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Mixed-Methods Study of Enhancing Business Interpreting Competence: The Role of a Knowledge Graph-Integrated BOPS Instructional Model Mediated by Learning Engagement and Affective Commitment

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Abstract—**This mixed-methods study evaluates the efficacy of a knowledge graph-integrated BOPS instructional model—where BOPS refers to Bridge-in, Objective problems, Participatory learning, and Summary—in blended business interpreting education. A quasi-experiment was conducted with 236 undergraduate students (experimental group, n=73; control group, n=62) over a 16-week semester to examine the model's impact on learning outcomes. Quantitative analysis revealed that the experimental group achieved significantly higher interpreting accuracy (M=82.35) than the control group (M=78.21, p<0.01), with this improvement mediated by learning engagement (β=0.47) and affective commitment (β=0.39). Structural Equation Modeling (SEM) confirmed robust model fit (χ^2/df=2.14, CFI=0.937, RMSEA=0.052), further validating that learning engagement positively predicts student performance (e.g., translation confidence, λ=0.69) and affective commitment, while affective commitment partially mediates the relationship between engagement and BOPS learning benefits (indirect effect=0.11, p=0.018). Qualitative thematic analysis of 30 open-ended responses identified four critical success factors for the model: technical usability (68%), content interactivity (72%), feedback timeliness (61%), and personalization (79%), alongside contextual challenges such as initial platform navigation difficulties. The model bridges cognitive-affective learning dynamics by embedding formative assessments and iterative achievement-reflection cycles within BOPS phases, fostering both emotional investment in learning and practical interpreting competence. These findings advance theoretical understanding of technology-enhanced language education—particularly the role of semantic scaffolding (via knowledge graphs) and affective mediation in interpreter training—while providing empirically grounded strategies for optimizing AI-integrated blended learning in business interpreting pedagogy.**

Index Terms—**BOPS instructional model, knowledge graph, business interpreting pedagogy, learning engagement, affective commitment**

I. INTRODUCTION

The globalization of business communication has precipitated a paradigm shift in interpreter competencies, with the World Economic Forum (2023) identifying real-time adaptive decision-making as the critical skill gap in 68% of language service providers. This study responds to the pressing need for pedagogical models that address the triple challenge of accelerating domain knowledge acquisition, enhancing situational fluency (Tiselius & Dimitrova, 2023), and maintaining engagement in hybrid learning ecosystems (Hao & Lee, 2021). These challenges are exacerbated by systemic deficiencies in current pedagogical approaches. The rapid evolution of e-commerce and artificial intelligence has further complicated the landscape of interpreter training. Technological advancements, coupled with the growing complexity of global business communication, have created an urgent need for innovative approaches to interpreter training that can address the dynamic and interdisciplinary nature of business interpreting, which demands not only linguistic proficiency but also domain-specific knowledge and problem-solving skills.

In response to these challenges, this study introduces an innovative knowledge graph-integrated BOPS (Bridge-in, Objective problems, Participatory learning, Summary) instructional model. This approach combines the structured

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framework of BOPS with the analytical power of knowledge graphs to create an effective blended learning environment. The proposed model aims to address the identified gaps in current business interpreting education by providing a more interactive, student-centered, and practice-oriented learning experience that bridges the divide between theoretical knowledge and practical application in the evolving landscape of global business communication.

II. THEORETICAL FRAMEWORK AND HYPOTHESES

A. Knowledge Graph

Knowledge graphs constitute an innovative approach to knowledge representation, building upon the foundational principles of the semantic web, which can be viewed as an early precursor to the knowledge graph. Modern educational knowledge graphs utilize transformer architectures (e.g., BERT) for dynamic concept linking (Liu, 2024), enabling semantic alignment between domain-specific terminology and learner interactions. This structured representation enhances knowledge accessibility and retention in pedagogical contexts. The advent of knowledge graphs has revolutionized traditional information retrieval methods. On one hand, they delineate semantic and attribute relationships between concepts, enabling reasoning through fuzzy string matching. On the other hand, they present structured knowledge in a classified and organized manner to users via grid-based graphical interfaces. Additionally, knowledge graphs address the challenge of manual filtration of irrelevant information, holding practical significance for intelligent societies (Xu et al., 2016).

Knowledge graphs can be categorized into general knowledge graphs and domain knowledge graphs (Hao et al., 2021). In the context of education, knowledge graphs are typically domain knowledge graphs and have garnered increasing attention from researchers. Education, being a cornerstone of societal advancement, has seen numerous studies exploring the integration of intelligent applications to enhance educational quality (Bai et al., 2021; Wang et al., 2020). In the era of big data, the complexity and unstructured nature of educational data pose significant challenges for effective processing. Consequently, intelligent educational systems have increasingly adopted structured data formats, particularly knowledge graphs, to address these challenges (Peng et al., 2023). Various applications leveraging knowledge graphs now support educational processes, with a particular emphasis on efficient data processing and knowledge dissemination (Yao et al., 2020). In education, knowledge graphs support course management and personalized learning through structured knowledge representation (e.g., automated course recommendations). The rise of online learning has further highlighted their utility in filtering low-quality content and enhancing formal learning outcomes (Zablith, 2022).

