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# Challenges of Implementing Blended Learning in Science Experiment Courses: An Empirical Study on Science College Teachers in Hebei Province

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**Abstract:** Science college teachers in Hebei, China, face core challenges in blended science experiment courses: insufficient digital literacy, difficult remote lab supervision, low online engagement, poor infrastructure, lack of targeted training, and inadequate online-offline integration. Based on Social Learning and Constructivist Theories, this quantitative study surveyed 245 randomly sampled teachers from 7 Hebei normal colleges. Results reveal a strong positive correlation between blended teaching challenges and strategy application. It provides Hebei's science education stakeholders with targeted insights, emphasizing discipline-specific frameworks for experimental courses.

**Keywords:** Blended learning; Implementation challenges; Science experiment courses; College science teachers

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## 1. Introduction

Technology has reshaped modern learning, enabling science students to access virtual labs for remote practical learning. Blended teaching—integrating online-offline experiments—has become prevalent in academia [1], especially in tertiary science education where seamless integration is critical. Yet educators face key challenges: inadequate infrastructure/training, insufficient technical skills [2], curriculum-aligned resource selection, and sustaining online engagement—amplified by labs' hands-on nature [3]. Blended learning is mainstream, but optimizing its balance remains a focus. This empirical study explores Hebei's science college teachers' specific challenges in blended science experiment courses, filling the region-specific research gap.

### 1.1. Background of the study

ICT has become an indispensable part of education [4]. The Internet has promoted the development of virtual labs and AR/VR technologies, which are transforming science education in China [5]. However, integrating ICT into science lab teaching still faces many challenges, including insufficient teacher training, poor infrastructure, digital divides, and difficulties balancing virtual and hands-on experiments. These problems worsened during the

pandemic. In Hebei Province, science trainees in three-year primary school teacher programs take experiment-integrated second-year courses such as Primary School Scientific Teaching Design. These courses rely heavily on face-to-face interaction, making online delivery especially difficult.

Blended learning, emerging in the 1960s, combines ICT-based digital learning with face-to-face instruction, regarded as the integration of traditional and online teaching. In China, it highlights teachers' guidance and students' initiative and has been widely promoted under policies including the 2019 "Six Excellents and One Top" Initiative [6]. As a globally recognized educational reform model, it optimizes educational resources and cultivates students' core competencies, and its effective implementation depends on scientific instructional design.

## 1.2. Problem statement

Despite the growing adoption of blended learning (BL) in science education, a critical gap remains in understanding Hebei's science college teachers' discipline-specific obstacles in conducting science experiments via BL. Existing studies emphasize BL's general benefits but overlook the unique challenges of experimental science education, such as designing hybrid lab workflows, aligning virtual pre-lab modules with hands-on activities, and maintaining student engagement in complex experimental settings [7,8]. For example, teachers struggle to synchronize online-offline lab components, reflecting a disconnect between pedagogical models and experimental requirements. Additionally, current Chinese teacher training prioritizes general digital literacy over lab-specific competencies, and a Hebei normal college survey shows a significant gap between institutional support and blended lab design needs.

## 1.3. Research objective and research question

### 1.3.1. Research objective

This study aims to investigate the challenges of blended learning in science experiments among science college teachers in China, with a specific focus on Hebei Province, with a specific focus on:

To investigate the challenges faced by science college teachers when implementing blended learning in teaching science experiment classes to science trainees.

### 1.3.2. Research question

Against the backdrop of technological advancements reshaping communication, information dissemination, and pedagogical practices [9], particularly the rise of blended learning (integrating online and face-to-face approaches) in university science courses [10], this study addresses the following core research question: What challenges do science college teachers face when implementing blended learning in teaching science experiment classes to science trainees?

## 1.4. Significance of the study

This study explores challenges in implementing blended learning in college science experiment courses, focusing on science teachers in China, especially in Hebei Province. Against the background of technology-driven teaching reform and the growing application of blended learning in university science education, this research has important theoretical and practical significance.

Focusing on teachers' practical difficulties, it identifies the core challenges, dimensions, and demographic differences in blended learning implementation, aiming to optimize teaching practice, improve online-offline integration, and enhance science education quality.

