

# Research on the Practical Dilemmas and Model Construction of Human-Computer Collaborative Teaching in Primary Schools in the Digital-Intelligent Era

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**Abstract:** Against the backdrop of in-depth educational transformation empowered by digital-intelligent technologies, primary school teaching faces the core challenge of effectively achieving human-computer collaboration and promoting teachers' adaptive development. This study focuses on the primary school stage, aiming to explore teachers' practical difficulties and transformation pathways in human-computer collaborative environments. The research identifies four major practical dilemmas in current educational practice, examines the symbiotic relationship between "teacher intelligence" and "machine intelligence," and constructs a "double helix" teaching model for human-computer collaboration in primary schools. It delineates the model's four-stage operational process of "intelligent diagnosis – human-computer collaboration – multi-dimensional feedback – reflective iteration," and further proposes a systematic pathway for fostering teachers' adaptive transformation. The conclusion points out that the key to successful human-computer collaboration lies in adhering to the value rationality of "teacher-led" instruction.

**Keywords:** Human-Computer Collaborative Teaching; Primary Education; Teacher Adaptability; Double Helix Model; Digital-Intelligent Era

## 1. Introduction

With the rapid advance of generative artificial intelligence, big data and related technologies, education is moving fully into the digital-intelligent era. The European Union's Digital Education Action Plan (2021–2027) has set out clear new directions for developing the ability to teach and learn using digital-intelligent technologies [1]. In China, policies such as the Ministry of Education's Digital Empowerment Action for Teacher Development (2025)

explicitly call for exploring effective pathways for human-computer collaborative teaching and have made digital literacy a core competency for teachers in the new era. For primary education – the starting point of basic education – digital-intelligent technologies not only bring the promise of personalized learning, but also reshape how knowledge is presented and how interaction takes place, through various immersive media, injecting fresh momentum into improving classroom teaching quality.

## 1.1 Core Features and Evolution of Digital-Intelligent Teaching

The teaching environment in the digital-intelligent era is shifting from "tool-assisted" to "ecologically integrated" [2]. Within this shift, virtual-real integration and data-driven approaches have become two notable features. For example, the "New Quality Classroom" in a Shenzhen Luohu district primary school uses smart interactive walls and sensors to build an immersive learning space [3]. Various intelligent lesson preparation systems based on large models have enabled a data-driven closed loop from learning diagnosis to personalised exercises. "Data-driven precision teaching" can dynamically match students' cognitive paths, allowing teachers to adjust their strategies in real time and moving instruction from "standardised indoctrination" towards "human-computer collaborative inquiry learning" [4].

## 1.2 Current State and Gaps in Research on Teacher Adaptability

Current research on teacher adaptability in the digital-intelligent era has moved beyond pure technical skills training toward a broader focus on role transformation and ethical literacy. Although scholars both at home and abroad have begun to pay attention to teacher role transformation in human-computer collaboration, clear gaps remain. One major gap is that most existing studies concentrate on higher or

vocational education, paying insufficient attention to the unique characteristics of the primary level. Primary teachers face challenges such as students' limited cognitive abilities and the strongly foundational nature of the curriculum, so their pathways to adaptability are quite different from those in higher education. Therefore, how to achieve effective adaptive transformation in primary teaching in order to realise the educational value of human-computer collaboration lies at the heart of this paper.

## **2. Practical Dilemmas of Human-Computer Collaborative Teaching in Primary Schools**

Although human-computer collaborative teaching shows promise at the primary level, its actual implementation is still beset by several practical dilemmas. These are mainly reflected in the four dimensions below.

### **2.1 Surface-Level Technology Application: From “Teaching Empowerment” to “Application Burden”**

Many primary schools fall into a “technology-centred” trap when introducing AI tools, failing to integrate them effectively with teaching objectives and student needs. Worse still, systems from different vendors are often incompatible with each other, which worsens fragmentation and runs counter to the goal of simplifying teaching and raising efficiency. As a result, due to complex operations, clumsy integration with the curriculum and frequent maintenance, technology actually increases the burden of lesson preparation and classroom management.

### **2.2 Teacher Role Conflict: Identity Anxiety from “Knowledge Authority” to “Collaborative Leader”**

In a human-computer collaborative environment, teachers' traditional role is challenged, triggering an identity crisis. Teachers show resistance to highly automated tools, rooted in a trade-off between control, trust and responsibility. On the one hand, when AI plays an important role in knowledge transmission, grading assignments and other tasks, some veteran teachers suffer from burnout because their teaching autonomy is weakened. On the other hand, some teachers worry that over-reliance on algorithms will reduce teaching to the mere execution of pre-established flows, suppressing their professional judgement and

creative design capacity. The uncertainty during this role transition leaves teachers feeling confused and anxious.