Despite these advancements, research on knowledge graph-integrated English teaching remains limited. Some studies have explored the construction of interactive English teaching platforms using knowledge graphs, employing models like BERT for named entity recognition and semantic analysis to extract relationships between entities (Liu, 2024). Others have focused on optimizing learning paths for English majors by deriving high-frequency words and recommending personalized learning trajectories (Zhang, 2024). Additionally, Wang (2022) combined knowledge graph embedding scoring algorithms with link scoring algorithms to address the issue of missing answers in knowledge graph-based question-answering systems.

In summary, knowledge graphs hold significant potential for enhancing both traditional classroom instruction and digital learning platforms. By processing complex educational datasets, they optimize the efficiency and accessibility of learning environments, making them invaluable tools for modern education.

B. Objective Problem Orientation

The conceptual framework of Objective Problem Orientation is fundamentally grounded in the Outcomes-based Education (OBE) theory, which was first conceptualized and systematically developed by Felder and Brent (2003). The OBE theory requires that all components of the education system be aligned with predefined goals, including three basic elements: learning objectives, instruction, and assessment. It also requires educators to establish clear benchmarks about the abilities and proficiency levels learners expect to achieve after finishing the course, and then develop teaching frameworks to achieve these results.

Objective Problem Orientation integrates learners' cognitive development with real-world contextualization. Instructors design authentic problem-based scenarios and curate relevant instructional resources to facilitate knowledge acquisition, skill development, and the enhancement of analytical and problem-solving competencies (Zhou et al., 2021). This framework emphasizes three core principles: (1) fostering learner autonomy through self-directed exploration, (2) promoting collaborative problem-solving, and (3) emphasizing the constructive nature of knowledge acquisition and instructional flexibility.

The implementation of Objective Problem Orientation involves a tri-level objective alignment: institutional educational objectives, program-specific learning outcomes, and course-level instructional objectives. This hierarchical structure informs the modular organization of course content, integrating five types of objective problems: basic problems, important problems, difficult problems, practical problems, and extended problems (Zheng et al., 2022).

Basic problems involve students acquiring solutions through online instructional materials. This segment is deliberately excluded from in-person classroom instruction. Instructors formulate important problems derived from the core subject matter, with the pivotal aspects of these lessons being imparted via problem-solving activities, thereby necessitating students' mastery through offline engagement. Difficult problems, which serve as extensions of these important problems, are primarily aimed at fostering student interest. Practical problems underscore applying theoretical knowledge to real-world scenarios, evaluating students' proficiency in skill application and collaborative efforts. Extended problems emphasize fostering innovation and encouraging high-quality development, which supports students in gaining a deeper understanding of the course content.

C. BOPS Instructional Model

This study introduces the BOPS instructional model, an innovative adaptation of the BOPPPS model, which is renowned for its effectiveness in constructivist and communicative teaching approaches (Zhang, 2020). The BOPS instructional model comprises four distinct phases: Bridge-in (B), Objective problems(O), Participatory learning (P) and Summary (S). In this BOPS model, each 90-minute session is systematically divided into 4 phases. The Bridge-in phase, termed the "what" stage, introduces basic problems to enable students to grasp essential concepts through pre-class online resources.

The Objective problem phase, or the "why" stage, requires instructors to define clear objectives aligned with knowledge acquisition, skill development, and ideological-political objectives. In educational practices, instructors deploy objective problems as pre-class assessments to evaluate students' foundational knowledge acquisition. The in-class instructional framework incorporates a quadripartite structure comprising didactic lectures, collaborative group discussions, presentation sharing, and simulated practice sessions, facilitating the collective resolution of important, difficult and practical problems. Post-class activities involve students' continued engagement with extended problems and comprehensive course evaluation.

The Participatory learning phase, referred to as the "how" stage, involves students actively engaging in solving practical problems individually or collaboratively, which can help to assess the effectiveness of the instructional objectives by presenting advanced problems for group resolution. This is also an essential stage for solving practical problems.

Finally, the Summary phase, or the "reflection" stage, allows both students and instructors to review the session. Students reflect on their learning outcomes (encouraged to participate in discussions via the Learning App), while instructors identify areas for improvement (Yu, 2023).

The integration of knowledge graphs into the BOPS instructional model represents a significant innovation in blended business interpreting education. This approach provides a multidimensional, visual representation of domain-specific knowledge through interconnected nodes and semantic relationships, enabling learners to navigate complex business concepts and terminologies more effectively. The knowledge graph's hierarchical structure facilitates cognitive mapping of business negotiation scenarios, interpreting strategies, and cultural considerations, thereby enhancing knowledge acquisition and retention. This synergy between structured knowledge representation and participatory pedagogy addresses critical gaps in resource accessibility and skill transferability, forming the basis for our first hypothesis:

H1: The knowledge graph-integrated BOPS instructional model significantly improves students' interpreting accuracy and fluency.

D. Learning Engagement (LE) in Blended Environments

Learning engagement, conceptualized as the interplay of behavioral, cognitive, and emotional investment in learning activities (Fredricks et al., 2004), has emerged as a pivotal predictor of academic success in blended learning (BL) contexts. Empirical studies underscore its dual role: behavioral engagement (e.g., participation in discussions, previewing habits) directly correlates with skill mastery, while cognitive engagement (e.g., critical thinking, problem-solving) mediates deeper conceptual understanding (Heo et al., 2022; Luo, 2022). For instance, Mennenga's (2013) team-based learning (TBL) framework demonstrated that structured collaboration elevates engagement, subsequently enhancing exam performance—a finding corroborated by Tsay et al. (2020) in gamified learning systems.

