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A B5G-Enabled Smart Webcast Teaching Framework for Integrating Civic Ideology into College English Writing Instruction

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Abstract The advent of Beyond 5G (B5G) communication technologies and intelligent sensing devices has introduced new paradigms in online education, enabling real-time, interactive, and high-fidelity remote instruction. This study proposes a novel live-streaming teaching model for college English writing courses that leverages B5G networks and smart IoT devices to integrate Civic and Political Education (CPE) into writing pedagogy. The framework combines a multimodal resource repository, intelligent classroom feedback mechanisms, and real-time student behavior monitoring to support immersive instruction and value leadership. By systematically modeling instructional quality—including audio clarity, interaction latency, feedback efficiency, and learning concentration—quantitative assessments under different network conditions demonstrate significant advantages of the B5G environment in reducing latency (30 ms), improving knowledge delivery integrity (99%), and enhancing teaching effectiveness scores (0.95). Pedagogically, the model incorporates writing tasks centered on cultural identity, civic responsibility, and ethical reflection, promoting student engagement through pre-writing discussions, live critiques, and iterative feedback. Experimental data collected from 50 university students indicate improved writing performance, increased peer interaction, and higher satisfaction across technical, service, and teaching dimensions.

Index Terms live English teaching, B5G, Internet of Things (IoT), mathematical modeling, transmission quality, interaction delay, teaching effectiveness

I. Introduction

With the rapid advancement of information and communication technologies (ICT), particularly the emergence of Beyond 5G (B5G) networks and smart sensing devices, educational practices have undergone a profound transformation. These technological innovations have not only removed the temporal and spatial constraints of traditional instruction but also fostered the development of more interactive, immersive, and personalized learning environments. Among various applications, online live teaching has become a pivotal instructional mode in higher education, especially during the global COVID-19 pandemic, when the policy of "suspending classes without stopping learning" accelerated the transition from offline classrooms to digital platforms. In this context, college English writing—a course that traditionally relies on interactive feedback and contextual understanding—faces both unique opportunities and challenges when migrated to webcast-based formats.

Despite the proliferation of platforms such as Rain Classroom, MOOCs, and Zoom, the effective delivery of college English writing courses continues to face several limitations. These include insufficient real-time interaction, lack of individualized monitoring, unstable network transmission, and difficulty in embedding value-oriented content such as Civic and Political Education (CPE) into the writing process. In China's higher education context, CPE is recognized as an essential complement to academic learning, aiming to cultivate ideological awareness and moral responsibility alongside knowledge acquisition. However, most existing webcast-based teaching models emphasize technical facilitation over substantive value integration, thereby missing opportunities to infuse civic elements seamlessly into instructional design.

Recent research has explored enhancements in online education through technical innovations such as adaptive bitrate streaming, automated behavioral analytics, and AI-driven writing assessment. While these approaches have improved certain aspects of content delivery and student engagement, they often lack a unified strategy that couples technical optimization with pedagogical enrichment, particularly in the integration of civic and ideological education. Furthermore, under 4G and early 5G conditions, persistent issues such as interaction latency, signal instability, and suboptimal audio-visual fidelity have hindered the precise, real-time communication essential for effective language instruction and timely feedback.

To address these gaps, this paper proposes a B5G-enabled smart webcast framework tailored for college English writing instruction. The model combines intelligent sensing technologies (e.g., eye-tracking, participation sensors), the ultra-low-

latency and high-bandwidth capabilities of B5G networks, and a civic-centered curriculum design to enhance both technical efficiency and pedagogical depth. The system continuously collects and analyzes data on student attentiveness, feedback, and interaction patterns, enabling dynamic adaptation of teaching strategies. Crucially, it embeds CPE into the writing process through topic selection (e.g., cultural identity, social ethics), collaborative discussion, process-oriented writing, and reflective feedback.

Through theoretical modeling and empirical validation, this study addresses the following research questions:

1) How can B5G networks and IoT-based sensing technologies improve the real-time performance and interactivity of live English writing classes?
2) In what ways can civic and political values be embedded within writing tasks to achieve both cognitive and ideological learning outcomes?
3) What is the impact of the proposed model on teaching effectiveness, student satisfaction, and participation under various network conditions?

