' behaviors were limited to "checking student notes" and "urging students to look at the screen," leaving them struggling to effectively respond to deep interactions initiated by the front-end teacher [14]. The root of this dilemma lies in the fact that remote-site teachers are often unable to learn about front-end interaction designs in advance [13], or fail to prepare adequately due to insufficient supervision [12], resulting in an inability to intervene and guide appropriately. Consequently, student participation remains low (research showed an average student interaction score of only 2.3 out of 5 points) [14]. The live-streaming system presupposes a "front-end output – remote-site reception" process, reducing teaching to signal transmission, embodying the concretization of Foucault's theory of discipline in educational space and time [15]. Superficially empowering, technology actually demotes remote-site teachers to "human monitors" through process solidification, restricting the exercise of their pedagogical tact.

3.3 Erosion of Professional Identity: Role Misalignment and Weakened Professional Authority

The remote live-streaming classroom model implicitly constructs a power hierarchy through its technical system: the front-end teacher occupies the center of the screen, students predominantly focus on the front-end teacher, and high-definition cameras further reinforce their image as the "knowledge authority"; meanwhile, the remote-site teacher operating equipment from a corner of the classroom, is reduced to a "signal relay operator." This spatial arrangement conveys the negative implication that "the teacher on the screen is the real teacher." During classroom observations in a Gansu school, students directly asked the remote-site teacher to "let the Chengdu teacher answer" [14], and some parents even questioned the professional competence of the local teacher [16]. More extremely, when remote-site teachers attempted to explain concepts, students complained that "both teachers talking at once was unclear," ultimately leading teachers into self-doubt characterized by a "damned if I do, damned if I don't" dilemma regarding speaking up. As one teacher expressed in a survey, "I suddenly feel superfluous" [17], profoundly reflecting their identity crisis.

Technical design also systematically undermines the professional value of remote-site teachers. A student questionnaire showed that while students acknowledged the supportive role of remote-site teachers, technological symbols constantly reinforced the perception that the "front-end teacher is more professional" [16]. This led 72% of remote-site teachers to perceive themselves as "inferior to the teacher on the screen" [14], with some even abandoning lesson preparation and merely "downloading courseware to cope with assessments" [18].

3.4 Pedagogical Disembodiment: Emotional Disconnection and Suppressed Teaching Creativity

As technology deprives them of temporal autonomy, the professional identity of remote-site teachers is continuously diminished, and significant cracks appear in the "dual-teacher collaboration" during actual teaching practice. Although data-intelligent technology claims to establish "cross-regional teaching and research communities," it effectively empties the collaboration mechanism through permission segregation and process solidification. Specific manifestations include: 1. Unidirectional transmission of lesson plans: Remote-site teachers cannot access front-end interaction designs in advance, leading to ineffective tutoring [13]; 2. Discriminatory resource allocation: Teachers not involved in the net-class program lack access to cross-grade resources; 3. Perfunctory collective lesson preparation: Teaching research activities devolve into "front-end teacher's teaching plan reading sessions," with remote-site teachers lacking channels to feedback student learning conditions or adjust teaching content [17].

Remote-site teachers often struggle between technical directives and educational responsibilities, ultimately forced to substitute technical pacing for professional judgment. For example, a remote-site math teacher in one school could, under the technical system's directives, "synchronously urge students to answer questions, explain briefly during minimal gaps, without arranging dedicated tutoring time" [17]. Other research found instances in some remote classrooms where teachers, "knowing students had not understood, dared not pause the live stream for fear of 'falling behind schedule'" [16].