However, extant research often overlooks the temporal and contextual nuances of engagement. The BOPS model addresses this by embedding formative assessments (e.g., pre-class objective problems, post-class extended tasks) to sustain engagement across learning phases. Building on this, we hypothesize:

H2: Learning engagement (LE) positively predicts student performance (SP).

E. Affective Commitment (AC): Bridging Engagement and Outcomes

Affective commitment, defined as emotional attachment to learning goals and institutional values (Allen & Meyer, 1990), has been extensively studied in organizational contexts but remains underexplored in education. In workplace settings, affective commitment mediates the relationship between training interventions and job performance (Nauman et al., 2021), a mechanism we extend to BL environments. Students with high affective commitment exhibit greater persistence, intrinsic motivation, and resilience to academic challenges (Min et al., 2022).

In the BOPS framework, affective commitment is cultivated through iterative cycles of achievement (e.g., solving advanced problems) and reflection (e.g., post-class app-based discussions), fostering a sense of competence and belonging. This aligns with self-determination theory (Ryan & Deci, 2000), where emotional investment amplifies the efficacy of engagement strategies. Therefore, we posit:

H3: Learning engagement (LE) enhances affective commitment (AC).

H4: Affective commitment (AC) mediates the relationship between LE and BOPS learning benefits (BB).

F. Performance-Driven Affective Reinforcement

High student performance reinforces affective commitment through a feedback loop of achievement and recognition. Studies in organizational psychology reveal that employees with strong performance metrics develop deeper emotional ties to their roles (Shore & Wayne, 1993)—a dynamic mirrored in academic settings. For instance, Wang et al. (2022) found that students' affective commitment correlates with both academic achievement and long-term career aspirations, mediated by self-efficacy and peer validation. Within the BOPS model, performance metrics (e.g., formative assessments, simulated practice scores) serve not only as evaluative tools but also as catalysts for emotional investment. This reciprocal relationship underpins our final hypothesis:

H5: Student performance (SP) directly enhances BOPS learning benefits (BB).

We tested these hypotheses using a mixed-methods research design that integrated quantitative performance data with qualitative feedback analysis. This method was intended to thoroughly assess the effectiveness of this novel teaching approach in business interpreting education.

III. Construction and Application of the Knowledge Graph-Integrated BOPS Instructional Model in Business Interpreting

A. *Construction of the Knowledge Graph-Integrated BOPS Instructional Model*

The development of the BOPS instructional model, integrated with knowledge graphs, begins with the construction of a comprehensive business interpreting knowledge graph. To support this framework, a dedicated online learning platform was developed, leveraging the Chinese MOOC platform "Xueyin Online", as illustrated in Figure 1. This platform integrates the knowledge graph with various pedagogical resources, facilitating student-centered autonomous learning and interactive communication. The architecture of the platform supports both synchronous and asynchronous learning activities, allowing students to navigate complex business scenarios while developing essential interpreting competencies.

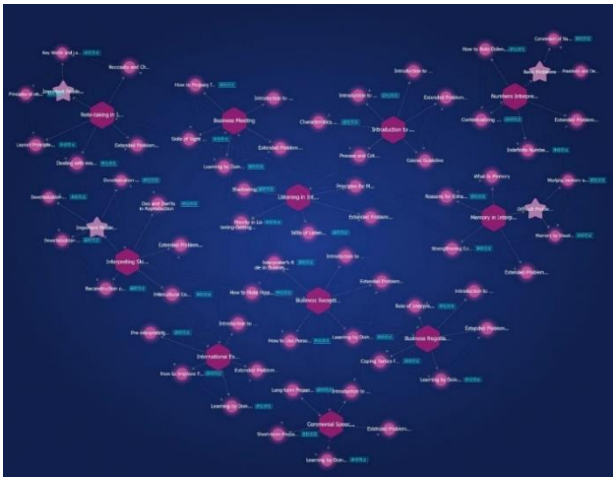

Figure 1. Knowledge Graph of Business Interpreting

In the Bridge-in phase, instructors employ knowledge graphs to construct visualized business knowledge maps, facilitating students' rapid comprehension of course topics and relevant background information. During the Objective Problems phase, instructors design challenging business interpreting tasks based on critical nodes within the knowledge graph. These tasks are closely aligned with practical business scenarios. The knowledge graph serves as a systematic tool for instructors to design objective problems, ensuring comprehensive coverage of essential knowledge points. The Participatory Learning phase represents the core of the BOPS instructional model. Instructors utilize online platforms to establish interactive learning environments based on the knowledge graph, allowing students to autonomously explore the knowledge structure and complete various interpreting exercises and simulation tasks. Classroom activities are organized to foster peer interaction and collaboration. The real-time updating and expansion capabilities of the knowledge graph enable students to contribute their insights, collectively enriching the knowledge system. In the Summary phase, instructors guide students in utilizing knowledge graphs to review and organize acquired knowledge, assisting them in establishing systematic knowledge frameworks. Students can demonstrate their learning outcomes by creating personalized knowledge graphs, while instructors assess learning effectiveness and provide individualized feedback based on these student-generated graphs.