The main contributions of this paper are as follows:

- Development of a mathematical framework for quantifying teaching effectiveness in live-streaming environments, incorporating metrics such as signal-to-noise ratio, interaction delay, and content delivery integrity.
- Introduction of an instructional model that integrates B5G infrastructure with intelligent behavior sensing for real-time learning analytics.
- Proposal of a scalable and adaptable pedagogical strategy for embedding CPE into the writing process.
- Empirical evidence, based on experiments with 50 undergraduate students, demonstrating substantial improvements in engagement, satisfaction, and writing quality under B5G conditions compared to 4G and 5G baselines.

II. Modeling the Physical Environment of English Live Streaming

This section presents a mathematical framework for modeling the effectiveness of live-streamed English teaching. The aim is to optimize learners' experiences, improve the quality of content delivery, and ensure efficient allocation of network resources. The proposed models not only guarantee smooth streaming but also enhance comprehension, interactivity, and overall learning outcomes.

The instructional quality of live videos is critical for language learning, encompassing both audio clarity and video resolution. The overall content quality, Q_{content}, is defined as:

$$Q_{\text{content}} = \alpha \cdot Q_{\text{audio}} + \beta \cdot Q_{\text{video}}, \tag{1}$$

where Q_{audio} ensures clear communication of the teacher's speech, Q_{video} ensures the visibility of gestures, expressions, and lesson content, and α and β are weighting coefficients reflecting their relative importance.

In English language instruction, audio clarity is paramount. The signal-to-noise ratio (SNR) for audio, SNR_{audio}, is:

$$SNR_{\text{audio}} = \frac{P_{\text{signal}}}{P_{\text{noise}}}, \tag{2}$$

where P_{signal} is the power of the instructional audio signal and P_{noise} is the background noise power. A higher SNR ensures clearer pronunciation and comprehension.

Interaction delay, $D_{\text{interaction}}$, is another critical factor in language acquisition and is given by:

$$D_{\text{interaction}} = D_{\text{e2e}} + D_{\text{proc}}, \tag{3}$$

where D_{e2e} is the end-to-end communication delay and D_{proc} is the processing and feedback delay. Lower delays enable more immediate question-and-answer exchanges, thereby improving interactivity.

Let S_i denote the feedback score of the i-th student. The overall teaching effectiveness, E_{teach}, is calculated as:

$$E_{\text{teach}} = \frac{1}{N} \sum_{i=1}^{N} S_i, \tag{4}$$

where N is the total number of students. Scores S_i range from 0 (not satisfied) to 1 (very satisfied), reflecting comprehension and satisfaction.

The completeness of knowledge delivery, $C_{\text{knowledge}}$, is defined as:

$$C_{\text{knowledge}} = \frac{L_{\text{sent}}}{L_{\text{total}}}, \tag{5}$$

where L_{sent} is the number of successfully transmitted knowledge-module packets, and L_{total} is the total number of packets scheduled for transmission.

For real-time speaking practice, latency directly impacts timely pronunciation feedback. Delay tolerance, D_{tol}, is modeled as:

$$D_{\text{tol}} = T_{\text{feedback}} + T_{\text{proc}}, \tag{6}$$

where T_{feedback} is the teacher's feedback time and T_{proc} is the audio processing and transmission time. Exceeding a certain threshold degrades the speaking practice experience.

Using IoT-enabled sensing, student concentration can be quantified as:

$$F_{\text{focus}} = \frac{T_{\text{attention}}}{T_{\text{total}}}, \tag{7}$$

where $T_{\text{attention}}$ is the total time a student actively engages with the screen and T_{total} is the duration of the session.

To maintain quality across varying network conditions, transmission rates and content parameters can be dynamically adjusted. The adaptation score, A_{score}, is defined as:

$$A_{\text{score}} = \alpha \cdot Q_{\text{content}} - \beta \cdot D_{\text{interaction}}, \tag{8}$$

where α and β control the trade-off between content quality and interaction delay.