### **2.3 Disconnect between School-Based Practice and Technology Promotion**

The poor fit between high-level technical solutions and micro-level classroom practice is a key obstacle to the implementation of human-computer collaboration. First, there are marked gaps between regions and between schools in the supply of infrastructure and high-quality digital resources. Second, the functional design of many intelligent tools is based on generic scenarios and does not match the specific learning context of a given school or class. Moreover, there is a huge gap between strong policy push and the weak digital literacy of frontline teachers; the shortage of teacher competence has become the main barrier to the spread of AI in education, making it hard for advanced technical solutions to take root in real school settings.

### **2.4 Ethical and Security Concerns: Risks of Data Privacy and Algorithmic Bias**

The deep datafication of teaching activities brings ethical and security problems to the fore. Data privacy risks are foremost among them; in recent years, incidents of educational data leakage have surged worldwide, exposing large amounts of sensitive learning data and classroom behaviour data to the threat of leakage and misuse. Data bias and algorithmic prejudice can also lead to subtle forms of educational inequity [5]. For example, if a recommendation system is poorly designed, it may lock students into ability labels based on gender, region or past performance, thereby restricting their developmental paths. Yet faced with these risks, most teachers lack the capacity to identify and address ethical issues.

The practical dilemmas in the above four aspects are shown in Figure 1.

## **3. Construction of a “Double Helix” Teaching Model for Human-Computer Collaboration in Primary Schools**

To address the above practical dilemmas, this paper draws on socio-technical systems theory and on the experience of advanced pilot schools to construct a “double helix” teaching model for human-computer collaboration at the primary level.

Dimension of Dilemma	Core Manifestations	Key Indicators / Manifestations
Surface-Level Technology Application	Technology-centered approach; complex operations; poor curriculum integration; incompatibility forming information silos	Increased lesson preparation burden and classroom management complexity; deviates from the original goal of simplification
Teacher Role Conflict	Transition from "knowledge authority" to "AI collaborator" blocked	Veteran teachers experience burnout due to weakened autonomy; teachers worry about devaluation of pedagogical creativity
Disconnect in School-Based Practice	Gaps in infrastructure between regions/schools; generic design mismatched with local learning conditions	Teacher competency shortage is the core barrier; large gap between policy push and digital literacy
Ethical and Security Concerns	Data privacy risks; algorithmic bias leading to educational inequity	Global surge in educational data breaches; few teachers receive algorithmic transparency training

**Figure 1. Four-Dimensional Practical Dilemmas of Human-Computer Collaborative Teaching in Primary Schools**

### 3.1 Core of the Model: the Double Helix Structure of “Teacher Intelligence” and “Machine Intelligence”

In this model, teacher intelligence (instructional design, emotional connection, ethical guardianship) and machine intelligence (AI’s process automation and cognitive extension) are seen as two interwoven, co-evolving “helical strands”. The aim is to clearly define the responsibilities of each side and to achieve a “1+1>2” synergy. The core idea is to break away from one-way thinking – whether “AI replacing teachers” or “teachers dominating AI” – and instead establish a symbiotic relationship where humans and machines complement each other.

#### 3.1.1 The teacher intelligence strand: upholding the value-rationality of education

Teachers’ digital-intelligent literacy includes digital knowledge and skills, higher-order digital thinking abilities, and digital beliefs and ethics [6]. As the leader of instruction, the teacher’s irreplaceable value is mainly embodied in three dimensions.

**Instructional designer:** The teacher is the core designer of interdisciplinary learning tasks. For example, in the practice of Jiangnan Experimental Primary School in Wuxi, teachers first pinpoint the core teaching objectives, then flexibly combine AI tools to generate highly customised teaching resources – such as animations and intelligent agents – and finally integrate these outcomes seamlessly into specific

teaching sessions.

**Emotional connector:** The teacher is responsible for recognizing and intervening in non-verbal signals and student emotions that AI cannot capture. The teachers at Bailu Experimental Primary School in Kunshan play a crucial role here: they organise interactive discussions and give real-time evaluations to control the pace of the lesson and maintain a positive learning atmosphere.