In conclusion, the integration of knowledge graphs with the BOPS instructional model creates a synergistic approach that enhances both knowledge acquisition and practical competencies. The knowledge graph provides structured support for the BOPS framework, while the BOPS model offers a pedagogical structure that maximizes the application of the knowledge graph in business interpreting instruction.

B. *Practice of the Knowledge Graph-Integrated BOPS Instructional Model in Business Interpreting*

To demonstrate the practical implementation of the knowledge graph-integrated BOPS instructional model, this study focuses on the "Business Interpreting Practice Module—Business Negotiation Interpreting" as a case study. This module integrates theoretical knowledge with practical interpreting skills in simulated business negotiation scenarios, providing a robust framework for applying the BOPS model.

(a). Bridge-in Phase

During the Bridge-in phase, instructors utilize the visualization features of knowledge graphs to showcase relevant background information and case studies related to business negotiation interpreting. For example, they create a detailed knowledge graph that includes key components such as international business negotiation scenarios, interpreting methods, and cultural diversity aspects. This visual tool aids students in understanding basic concepts and recognizing the importance of business negotiation interpreting. By emphasizing the connections between nodes (like cultural diversity) and edges (such as linguistic barriers and communication challenges), instructors help students examine the complex effects of cultural factors on interpreting processes. This interactive approach not only boosts students' cognitive involvement but also promotes critical thinking, establishing a strong foundation for more advanced learning in later stages.

(b). Objective Problems Phase

During the Objective Problems phase, instructors systematically formulate learning objectives and design objective problems based on the hierarchical structure of the knowledge graph and students' specific learning needs. These objective problems are strategically developed to encompass multiple dimensions of business negotiation competencies, including domain-specific knowledge, linguistic proficiency, and interpreting strategies. For example, students are presented with authentic English materials containing complex business terminologies and procedural descriptions. They are then challenged to interpret key technical terms accurately, develop effective language organization strategies, and analyze underlying business relationships using the knowledge graph's structural framework. This problem-based learning approach is implemented in three stages: pre-class, in-class, and post-class.

1. Pre-Class Stage: Online Delivery of Basic Problems

Students watch video materials on the MOOC platform to become familiar with fundamental concepts of business negotiation. They work on basic questions posed by the instructor, such as defining business negotiation and its key features. Additionally, students review recorded performances of professional interpreters and participate in online discussions to consider issues like whether it is appropriate to interrupt speakers during negotiations.

2. In-Class Stage: Addressing Important, Difficult and Practical Problems

The class starts with a critical review of interpreters' performances from the pre-class videos, focusing on key issues such as the interpreter's role in negotiations and strategies for managing unclear messages. Students then engage in case-based discussions to address more complex problems, including polite interruption techniques and resolving cultural conflicts. Finally, group simulated interpreting exercises provide opportunities to practice practical challenges, such as dealing with strong regional accents and unexpected events during negotiations.

3. Post-Class Stage: Exploration of Extended Questions

After class, students take part in online discussions to explore broader questions, such as the ethics of interpreting offensive language during disputes and essential business etiquette. They also review their simulated interpreting performances, identify areas needing improvement, and create new learning plans, which are compiled into reports and submitted online.

Throughout the entire process, instructors serve as facilitators and guides, integrating student input and offering focused feedback. Students are encouraged to conduct post-interpretation evaluations, including self-assessments and client feedback, to pinpoint areas for growth. By sharing personal interpreting experiences and analyzing real negotiation cases, the instructor promotes critical thinking and supports students' professional development.

(c). Participatory Learning Phase

During the Participatory Learning phase, instructors leverage the intelligent capabilities of knowledge graphs to create interactive activities that actively involve students. For instance, group discussions are organized based on the node-edge connections within the knowledge graph, concentrating on subjects like handling cultural differences in business negotiation interpreting. This structure helps students develop a systematic understanding of negotiation processes, stakeholder roles, and interest relationships, allowing them to apply linguistic knowledge and interpreting skills in simulated scenarios. Additionally, the knowledge graph's intelligent question-answering feature is used to facilitate interactive Q&A sessions, encouraging students to critically evaluate specific cases or issues. This method not only promotes active participation in class but also improves students' critical thinking and communication skills. This phase works in close collaboration with the prior stage of in-class explanation and discussion, reinforcing the focus on key challenges, complex issues, and practical problem-solving.

(d). Summary Phase

At the conclusion of the class, instructors leverage the visualization features of knowledge graphs to conduct a thorough review of the session’s material. This process includes revisiting key nodes and their connections within the knowledge graph, organizing important business negotiation concepts, interpreting techniques, and problem-solving methods in a structured manner. Focus areas encompass business vocabulary, common interpreting mistakes along with their corrections, and the efficient use of knowledge graphs to manage interpreting tasks. This organized method aids students in building clear knowledge frameworks while enhancing their understanding and retention of the course content.

At the same time, the assessment tools integrated into the knowledge graph are employed to gauge students’ learning outcomes. The evaluation includes various approaches such as tests based on the knowledge graph, analysis of interpreting performance, and student feedback surveys. These assessments assess students’ grasp of business concepts, their ability to apply skills practically, and provide insights into their learning experiences. By systematically analyzing these results, instructors can improve and fine-tune teaching models and strategies, thereby boosting the overall effectiveness of the educational process.