III. The Practice of Integrating Ideological and Political Education into College English Writing Webcast Classes

Incorporating curricular ideology into a live college English writing course can be implemented through the following practices:

1) **Course Content Design**
   - *Select writing topics with elements of Civic-Political thinking:* Design writing tasks related to social responsibility, cultural identity, ecological protection, and other relevant themes. For example, students may be required to write an argumentative essay on the topic "How to Present Chinese Culture in the Context of Globalization" to cultivate their cultural self-confidence.
   - *Introducing hot cases of current affairs:* Combine current hot issues in society, such as the digital impact on industries or artificial intelligence ethics, using them as writing materials to inspire students to think and express their own views from multiple perspectives.
   - *Incorporating traditional Chinese culture:* Integrate topics such as "family customs and discipline" and "Confucius' thinking and modern education" into writing assignments to guide students in understanding and passing on excellent traditional culture.
2) **Innovative Teaching Methods**
   - *Using interactive functions to deepen ideological and political education:* Through interactive live course features (such as real-time discussion and voting), guide students to consider issues such as "how to view cultural equality in international exchanges," stimulating critical thinking.
   - *Role-playing and case study:* Set up simulation scenarios, such as "How to introduce Chinese New Year culture to foreigners as a Chinese student," allowing students to complete the task through both writing and oral expression, thereby strengthening the integration of Civic Education.
   - *Teachers and students discussing together:* During writing correction, teachers can discuss students' views—via text feedback or live explanation—leading them to think deeply about the relationship between social responsibility and personal development.
3) **Evaluation and Feedback**
   - *Integration of Civic and Political evaluation indicators:* Include Civic and Political elements in the writing evaluation criteria, such as whether the article reflects positive values and conveys positive energy.
   - *Instant feedback:* Review or critique students' writing in real time during the live class and provide guidance on expressing Civic-Political content, for example, by suggesting ways to better demonstrate a sense of personal responsibility or social mission.
   - *Encouragement of diverse expressions:* In evaluations, emphasize students' articulation of social issues from different cultural perspectives and guide them to appreciate the importance of multiculturalism and a global vision.
4) **Curriculum Resources and Platform Construction**
   - *Provide a Civic and Political material bank:* Create a dedicated Civic and Political Writing Resource Board on the course platform, including model essays, current affairs topics, cultural resources, and more for students' reference.
   - *Introducing expert lectures:* Invite experts in relevant fields to give lectures on hot topics such as ecological civilization, science and technology, and ethics, delivered via live or recorded broadcasts, to broaden students' perspectives and enrich their writing material.

5) **Student Participation and Reflection**

- *Encourage self-reflection:* After completing a writing task, require students to submit a self-reflection paragraph describing how they integrated Civic and Political elements into their work and their understanding of the topic.
- *Discussion and sharing within the group:* After the live course, organize online sharing sessions where students discuss their writing experiences and explore value expression across different themes, enhancing both interactivity and reflective thinking.

Through the above specific implementation methods, Civic Education can be naturally integrated into the live college English writing classroom, achieving an organic combination of knowledge transfer and value leadership.

The experimental results focus on the performance of English teaching live streaming under different network and interaction conditions, including content delivery quality, audio clarity, interactive delay, and other indicators. A sample experimental result is shown in Table 1, assuming testing of live English teaching in B5G and IoT environments, mainly examining the impact of multiple factors on teaching effectiveness.

Table 1: Data results under different network conditions

Indicator	4G Network	5G Network	B5G Network	Remarks
Video clarity Q_{video}	720p	1080p	4K	B5G networks support higher video quality
Audio SNR SNR_{audio}	18 dB	25 dB	30 dB	Significant improvement in audio clarity under B5G
Interaction delay $D_{\text{interaction}}$	200 ms	80 ms	30 ms	Low latency ensures smoother interaction
Content delivery integrity $C_{\text{knowledge}}$	87%	95%	99%	B5G reduces packet loss
Learning concentration F_{focus}	0.58	0.77	0.86	Higher focus and engagement under B5G
Teaching effectiveness score E_{teach}	0.68	0.87	0.95	Significant improvement in student satisfaction under B5G
Network adaptability score A	0.58	0.87	0.97	B5G shows higher adaptability

Experimental Conditions: Test environment: An IoT platform under B5G, simulating different network speeds and latencies (4G, 5G, and B5G). Number of students: 50 online participants under varied network conditions. Test content: English listening, speaking interaction, and class presentation.