For college science teachers and students, this study clarifies the challenges and underlying causes of blended experiment teaching, helping teachers adopt targeted improvement strategies. Optimized teaching can strengthen instructional effectiveness, promote student engagement and performance, and lay a solid foundation for high-quality science experiment education.

## 1.5. Limitation and delimitation of the study

This study explores the blended learning challenges (e.g., inadequate online training, low student motivation, large online class management difficulties, and limited engagement) faced by science college teachers in Hebei Province, China, in science experiment courses. Key limitations and delimitations are as follows:

### 1.5.1. Limitations

(1) Sample Representativeness: The small sample of 245 teachers from 7 Hebei normal colleges may limit generalizability to all science college teachers in the province.

(2) Geographical Restriction: As the study is limited to Hebei, findings cannot be generalized nationwide due to regional educational differences and should be interpreted with caution.

Future research could expand the sample to multiple provinces to enhance generalizability.

### 1.5.2. Delimitations

This study focuses on specific participants: Hebei's college science teachers teaching second-year science trainees at 7 selected normal colleges. A quantitative approach is adopted to identify patterns, enabling focused examination of targeted challenges.

## 1.6. Definitions of key terms

This section will discuss the definitions and concepts of Blended Learning and Science Experiment Courses by reviewing the relevant literature.

### 1.6.1. Blended learning

Blended learning integrates face-to-face instruction with online learning, combining digital resources and in-person lab guidance to enable flexible, structured learning for science trainees [11].

### 1.6.2. Science experiment courses

Science experiment courses are practical courses that combine theory and hands-on lab work, requiring online pre-experiment preparation and offline practice—key to blended learning in tertiary science education.

# 2. Theoretical basis and research perspective

To address the core research question on the implementation challenges of blended learning in science experiment courses among Hebei's college science teachers, this study adopts two complementary theoretical frameworks covering the social and cognitive dimensions of teaching: Social Learning Theory and Constructivism.

## 2.1. Social learning theory

Proposed by Bandura (1977), Social Learning Theory posits that learning occurs via observation, modeling, and

social context. This study explains key teacher challenges: limited blended teaching role models and insufficient institutional/collegial support hinder mastery of experiment-specific skills (e.g., online pre-experiment simulation design, offline hands-on guidance) [12]. It also highlights that social reinforcement shapes teachers' motivation to tackle these novel challenges in Hebei's context.

### 2.2. Constructivism

Constructivism emphasizes that learners actively construct knowledge from prior experiences [13]. In blended science experiment teaching, it underscores linking online simulations with offline practice—a key integration posing teacher challenges (e.g., aligning virtual-physical procedures, adapting to diverse learning paces). Its focus on individual/collaborative learning further explains difficulties in managing student needs and cross-environment interaction.

### 2.3. Comparison of theoretical frameworks

Unlike Behaviorism (focused solely on external reinforcement) and Cognitivism (ignoring social interaction), combining these two frameworks enables holistic analysis of teachers' challenges—covering both social support and cognitive integration needs—and lays a solid theoretical foundation for subsequent empirical analysis.

## 3. Research design and methodology

This study used a quantitative design to investigate blended learning challenges among Hebei College science teachers in experimental courses. Quantitative research was selected for its ability to analyze variable relationships, provide statistical descriptions, and produce reliable results, suitable for identifying challenge patterns across teacher samples.

### 3.1. Data collection and ethical considerations

(1) Sample: A total of 245 college science teachers were recruited, all of whom instruct second-year science trainees in science experiment courses.

(2) Instrument: Data were collected using a validated questionnaire revised through a pilot study to ensure reliability. It focused on core dimensions of blended experiment teaching challenges: online-offline integration, student engagement, and institutional support.

(3) Ethics: Strict ethical standards were followed, including voluntary participation, information confidentiality, and the right to withdraw at any stage without penalty.

### 3.2. Research setting and sampling

(1) Location: The study was conducted at 7 representative Hebei normal colleges, selected for geographic diversity, strong science programs, and blended learning experience. Hebei was chosen as typical of northern China's education system, ensuring feasibility and reliable data.