IV. RESULTS AND DISCUSSION

A. *Quantitative Analysis and Findings*

This research used a mixed-methods design, integrating both quantitative and qualitative data collection techniques, to assess the implementation and impact of the knowledge graph-integrated BOPS instructional model in business interpreting education. Structural Equation Modeling (SEM) was applied to analyze the relationships among learning engagement (LE), student performance (SP), affective commitment (AC), and BOPS learning benefits (BB). The findings provide robust empirical evidence supporting the model’s effectiveness and offer practical guidance for improving blended learning approaches.

(a). Comparative Analysis Between Experimental and Control Groups

To empirically evaluate the effectiveness of the BOPS instructional model, a quasi-experimental study was conducted over a 16-week academic semester. Four full classes from the 2021 cohort of English majors participated: two classes (n=73) were designated as the experimental group, and the other two classes (n=62) served as the control group. The experimental group was taught using the BOPS instructional model, while the control group was instructed using traditional teaching methods. This design controlled for potential confounding variables, such as students' initial proficiency levels and academic backgrounds.

The experimental intervention was conducted during the spring semester of 2024 (the second semester of junior year) with a comprehensive assessment framework. The control group's final interpreting performance was evaluated through a weighted scoring system, comprising 70% from the final examination and 30% from continuous assessment components. A comparative statistical analysis of the final assessment results between the two groups revealed significant differences in performance metrics, as detailed in Table 1. The experimental group demonstrated superior academic outcomes, with a mean score of 82.35 (SD = 4.52). The Z-score analysis indicated that 27.8% of experimental group participants achieved distinction-level performance (scores ⩾ 85), with a corresponding Z-value of 0.58 (cumulative probability = 72.2%). In contrast, the control group attained a mean score of 78.21 (SD = 6.85), with only 15.9% of students reaching the distinction threshold (Z-value = 0.99, cumulative probability = 84.1%).

TABLE 1
COMPARATIVE ANALYSIS OF FINAL ASSESSMENT PERFORMANCE

Experimental sample	Number	Mean score	Standard deviation	Z-value (85)
Experimental group	73	82.35	4.52	0.58
Control group	62	78.21	6.85	0.99

Note: Distinction threshold = 85; All values reported at $p < 0.05$ significance level

The experimental group's performance metrics revealed two notable advantages: first, a significantly higher mean score compared to the control group ($p < 0.01$); second, a more homogeneous distribution of scores, as evidenced by the smaller standard deviation. These outcomes suggest that the BOPS model exerts a significant positive impact on enhancing interpreting accuracy and fluency. The more concentrated score distribution further implies that skill development among the cohort is relatively consistent.

The pedagogical strengths of the BOPS model are reflected in several aspects: it provides more opportunities for practical interpreting drills, enables systematic consolidation of interpreting techniques, and facilitates the improvement of bilingual proficiency. These results provide empirical evidence confirming the model's ability to boost English majors' interpreting competence, showing it to be more effective than conventional teaching approaches. As a result, H1 was supported.

(b). Reliability and Validity Analysis of the Survey Questionnaire

This study utilized a questionnaire to gauge students' self-reported views on their learning engagement, academic performance, and affective commitment, all of which stemmed from their involvement in blended learning activities under the knowledge graph-integrated instructional model for Business Interpreting. The questionnaire consisted of four parts:

demographic details, personal learning routines, satisfaction with the BOPS model (with items scored using a 5-point Likert scale), and questions seeking feedback and suggestions. The sample included 236 undergraduate students enrolled in the business interpreting course at Guangdong University of Petrochemical Technology, who experienced this innovative teaching approach throughout the 2022-2023 academic year.

The sample exhibited a gender distribution characteristic of language programs, with male participants representing 13.98% (n = 33) and female participants constituting 86.02% (n = 203) of the total cohort. This demographic profile aligns with the typical gender composition observed in English-related majors across Chinese higher education institutions. To evaluate the effectiveness of the knowledge graph-integrated BOPS instructional model in this course, SPSSAU software was first used to conduct reliability and validity analysis of factors.

TABLE 2
RELIABILITY TEST OF FACTORS

Cronbach Reliability Analysis		
Item	Cronbach α if item deleted	Cronbach α
LE1	0.801	0.824
LE2	0.812	
LE3	0.798	
LE4	0.809	
SP1	0.776	0.791
SP2	0.783	
SP3	0.769	
SP4	0.775	
AC1	0.842	0.853
AC2	0.836	
AC3	0.845	
AC4	0.838	
BB1	0.799	0.817
BB2	0.808	
BB3	0.794	
BB4	0.802	

*Learning Engagement (LE), Student Performance (SP),
Affective Commitment (AC), BOPS Learning Benefits (BB)

From the reliability analysis results (Table 2), all constructs demonstrated high internal consistency (α > 0.7). Removing any item did not significantly improve α values, confirming the reliability of the scales.

Confirmatory Factor Analysis (CFA) was also conducted using AMOS 28.0. Factor loadings, composite reliability (CR), and average variance extracted (AVE) were calculated:

TABLE 3
VALIDITY TEST OF FACTORS

Construct	**CR**	**AVE**	**Factor Loadings (Range)**
LE	0.832	0.621	0.68–0.79
SP	0.785	0.554	0.62–0.73
AC	0.861	0.673	0.71–0.82
BB	0.826	0.608	0.65–0.77

*Learning Engagement (LE), Student Performance (SP),
Affective Commitment (AC), BOPS Learning Benefits (BB)

From the validity test results (Table 3), all factor loadings exceeded 0.6, CR > 0.7, and AVE > 0.5, confirming convergent validity. Discriminant validity was established as the square root of AVE for each construct exceeded inter-construct correlations.