Under B5G conditions, video clarity reaches 4K, and audio SNR achieves 30 dB, enabling students to clearly hear pronunciation and observe subtle mouth shapes and gestures—particularly suitable for pronunciation and expression training. The low latency of B5G controls interactive delay within 30 ms, significantly enhancing real-time feedback and simulating in-class experiences. Content delivery integrity approaches 99%, compared to 87% (4G) and 95% (5G), reducing packet loss and ensuring complete delivery of instructional material.

Learning concentration, measured via IoT devices, reaches 0.87 in B5G conditions—significantly higher than 0.58 in 4G—reflecting improved engagement. Teaching effectiveness scores also rise to 0.95.

Before writing activities, teachers leverage mainstream media reports on the epidemic, both domestic and international, as language and thought input. The internet has democratized knowledge access, removing the teacher's monopoly on information—both teachers and students are learners. Teachers encourage active participation by assigning each group to submit two curated media reports, from which four are selected as pre-writing materials. Students extract linguistic and ideological elements, engage in group discussions, critically analyze content and viewpoints, and develop outlines. Writing proceeds through 2–4 drafts with multi-dimensional feedback—self-revision, peer review, and teacher comments—focusing on language, structure, content, and ideas. Final drafts are analyzed collectively to broaden perspectives and foster critical thinking.

In their final works, most students analyzed why the United States lagged in pandemic response, citing factors such as cultural prioritization of individual freedom, mask-wearing attitudes, the political system, and governmental negligence. For example, one student wrote: *"There are three reasons why the U.S. fell behind in the war on epidemics—misjudging the situation, unique culture, and lack of governmental responsibility."* Another stated: *"But as the most powerful country in the world, why was the U.S. most affected by the pandemic? I blame it on the president's early negligence and inaction, as well as Americans' cultural habit of avoiding masks to prevent infection. The American federal system is also to blame."*

IV. Research Methodology and Design

IV. A. Data Collection

The Likert five-point scale was chosen as the data collection tool for learning attitude and satisfaction. The dimensions of the scale were determined by referring to the research results of relevant scholars, and the measurement of learning attitude was divided into three dimensions: perceived usefulness, perceived ease of use, and willingness to continue to use. Each dimension

was set up with two to four questionnaire questions. The measurement of satisfaction was divided into three dimensions: technical satisfaction, service satisfaction, and teaching satisfaction. Technical satisfaction contained three indicators: usability, reliability, and safety. Service satisfaction contained three indicators: responsiveness, assurance, and empathy. Teaching satisfaction contained four indicators: teaching methods, teaching resources, teaching interactions, and teaching evaluation. Technology satisfaction includes three indicators of usability, reliability, and security; service satisfaction includes three indicators of responsiveness, assurance, and empathy; and teaching satisfaction includes four indicators of teaching methods, teaching resources, teaching interaction, and teaching evaluation, with two to three questionnaire items for each indicator.

The descriptions of each item were scored from 1 to 5 on a scale from "completely disagree" to "completely agree." The scores of each dimension were averaged with the scores of the corresponding items. The reliability of the scale was examined, and the factor loadings of the revised scale were above 0.552, the cumulative variance contribution rate reached 70.69%, the alpha coefficient of the whole scale was 0.877, and the α coefficients of the dimensions were above 0.782, indicating high reliability of the scale. On the basis of this scale, a web-based questionnaire survey was conducted for all students who participated in the teaching practice.

Data on attendance, viewing of video resources, frequency of effective live speeches, and number of effective forum posts created during the teaching process were gathered for the study of course engagement. The data was coded, categorized, and parsed using the content analysis method, which also removed forum posts and live speeches that had nothing to do with the teaching content.

IV. B. Attitude Towards Learning

The scores of each dimension of the learning attitude scale obeyed a normal distribution. Among them, perceived usefulness was (4.16 ± 0.77), perceived ease of use was (2.99 ± 0.55), and willingness to continue using was (3.15 ± 1.55).