Once teaching falls into mechanical execution, the emotional dimension of education gradually vanishes. Students reported: "The front-end teacher is 'familiar' but emotionless; after three years of just watching the screen, we couldn't even get a smile." Teachers stated: "I want to expand on content, but the front-end teacher glosses over it with a few words; students find you amiable but not respectable" [17]. When education degenerates into one-way information transmission, remote-site teachers can neither build deep teacher-student relationships nor become pure learners, ultimately trapped in an identity crisis of being neither fully teacher nor student. This phenomenon confirms Freire's critique: technology can enact cultural domination in the name of "sharing," alienating rural (remote-site) teachers into "secondary components" of the educational system [19]. The most profound harm of live-streaming classrooms is not resource inequality, but rather the constant reinforcement of the "inferiority of rural teachers" through technical processes (e.g., proprietary courseware players, close-up shots of the front-end teacher). Once remote-site teachers internalize this identity, their professional development loses intrinsic motivation—attending training merely to "fulfill tasks" rather than pursuing genuine growth.

Behind the rhetoric of "empowerment" in the context of data-intelligent technology lies an implicit closed-loop logic that oppresses teacher professional development: time control forces teachers to abandon professional judgment → identity diminution undermines teaching confidence → pedagogical ineffectiveness fragments the educational context → emotional exhaustion negatively impacts learning outcomes. Research indicates that this logical chain can ultimately lead to decreased rather than improved student performance [18]. Breaking this cycle requires overcoming technological hegemony and reconstructing an educational ethic centered on teachers.

4. Pathways to Breakthrough: Reconstructing Teacher Agency within the Technological Framework

To address the aforementioned professional development crises, the reconstruction of agency for remote-site teachers requires systematic innovation across three dimensions: technological design, professional paradigm, and policy and institutional aspects. This aims to tame instrumental rationality and reaffirm value rationality in education.

4.1 Technological Design: From "Efficiency-First" to "Contextual Adaptation"

The core issue with current live-streaming systems lies in their exclusion of educational situatedness and humanistic elements. Technological design must create space for educational authenticity, with improvements directed towards the following goals:

Promoting Localized Contextual Translation (Transcreation). Knowledge transfer must undergo filtering and reconstruction through local culture [20]. For instance, in a pilot collaboration between Chengdu No.7 Middle School and a school in Yunnan, remote-site teachers replaced the "coffee profit case" in an example problem with "highland barley yield calculation." This increased student classroom participation by 37% [18]. This practice demonstrates the significant impact of adaptive technological adjustments on learning outcomes.

Establishing a Two-Way Data Feedback Mechanism. The unidirectional transmission model of "front-end output – remote-site reception" must be broken, and a reverse channel for learning analytics must be constructed. For example, a middle school in Gansu developed a "Real-time Confusion Tagging System" that allows remote-site teachers to mark students' points of misunderstanding in real-time. Front-end teachers can then dynamically adjust their pacing and explanation strategies accordingly [14]. Such designs transform the technological framework from an oppressive tool into a medium supporting dynamic interaction.

4.2 Professional Paradigm: From "Technical Appendage" to "Reflective Practitioner"

The professional development of remote-site teachers is essentially a struggle of educational value rationality against instrumental rationality. Its paradigm shift needs to focus on the following three levels.

Implementing Critical Education against Technological Measurability. The "black box" of technology should be opened, transforming the evaluation logic of monitoring systems into tools for teaching reflection. For example, a teacher community organized "Data Deconstruction Workshops" to analyze the composition of "participation" metrics (e.g., frequency of speaking contributing 40%, screen gaze duration 30%). They discovered these metrics neglected students' deep thinking behaviors and subsequently co-developed an alternative evaluation scheme featuring "visualization of thinking trajectories" [12].

Promoting Critical Lesson Study. Traditional "master teacher observation" models should be replaced by establishing a "Contradiction Analysis Method for Dual-Teacher Teaching." Through deliberation mechanisms (involving representatives of both front-end and remote-site teachers and students), the gap between the front-end teacher's questioning pace and the cognitive level of remote-site students can be analyzed, leading to the development of practical guidelines for coordinating cross-regional classroom interaction.