(2) Sampling Method: Simple random sampling was applied following Krejcie and Morgan (1970). Eligible teachers were randomly selected by unique identifiers to reduce bias and ensure representative results in Hebei.

## 4. Data analysis

Data were collected via an online questionnaire from 245 science teachers across 7 Hebei normal colleges teaching blended science experiment courses. Online administration reduced social desirability bias, and the questionnaire focused on core dimensions of blended teaching challenges.

SPSS 20.0 was used for data analysis. After data cleaning, reliability and validity were examined using Cronbach's α, KMO, and Bartlett's test. Descriptive statistics summarized demographic and challenge data, while linear regression analyzed the relationship between challenge intensity and strategy use.

### 4.1. Preliminary data processing

#### 4.1.1. Data cleaning

Data cleaning was performed using SPSS 20.0. The core variable CBLI included 245 valid entries with no missing data. Error checking and standardization removed anomalies, providing a reliable basis for later analysis.

#### 4.1.2. Reliability and validity

The CBLI scale showed robust reliability (Cronbach's $\alpha = 0.977 > 0.7$, excellent internal consistency) and construct validity (KMO = 0.967, Bartlett's Sphericity Test $p < 0.001$), confirming data suitability for factor analysis and the questionnaire's validity in measuring blended experiment teaching challenges.

### 4.2. Demographic profile overview

Of 245 participants: 54.3% male (133), 45.7% female (112); 55.9% aged 30–39, 55.5% with 5–10 years of teaching experience, 78.8% holding master's degrees. Notably, 85.3% had < 5 years of blended learning experience—a key contextual factor linking to their challenges, given the approach's novelty in local science experiment courses.

### 4.3. Core statistical analysis for the research

Core research question: What challenges confront Hebei's college science teachers in implementing blended learning for science experiment courses? Linear regression was applied to analyze the relationship between Blended Learning Strategies (BLS, independent variable) and CBLI (dependent variable).

Results: $R^2 = 0.852$ (adjusted $R^2$ comparable), meaning 85.2% of CBLI variance is explained by BLS. This strong positive correlation reveals a local trend: teachers adopting new blended lab strategies (mostly without targeted training) encounter increased short-term challenges, which does not negate BLS' long-term value. Coefficients: intercept = 0.752 (baseline CBLI without formal BLS), BLS coefficient = 0.821 (a 1-unit increase in BLS correlates with a 0.821-unit rise in CBLI); standardized Beta = 0.923, t = 37.473, $p < 0.001$ (statistically significant).

This analysis directly answers the core research question, provides a quantitative foundation for group difference analyses (e.g., by teaching experience), and offers guidance for targeted interventions (e.g., tailored BLS training for science experiment courses) for Hebei's science education stakeholders.

## 5. Discussion and conclusion

Based on quantitative results, this section addresses the core research question: What challenges do Hebei's science college teachers encounter in blended experiment teaching? Grounded in Social Learning Theory,

Constructivism and related literature, it interprets key findings, compares them with previous studies, and explores implications for improving blended learning in Hebei's science experiment education.

It further analyzes dimensional characteristics of challenges (e.g., technical barriers, integration difficulties) combined with local teaching contexts, discusses theoretical, practical and policy contributions, offers future research suggestions, and draws key conclusions.

## 5.1. Key challenges of blended learning in science experiment courses: Quantitative findings and practical insights

To address the core research question: What challenges do science college teachers face when implementing blended learning in science experiment classes? This section presents condensed, data-driven insights into the most pressing obstacles for Hebei's science educators, grounded in responses from 245 participating teachers.

### 5.1.1. Core quantifiable challenges

All challenges are supported by direct teacher feedback, reflecting critical barriers to effective blended instruction:

(1) Remote supervision difficulties (82%): The most acute obstacle—teachers cannot enforce lab safety protocols, correct operational errors promptly, or ensure comprehension during online experiments, especially for at-home tasks (unique to science experiment teaching).

(2) Diminished student engagement (75%): Virtual experiment components lack hands-on interaction, reducing trainee participation and deep understanding of complex experimental principles compared to physical labs.