IV. C. Satisfaction

The scores of each dimension of the satisfaction scale followed a normal distribution. The technology satisfaction score was (2.40 ± 0.60), of which the usability index was (2.92 ± 1.06), the reliability index was (2.10 ± 0.71), and the safety index was (2.17 ± 0.88). The service satisfaction score was (3.58 ± 0.75), with responsiveness (3.88 ± 1.09), assurance (3.70 ± 1.02), and empathy (3.10 ± 0.87). The teaching satisfaction score was (3.89 ± 0.74), of which teaching methods (3.93 ± 0.88), teaching resources (3.89 ± 0.78), teaching interaction (3.90 ± 1.23), and teaching evaluation (3.82 ± 1.20).

IV. D. Course Participation

Student attendance is shown in Figure 1: the average attendance for the entire course was 93.96%, with the highest attendance at 100% (weeks 1 and 16) and the lowest attendance at 86.59% (week 4). Attendance for the various topics of instruction is usually at its highest in the first session and gradually decreases thereafter.

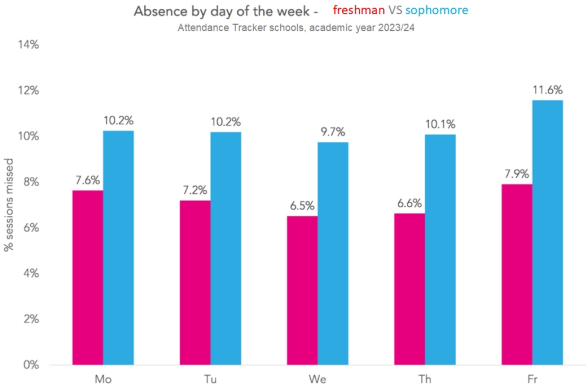

Figure 1: Attendance by week

The average regurgitation ratio (regurgitation ratio = length of video viewed / actual length of video) of the students' viewing of the video resources is shown in Figure 2: the average regurgitation ratio of all the videos was (2.66 ± 0.94), with the highest average regurgitation ratio being 3.62 (week 7) and the lowest being 1.19 (week 4).

The difference in regurgitation ratios of the video resources in each topic was statistically significant ($F = 10.793$, $P < 0.001$), and pairwise comparisons revealed that the average regurgitation ratios of each video in topic one were lower than those in topic two (-4.007 ± 0.77), three (-4.544 ± 1.00), and four (-2.568 ± 0.76), all $P < 0.05$.

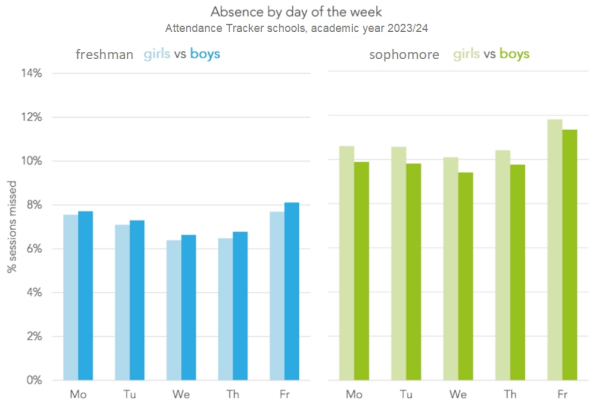

Figure 2: Average regurgitation ratio of video resources by week

The effective speaking frequency of each week's live broadcast is shown in Figure 3: the average effective speaking frequency per student in each class was (3.33 ± 1.18) times. There was a statistically significant difference in the effective speaking frequency among different topics ($F = 4.677$, $P = 0.002$). Pairwise comparison showed that the effective speaking frequency of students in topic one was lower than that in topic two (-4.490 ± 1.19), three (-3.086 ± 0.88), and four (-3.626 ± 1.06), all $P < 0.05$.