Building Cross-Regional Symbiotic Communities. Moving beyond the traditional logic of "aid provider - aid recipient," networks for collaborative knowledge production based on equality should be constructed. For instance, the "Highland Barley Teaching-Research Alliance," self-established by remote-site teachers from Qinghai, Yunnan, and Gansu provinces in China, achieved three breakthroughs through online collective lesson preparation: (1) Co-adapting textbook cases (e.g., changing "urban traffic modeling" to "pasture road planning"); (2) Sharing technology use strategies (e.g., delaying the submission of non-critical data to protect struggling students); (3) Jointly compiling a "White Paper on Teacher Rights in Data-Intelligent Classrooms" to combat professional isolation through collective action.

4.3 Policy and Institutional Aspects: From "Techno-Instrumentalism" to "Agentive Empowerment"

Education administrative departments need to break the cycle of technological alienation at the institutional level. The core of this effort lies in placing teacher agency at the heart of policy design.

The key is to establish teachers' technological autonomy. Clauses on the "right to question technology" should be introduced in policy documents or school charters, explicitly granting teachers the right to refuse technological directives that violate educational principles. When a remote-site teacher judges that "synchronizing the pace will cause students to become cognitively disconnected," they can independently activate a pre-established localized teaching plan, thereby ensuring instructional flexibility.

Furthermore, it is necessary to construct peer communities between Eastern and Western teachers. The model of "one-way output of high-quality resources" should be abandoned in favor of establishing collaborative mechanisms based on knowledge co-creation. For instance, the "Dual Lead Designer" system piloted by Beijing No.4 High School and a middle school in Yunnan stipulates that the front-end teacher is responsible for the structured design of subject knowledge, while the remote-site teacher leads the local contextual adaptation, with both parties holding co-authorship of the lesson plans. This institutional design effectively mitigates the potential cultural hegemony in technology application and provides a new model for cross-regional collaboration.

5. Discussion and Conclusion

5.1 Conclusion

Based on an in-depth analysis of the professional development difficulties faced by remote-site teachers within the context of China's data-intelligent technology, this paper has revealed three systemic crises triggered by technological alienation: temporal-spatial subordination, erosion of professional identity, and pedagogical disembodiment. Through empirical cases, an "alienation logic model of remote-site teacher professional development" was constructed, pointing out that its essence is the obscuring of educational authenticity by instrumental rationality, putting teachers at risk of being reduced to "digital vassals." The theoretical contribution of this model lies in breaking through the limitation of existing educational technology research, which often focuses on technical efficacy while neglecting teacher agency, by proposing an analytical framework that integrates perspectives of technology criticism and teacher development. This model is not only applicable for explaining the mechanism of teacher alienation in the Chinese context but also provides a theoretical reference for Global South countries and regions with uneven resources to address structural inequalities in digital education. On a practical level, the study proposes breakthroughs should be achieved from three aspects: technological design, professional paradigms, and policy systems, to push technology from a "logic of control" towards a "logic of empowerment," thereby reconstructing teachers' professional autonomy as critical educational subjects.

In the future, the application of data-intelligent technology in education should seek a dialectical unity between instrumental and value rationality, truly serving the dual goals of teacher development and student growth. The international academic community is called upon to pay more attention to the power structures and cultural politics implicit behind technological empowerment, especially in cross-regional and cross-cultural educational collaborations, valuing the local knowledge and situational wisdom of teacher subjects

5.2 Limitations and Prospects

This study has constructed a preliminary theoretical analytical framework, but its validity has primarily been verified through in-depth analysis of existing literature and public cases. Future research could employ empirical methods such as interviews and questionnaires to further test and refine this framework.

Furthermore, this study is primarily based on the Chinese educational context. Although it suggests referential significance for Global South countries, its applicability across different cultural backgrounds and educational systems requires further validation through comparative studies. As new technologies like artificial intelligence continue to evolve, the forms of distance education and teacher roles will keep changing. Subsequent research should continue to focus on the dynamic relationship between technological evolution and teacher development.

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