(3) Inadequate targeted training (70%): General ICT workshops fail to cover virtual lab operation, online experiment design, and other experiment-specific skills, leaving teachers ill-equipped for blended instruction.

(4) Digital literacy deficits (68%): Poor proficiency in virtual lab tools and online experiment design hinders replication of in-person lab experiences.

(5) Technical infrastructure issues (64%): Unstable internet and limited software access disrupt instruction; large classes increase troubleshooting demands, diverting time from teaching.

(6) Poor online-offline integration (60%): Misalignment between digital simulations/videos and in-person lab work leads to fragmented learning, failing to connect virtual preparation to hands-on practice.

(7) Large cohort management: Teachers struggled to personalize instruction, provide timely feedback, and monitor engagement across modes—particularly during virtual-physical transitions.

### 5.1.2. Practical insights from empirical alignment

Further analysis reinforces recurring, practice-focused obstacles, consistent with existing research:

(1) Technical infrastructure as a foundational barrier: 64% of teachers reported connectivity and software issues, indicating that sound infrastructure is a key prerequisite for successful blended learning.

(2) Need for discipline-specific training: 70% of underprepared teachers underscore the gap in general ICT training, indicating that blended laboratory instruction requires tailored pedagogical development [14].

(3) Structured integration of resources is lacking: Nearly 60% of teachers struggled with online-offline alignment, indicating that unstructured resource integration weakens conceptual learning [15].

(4) Large cohorts compromise quality: Reduced face-to-face interaction limits formative assessment, making

accountability and personalized support unfeasible in mixed-mode settings.

### 5.1.3. Summary

Blended science experiment teaching faces intertwined technical (infrastructure, digital literacy), pedagogical (engagement, integration), and systemic (training, cohort management) challenges. Solutions for Hebei's science colleges must prioritize teacher-centric, experiment-specific interventions.

## 5.2. Contribution of the study

This study focuses on teachers' challenges in blended science experiment courses, delivering targeted contributions to theory, practice, and policy—aligned with Chinese science colleges' hands-on instruction context:

### 5.2.1. Empirical contribution

This study identifies region-specific, experiment-related challenges (e.g., remote lab supervision, virtual-physical experiment alignment) from quantitative data across 7 Hebei normal colleges. It fills a research gap, as most blended learning studies focus on lectures rather than hands-on laboratory courses.

### 5.2.2. Practical contribution

Provides actionable, data-driven recommendations for Hebei's institutions (e.g., experiment-specific digital training, peer mentorship for novice teachers, technical support for virtual labs) targeting measurable barriers (e.g., 82% remote supervision difficulty). Highlights group differences (novice teachers face more intense challenges) to guide differentiated interventions.

### 5.2.3. Theoretical and methodological contribution

Enriches the application of Social Learning Theory and Constructivism in experiential learning: limited peer modeling and difficulties connecting digital tools with hands-on practice explain the challenges in blended lab teaching, bridging theory and practice in science education.

### 5.2.4. Policy and curriculum contribution

Guides Hebei's science education policy by emphasizing "teacher-centric support" over mere blended learning advocacy. Advocates for targeted investments (infrastructure, embedded training, integration frameworks) to promote sustainable blended learning implementation in experiment courses.

## 5.3. Conclusion

This empirical study identified core challenges among 245 science teachers from 7 Hebei normal colleges in blended experiment teaching: insufficient digital literacy, difficult remote lab supervision, low student engagement, poor infrastructure, lack of targeted training, and weak online-offline integration.

Group analysis showed that teachers with less teaching or blended learning experience (< 5 years) encountered greater challenges (no relation to academic qualifications), consistent with Social Learning Theory and Constructivism.

Although blended learning supports integration of theory and practice, its success depends on resolving teacher-related barriers. Targeted measures (virtual lab training, technical support, peer mentorship, structured

integration) are essential. This study offers Hebei-specific evidence and practical guidance for optimizing blended teaching, supporting future research on experiential blended learning.

## Disclosure statement

The author declares no conflict of interest.

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