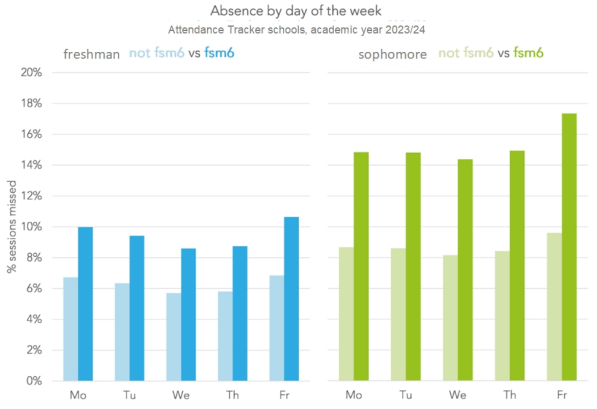

Figure 3: Effective speaking frequency of live broadcasts in each week

The number of valid posts per week on the course forum is shown in Figure 4: the average number of valid posts per student in each topic study was (3.13 ± 1.33). Categorizing the student IDs revealed that the most active students averaged 17.77 valid posts per topic, the least active students averaged 0.77 valid posts per topic, and 68% of the students averaged four or more valid posts per topic. There was a statistically significant difference in the number of effective posts for each topic ($F = 7.018$, $P < 0.001$). Pairwise comparisons showed that the number of effective posts for topic one was lower than that for topic two (-4.827 ± 1.30), three (-6.052 ± 1.33), and four (-4.127 ± 1.35), all $P < 0.05$.

IV. E. Teaching Effectiveness

This survey questionnaire aims to comprehensively evaluate students' subjective feelings about the overall effectiveness of the course, with a focus on improving writing skills and specific directions for progress. Through clear questions and options, we can quantify students' growth in writing content, language expression, discourse structure, and thinking expansion, providing data support for teaching effectiveness. The data of this module can help identify strengths and weaknesses in teaching, and guide future curriculum design and teaching improvement.

Overall evaluation of course effectiveness: What do you think is the impact of this course on improving your writing skills? A. It has no impact at all; b. Less impact; c. Commonly; d. Significant impact.

In which aspects of writing ability have you felt significant improvement? (Multiple Choice) A. The richness of writing content; b. Logical coherence of discourse structure; c. Accuracy of language expression; d. Expansion of thinking depth.

What is your evaluation of the effectiveness of writing activities in the course, such as language input, thinking training, peer feedback, teacher feedback, etc.? A. Very ineffective; b. Invalid; c. Commonly; d. Effective; e. Very effective.

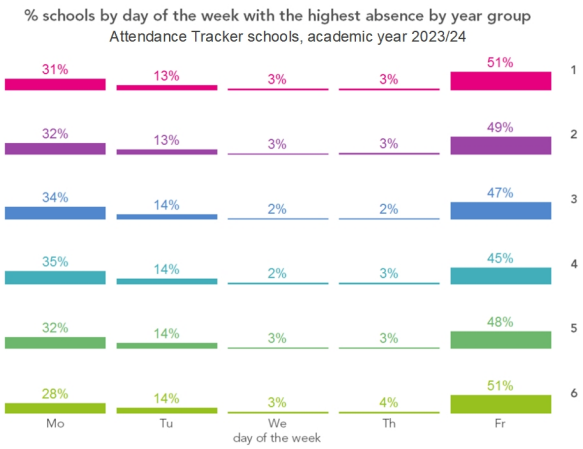

Figure 4: Effective number of posts by week in course forums

V. Conclusion

This research presents a comprehensive smart teaching framework that integrates B5G technology and intelligent sensing devices into the live instruction of college English writing, with an emphasis on the organic fusion of knowledge dissemination and civic ideological education. The study demonstrates that B5G-enabled networks significantly improve live teaching quality, with enhancements in video clarity, audio signal-to-noise ratio, interaction latency, and content delivery completeness. Through quantitative modeling and controlled experiments, we establish that the B5G environment fosters greater student concentration, interactivity, and learning satisfaction compared to 4G and 5G networks. Furthermore, by embedding Civic and Political Education into the writing curriculum via thematically relevant assignments, real-time feedback loops, and reflection-based learning, the model supports both cognitive skill development and value cultivation. Survey and behavioral data validate the system's effectiveness in boosting participation, enhancing writing proficiency, and fostering ideological depth. This study offers a technically robust and pedagogically meaningful strategy for higher education institutions aiming to modernize writing instruction and instill civic consciousness in a digitally connected, post-COVID educational landscape.

Conflict of interest

The author declares no conflict of interest.

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