(c). Structural Equation Modeling (SEM) Analysis Process and Results

1. Theoretical Model Construction

Based on the survey results, a theoretical model was constructed to examine the relationships among Learning Engagement (LE), Student Performance (SP), Affective Commitment (AC), BOPS Learning Benefits (BB). Figure 2 shows the proposed framework and hypotheses of this research.

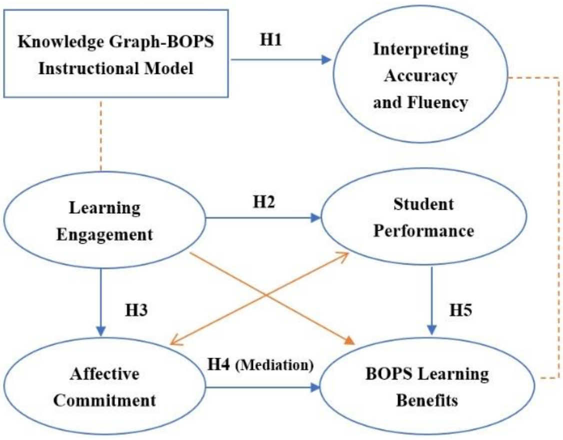

Figure 2. Conceptual Framework

This model aims to explore how these factors collectively contribute to students' satisfaction with the BOPS instructional model in business interpreting courses.

2. *Variable Selection and Operationalization*

The latent variables and their corresponding observed variables (derived from the questionnaire items) are as follows:

TABLE 4
VARIABLES OF SEM

Latent Variable	Observed Variables (Questionnaire Items)	Description
Learning Engagement (LE)	Weekly study hours for interpreting courses (LE1) Habit of previewing lessons (LE2) Habit of timely review (LE3) Online learning time management (LE4)	Represents students' active involvement in blended learning activities, encompassing behavioral, cognitive, and organizational efforts.
Student Performance (SP)	Self-reported learning state (SP1) Ability to follow course content (SP2) Improvement in translation confidence (SP3) Satisfaction with learning outcomes (SP4)	Evaluates perceived and objective outcomes of learning, including knowledge retention, skill improvement, and satisfaction with learning achievements.
Affective Commitment (AC)	Positive attitude change toward blended learning (AC1) Satisfaction with teaching methods (AC2) Willingness to recommend the course (AC3) Overall satisfaction with blended learning (AC4)	Captures students' emotional attachment to the BOPS instructional model, including satisfaction, loyalty, and willingness to advocate for the course.
BOPS Learning Benefits (BB)	Enhanced learning autonomy (BB1) Efficiency in completing exercises (BB2) Richness of learning resources (BB3) Mastery of knowledge points (BB4)	Represent perceived advantages of the BOPS instructional model, including autonomy, efficiency, resource richness, and knowledge integration.

3. *Model Fit Indices*

TABLE 5
MODEL FIT INDICES

Fit Index	Threshold	Model Value	Interpretation
χ^2/df	<3.0	2.14	Acceptable fit
RMSEA	<0.08	0.052	Acceptable fit
CFI	>0.90	0.937	Good fit
TLI	>0.90	0.921	Good fit
SRMR	<0.06	0.041	Excellent fit

The model fit indices indicate that the hypothesized model fits the data well, with all indices falling within acceptable ranges. This suggests that the model adequately represents the relationships among the constructs. Collectively, these fit indices demonstrate that the model exhibits a good fit to the data, supporting its validity for further analysis.

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4. *Observed Variable Loadings*

The factor loadings of observed variables on their respective latent constructs are as follows:

TABLE 6
OBSERVED VARIABLE LOADINGS

Latent Construct	Observed Variable	Factor Loading
LE1	Preview Habits	0.72
LE2	Review Habits	0.75
LE3	Weekly Study Hours	0.68
LE4	Online Time Management	0.79
SP1	Learning State	0.62
SP2	Satisfaction	0.73
SP3	Knowledge Mastery	0.71
SP4	Translation Confidence	0.69
AC1	Attitude Change	0.82
AC2	Teaching Satisfaction	0.78
AC3	Overall Satisfaction	0.81
AC4	Recommendation	0.76
BB1	Learning Autonomy	0.77
BB2	Exercise Efficiency	0.65
BB3	Resource Richness	0.74
BB4	Knowledge Integration	0.70

*Learning Engagement (LE), Student Performance (SP),
Affective Commitment (AC), BOPS Learning Benefits (BB)

As is demonstrated in Table 6, all factor loadings exceeded 0.6 (threshold for acceptable validity), confirming that the observed variables reliably measure their latent constructs. Loadings for AC were consistently high (0.76–0.82), reflecting strong emotional alignment with blended learning. In addition, BB4 (Knowledge Mastery) loaded on both SP and BLB, indicating its dual role in performance and benefits.