**Ethical guardian:** The teacher needs to remain alert to issues such as algorithmic bias and data privacy, and exercise the right to review. For instance, in a writing class at Tianjin Experimental Middle School, the teacher guided students to compare their own original ideas with AI suggestions, using a “red versus black” contrast to deepen students’ understanding of writing and to help them grasp AI’s instrumental nature. In this process, the teacher played a key ethical guiding role.

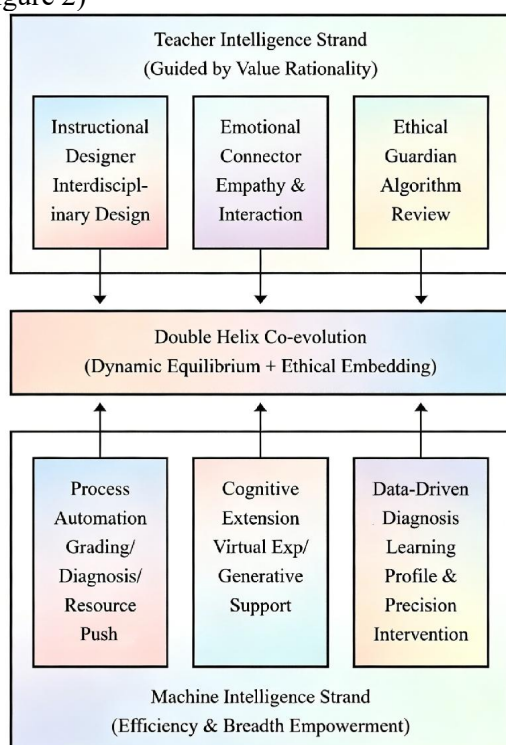
#### 3.1.2 The machine intelligence strand: empowering teaching efficiency and breadth

As an efficient tool, AI empowers teaching in two dimensions:

**Process automation:** AI can take over repetitive tasks such as grading assignments, learning diagnosis and resource delivery. For example, at Guanyao Central Primary School in Foshan, the AI system automatically analyses students’ preview data, generates visual learning reports, and accurately pushes tiered consolidation exercises, greatly reducing teachers’ routine

workload.

Cognitive extension: AI can extend the boundaries of students' thinking through generative inquiry support and virtual experimental environments. Jiangji No.2 Primary School in Longtan District, Jilin City, integrates AI tools into lesson preparation, classroom observation and homework stratification. Similarly, Xincun Tongchuang Primary School in Jiangbei District, Chongqing, uses natural language processing technology in its "AI Poetry Maker" course to generate personalised suggestions for revising poems. (Figure 2)



**Figure 2. Structural Diagram of the "Double Helix" Teaching Model for Human-Computer Collaboration in Primary Schools**

### 3.2 Operational Process: A Four-Stage Cyclical Teaching Flow

In practice, the model follows a dynamic, four-stage cyclical process to ensure orderly and effective teaching.

Intelligent diagnosis, precise goal setting: The teacher uses AI tools to analyse learning conditions and jointly set differentiated, personalised teaching objectives. At Guanyao Central Primary School, before class, the teacher pushes preview materials through the National Smart Education Platform, and the AI system analyses the preview data to help the teacher plan instruction accordingly.

Human-computer collaboration, differentiated instruction: During class, AI handles knowledge transmission and repetitive practice tasks, while the teacher organises higher-order cognitive activities. In the lesson "The Power of Science and Technology" at Jinshufu Primary School in Longtan District, Jilin City, the design "ancient-modern comparison introduction → group inquiry into technological achievements AI-assisted student presentations" achieved an integration of competencies.

Multi-dimensional feedback, dynamic intervention: Real-time data feedback from AI is combined with qualitative teacher evaluation to adjust teaching dynamically. Wenzhou Experimental Middle School uses "competency portraits" to accurately show students' growth trajectories, letting evaluation support students' diverse development and providing a basis for instructional intervention.

Reflective iteration, model optimisation: The teacher reviews the whole human-computer collaboration process, adjusts strategies, and feeds experience back to improve the AI model. Jiangnan Experimental Primary School in Wuxi has formed a virtuous cycle of "practice – research – feedback – optimisation", using district-level research projects to provide theoretical support for teaching practice.

### 3.3 Example Illustration: Application in Primary Chinese Writing Teaching

Take a primary Chinese writing class on "My Animal Friend" as an example to show how the double helix model works.

Before class – intelligent diagnosis: The AI pushes sample essays describing animals and intelligently analyses students' first drafts, identifying common problems such as "limited vocabulary" and "lack of detail", thus providing data to help the teacher set the core objective of "using multiple senses in description".