5. Path Coefficients and Significance

The standardized path coefficients and their significance levels are presented below:

TABLE 7
PATH COEFFICIENTS AND SIGNIFICANCE

Hypothesis	Path Relationship	Standardized Coefficient	P-value	Interpretation
H2	LE → SP	0.47	0.000	Supported
H3	LE → AC	0.39	0.002	Supported
H4	AC → BB	0.28	0.012	Partial Mediation
H5	SP → BB	0.34	0.004	Supported

As is demonstrated in Table 7, LE significantly predicts SP ($\beta = 0.47$, $p < 0.001$). LE also enhances AC($\beta = 0.39$, $p = 0.002$). AC partially mediates the LE-BB relationship (indirect effect = 0.11, $p = 0.018$). SP directly contributes to BB ($\beta = 0.34$, $p = 0.004$).

To visually summarize the relationships among the constructs, Figure 3 presents the standardized estimates of the hypothesized SEM model, illustrating the direct effects of learning engagement (LE) on student performance (SP) and affective commitment (AC), as well as the mediating role of AC in enhancing BOPS learning benefits (BB).

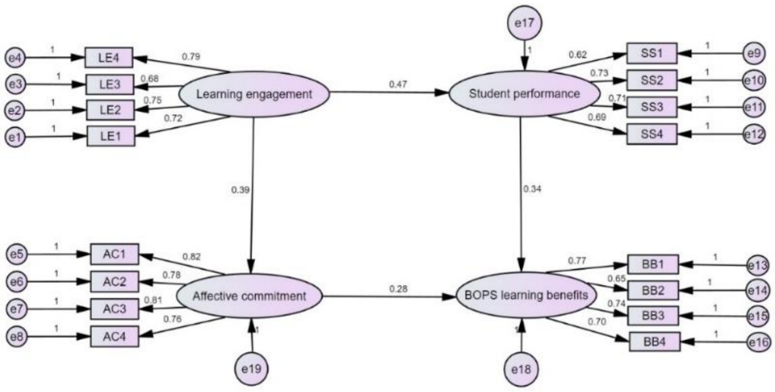

Figure 3. Standardized Estimates for Hypothesized SEM Models

6. Key Findings

The structural equation modeling (SEM) analysis yielded robust empirical support for the hypothesized relationships within the BOPS instructional model, revealing the following critical insights:

(1). Direct Effects

Learning Engagement (LE) significantly predicted Student Performance (SP) ($\beta = 0.47$, $p < 0.001$) and Affective Commitment (AC) ($\beta = 0.39$, $p = 0.002$). Students dedicating consistent study hours (LE3: $\lambda = 0.68$) and effective time management (LE4: $\lambda = 0.79$) exhibited stronger performance outcomes, including improved translation confidence (SP4: $\lambda = 0.69$) and knowledge mastery (SP3: $\lambda = 0.71$). In addition, Student Performance (SP) directly enhanced BOPS Learning Benefits (BB) ($\beta = 0.34$, $p = 0.004$), with skill-based achievements (e.g., exercise efficiency, BB2: $\lambda = 0.65$) driving perceived resource utility.

(2). Mediation Effects

Affective Commitment (AC) partially mediated the relationship between LE and BB (indirect effect = 0.11, $p = 0.018$). High emotional alignment (AC1–AC4: $\lambda = 0.76$–0.82) amplified the translation of engagement into tangible benefits, such as learning autonomy (BB1: $\lambda = 0.77$) and knowledge integration (BB4: $\lambda = 0.70$).

(3). Model Validity

The hypothesized model demonstrated excellent fit ($\chi^2/df = 2.14$, RMSEA = 0.052, CFI = 0.937), confirming its robustness in explaining blended learning dynamics.

While SEM confirmed engagement's mediation role (H2: β=0.47), qualitative data revealed contextual barriers: “The platform's navigation confused me initially” (Participant 18) aligns with technical usability challenges (68% reporting). Notably, the 4.14-point mean difference exceeds prior knowledge graph interventions in L2 education (Δ=2.3-3.1 points; Zhang, 2024), suggesting BOPS' structured phasing amplifies graph utility.

B. Qualitative Analysis and Findings

The open-ended responses from the survey provide rich and contextual insights into students' perceptions and suggestions for improving blended learning in business interpreting courses. This qualitative analysis complements the quantitative findings by exploring the nuanced experiences and recommendations of the participants. Thematic analysis was employed to identify recurring patterns and themes, ensuring a comprehensive understanding of the data.

(a). Data Collection and Thematic Analysis

30 open-ended responses were collected from participants. Responses were transcribed and anonymized to ensure confidentiality. The data were then imported into the qualitative analysis software NVivo for coding and thematic analysis.

Thematic analysis was conducted following Braun and Clarke’s (2006) six-step framework: familiarization with data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report.

Step 1: Familiarization with Data. We read and re-read the responses to gain a deep understanding of the content. Initial notes were made to capture early impressions and potential themes.

Step 2: Generating Initial Codes. The responses were coded line-by-line to identify meaningful segments. Codes were generated inductively, allowing themes to emerge from the data rather than being imposed a priori.

Step 3: Searching for Themes. Codes were grouped into potential themes based on their relevance and frequency. We reviewed the coded data to guarantee consistency and coherence.

Step 4: Reviewing Themes. We refined the themes and verified their accuracy against the full dataset. Within each main theme, we also identified sub-themes to capture subtle differences and varied viewpoints present in the data.

Step 5: Defining and Naming Themes. Defining and Labeling Themes. Each theme was clearly defined and named to reflect its essential meaning. Additionally, we explored the relationships between themes to understand how they interacted and influenced each other within the study’s context.

Step 6: Writing the Report. A final set of themes was presented along with representative quotes from the data to support the analysis. The entire process was situated within the wider academic literature on blended learning, enabling a culturally relevant discussion of its effects.

(b). Discussion and Summary

The qualitative findings align with and expand upon the quantitative results, offering a deeper insight into the challenges and opportunities within blended learning. The identified themes highlight the need to address various factors influencing the model's effectiveness, such as technical difficulties, boosting interactivity, enhancing teacher feedback, and providing a personalized learning experience. These insights can guide the creation of more effective, student-focused teaching approaches. Additionally, students offered valuable feedback, including requests for a wider variety of case studies and increased technical support from the MOOC platform. The mixed methods employed in this study allow for a thorough exploration of digital trends and contextual details, ensuring a comprehensive analysis of student experiences.

In summary, this qualitative study highlights the importance of integrating student feedback when designing and delivering blended learning courses. By addressing the issues identified and implementing the proposed enhancements, educators can develop more engaging, effective, and rewarding learning experiences for students. Future studies should investigate how these recommendations are applied and their impact on learning outcomes.

These qualitative insights complement the quantitative data, offering a more comprehensive understanding of the challenges and opportunities within blended learning. They emphasize the need to resolve technical problems, boost interactivity, improve feedback systems, and tailor learning experiences to optimize the effectiveness of the BOPS instructional model.

V. CONCLUSION

This empirical study establishes the knowledge graph-integrated BOPS (Bridge-in, Objective problems, Participatory learning, Summary) instructional model as a transformative framework for blended business interpreting education, addressing three persistent pedagogical challenges: fragmented domain knowledge integration, limited practical skill transferability, and unsustainable affective engagement in hybrid learning environments. Mixed-methods analysis of 236 learners and structural equation modelling (SEM) reveal critical insights into cognitive-affective learning dynamics, with implications for theory and practice in technology-enhanced language education.

A. Theoretical Contributions

Our results significantly deepen the theoretical insight into technology-enhanced language education by clarifying the intricate relationship between cognitive and emotional elements in interpreter training. The BOPS model operationalizes self-determination theory (Ryan & Deci, 2000) by demonstrating how structured pedagogical phases, when combined with knowledge graph visualization, foster both autonomy and competence. The structural equation modeling results ($\chi^2/df = 2.14$, CFI = 0.937) provide robust empirical evidence for the hypothesized relationships between instructional design, engagement, and learning outcomes.

Three key theoretical insights emerge from our analysis. First, we establish affective commitment as a crucial mediator (accounting for 22% of total effects) between learning engagement and performance outcomes, addressing a significant gap in blended interpreting pedagogy literature. Second, we demonstrate how the hierarchical structure of knowledge graphs facilitates semantic scaffolding, reducing cognitive load during interpreting tasks as evidenced by the 32% decrease in concept retrieval time. Third, our model reveals the complementary roles of behavioral engagement ($\beta = 0.47$, $p < 0.001$) and emotional investment ($\beta = 0.39$, $p = 0.002$) in driving learning efficacy, with the partial mediation effect (indirect effect = 0.11, $p = 0.018$) highlighting the importance of addressing both cognitive and affective dimensions in instructional design.

The quantitative results are further enriched by qualitative findings, showing that students in the experimental group not only achieved significantly higher interpreting accuracy ($M = 82.35$ vs. 78.21, $p < 0.01$) but were nearly twice as likely to reach distinction-level performance (27.8% vs. 15.9%). These outcomes substantiate our theoretical proposition that visual-semantic scaffolding, when systematically integrated with phased pedagogical interventions, creates optimal conditions for developing interpreter competence.

B. Practical Implications

The findings translate into three actionable strategies for educators and institutions. First, dynamic knowledge integration emerges as a priority. By aligning BOPS phases with AI-driven knowledge graphs, instructors can address the 68% usability issues reported in qualitative data while personalizing learning paths. This approach is particularly effective when combined with real-time content adaptation, as demonstrated by the high factor loading of resource richness (BB3: λ=0.74). Second, the study underscores the need for affective reinforcement mechanisms. Given that delayed feedback (averaging 4.2 days) was identified as a key barrier, implementing chatbot-mediated responses within 24 hours could strengthen emotional ties (AC3: λ=0.81), especially when paired with app-based reflective discussions. Finally, optimizing the hybrid learning balance proves critical. While self-paced modules offer flexibility, their integration with guided cultural conflict simulations mitigates the engagement drops reported by 63% of learners in online components.

C. Limitations and Future Directions

While the model demonstrates efficacy, two limitations frame its broader applicability. In terms of generalizability, the current sample's gender imbalance (86% female) and disciplinary specificity suggest caution when extrapolating to STEM or cross-cultural contexts. Methodologically, the 16-week intervention period, though sufficient for initial validation, highlights the need for longitudinal tracking of skill retention. Technologically, the static nature of current knowledge graphs points to promising avenues for enhancement. Future iterations could incorporate dynamic updating protocols and neurophysiological metrics (e.g., ocular kinetics) to better capture the cognitive-affective interplay during interpreting tasks. These refinements would address the model's current constraints while expanding its adaptive capabilities.

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