During class – differentiated instruction: Students give commands to the AI, for example "generate some nice sentences describing a cat's appearance", using it as a tool to diverge their thinking and spark creative inspiration.

After class – precise intervention: AI process automation performs an initial screening of the students' revised essays, marking possible misspellings and grammatical errors. The teacher then, based on the AI-generated analysis report, groups those students who still struggle with "detailed description" and runs a

mini-workshop on “observing animal features”, providing targeted face-to-face guidance.

#### **4. Pathways for Teacher Adaptive Transformation**

Primary teachers’ adaptive transformation in a human-computer collaborative environment is a systematic endeavour involving three levels: individual, organizational and technological.[7] To ensure the effective implementation of the double helix teaching model, a synergistic development framework – “capacity reshaping – ecological support – technology burden reduction” – needs to be built.

##### **4.1 Individual Level: Dual-Core Capacity Reshaping**

At the individual level, the core of teacher transformation lies in developing two key abilities [8]. The first is technological integration capacity – the skill of adapting AI for pedagogical use. This requires teachers to accurately evaluate and select appropriate AI tools and then transform them for subject-specific teaching. For example, through an “AI Teaching Assistant Workshop”, Jiangnan Experimental Primary School helped Chinese language teachers learn to use natural language processing technology to design an intelligent assistant that can automatically correct basic sentence patterns and generate personalised writing suggestions, turning a general-purpose technology into a powerful subject-teaching assistant.

The second is interdisciplinary design capacity. Teachers need to break down disciplinary walls and design integrated learning tasks that merge technological logic with educational goals. For example, a science teacher could design a project around “observing plants on the school campus”, guiding students to use AI image recognition tools to identify plants, integrate language arts by writing observation diaries, and use mathematics to count plant distributions – thereby developing an AI-enhanced STEAM curriculum. These two capacities together form the core pillar that allows teachers to maintain their professional leadership in human-computer collaborative settings.

##### **4.2 Organisational Level: Systemic Innovation in Ecological Support**

Schools must build an institutionalised support network for teacher transformation, breaking the

dilemma of “fighting alone” [9].

First, create virtual collaboration platforms. For instance, some school groups in Jinhua have set up cross-school “virtual teaching research offices”, sharing AI teaching case libraries; teachers collaboratively prepare lessons online and jointly design emotional-education intervention strategies in AI-integrated teaching scenarios, enabling the flow of high-quality resources and ideas.

Second, cultivate competition incubation mechanisms. Hold school-level or regional AI teaching innovation competitions, using practical topics such as “design of an intelligent diagnostic teaching plan” to drive teachers’ innovation. Award-winning projects receive incubation support and resources to promote the application and dissemination of outcomes.

Third, reform evaluation mechanisms. Incorporate teachers’ digital-intelligent literacy and human-computer collaboration teaching effectiveness into the appraisal system. For example, add dimensions such as “technology-integrated teaching ability” and “digital resource construction and innovative application” to the criteria for professional title evaluation, and develop specific, actionable assessment indicators, thereby guiding and motivating teachers’ transformation practices through institutional measures.

##### **4.3 Technological Level: Two-Way Adaptation through Human-Centred Design**

The design of technological systems must serve teachers and ease their burden – genuine empowerment [10]. On the one hand, we need teacher-friendly interfaces, and should vigorously promote low-code or even no-code educational tools. For example, Guanyao Central Primary School introduced a visual-programming courseware creation system, allowing teachers to generate interactive courseware through simple drag-and-drop configuration, greatly lowering the technical barrier. At the same time, it is advisable to promote intelligent lesson preparation assistants that support natural language interaction, enabling teachers to customise subject-specific agents using plain-language commands like “create a virtual teaching assistant that can interactively explain the ancient poem ‘Spring Dawn’ to third-graders”.

On the other hand, we should develop precise delivery channels for developmental resources.

Using public service systems such as the National Smart Education Platform, we can build digital profiles of teachers, intelligently diagnose their competence gaps, and accurately push modular, micro-credential learning resources such as “intelligent diagnostic teaching” or “interdisciplinary project design”, thus providing personalised support for teachers’ continuous professional growth.

In summary, teachers’ adaptive transformation is not accomplished overnight. It requires the synergy of three forces – the continuous evolution of individual capacities, the strong support of the organisational ecology, and the user-friendly adaptation of technological tools – to steadily advance, ultimately empowering teachers to move from passive adapters of technology to active leaders of human-computer collaborative teaching.

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