

Construction and Application of Knowledge-Graph-Driven Smart Curriculum for *General English*

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Abstract

Against national digital-driven educational strategies, college English for non-English majors is troubled by fragmented resources, homogeneous teaching and limited personalized feedback. Targeting first-year non-English students, this study develops a knowledge-graph-enabled smart curriculum for *General English*. Combining top-down and bottom-up strategies, a two-tier knowledge graph is established: an ontology knowledge layer sorted from syllabus-centered five-skill knowledge points, and a data-resource layer built upon MOOC and SPOC resources on the Chaoxing Fanya platform. Based on a “teacher-student-machine” interactive framework, this paper presents the full-cycle teaching workflow covering pre-class guidance, in-class interaction and post-class adaptive push. Integrating ideological-political education and power-industry materials, this two-year research uses case studies. Pilot results show knowledge-graph visualization clarifies implicit links between language knowledge points, supports adaptive recommendation and multi-dimensional formative assessment. It offers feasible references for digital transformation of college foreign-language courses.

Keywords: Knowledge Graph; Smart Curriculum; Teacher-Student-Machine Interaction.

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1. INTRODUCTION

Digital transformation has become an essential driving force for higher-education foreign-language reform in China. National educational digital strategies advocate empowering curriculum construction with artificial-intelligence and big-data tools to realize student-centered personalized teaching (Zhu *et al.*, 2022). As a compulsory foundational public course for non-English majors, *General English* shoulders dual missions: improving students’ comprehensive language proficiency and fostering talents with global vision and national sentiments. Nevertheless, traditional *General English* instruction is frequently restricted by homogeneous lesson arrangements, scattered online resources, and delayed learning assessment feedback (Wang, 2019). Conventional static MOOC and SPOC resources cannot automatically map knowledge nodes or generate individualized learning routes for learners with varied proficiency levels.

Knowledge graph, first proposed by Google in 2012, structures domain knowledge into interconnected node-edge networks, visualizing complex knowledge associations and enabling intelligent resource matching, learning-diagnosis and adaptive recommendation (Singhal, 2012). Recent years have witnessed growing

explorations applying knowledge graph to language education. Existing studies mainly focus on resource organization and test-score analysis in college-English contexts, yet many projects remain confined to theoretical framework discussion or partial module development (Mu *et al.*, 2023). Empirical research on complete smart-curriculum development is still limited. Most implementations neglect the organic integration of disciplinary characteristics and curriculum ideological-political requirements.

This research takes the provincial-level ideological-political demonstration course *General English* at North China Electric Power University as the research object. Its supporting MOOC General English has been officially released on China University MOOC platform. Oriented toward first-year undergraduates of electrical-engineering international cooperative programs, this study develops a complete knowledge-graph-supported smart-curriculum solution. The research addresses three core questions: First, how can we construct a discipline-adapted knowledge graph for *General English* combining ontology knowledge and heterogeneous online teaching resources? Second, what practical instructional pathways can realize deep-level “teacher-student-machine” interaction under

knowledge-graph support? Third, how to sustainably iterate knowledge-graph structures and associated digital resources in real teaching contexts?

2. LITERATURE REVIEW

Existing scholarship identifies two dominant paradigms for educational knowledge-graph construction: top-down ontology-driven modelling based on course syllabi and bottom-up data-driven extraction from heterogeneous teaching resources (Zhong *et al.*, 2020; Mu *et al.*, 2023). Prior college-English research applies knowledge-graph technologies mainly to reorganize multi-modal learning resources and conduct fine-grained formative assessment (Wang, 2019). Nevertheless, notable research gaps remain: most existing studies focus on isolated teaching segments instead of end-to-end smart-curriculum implementation covering pre-class, in-class and post-class phases. Long-term dynamic tracking and human-AI generative evaluation mechanisms are insufficient, and few projects integrate knowledge graphs with curriculum-based ideological-political education or institutional disciplinary characteristics (Yang, 2019). The “teacher-student-machine” collaborative community stresses iterative, context-oriented smart-curriculum development rather than mere technical deployment (Liu *et al.*, 2022). Drawing on these research insights, this study constructs a holistic smart-curriculum framework tailored for *General English*.

3. RESEARCH METHODOLOGY

3.1 Research object

1855 Participants are first-year non-English-major undergraduates at North China Electric Power University (Baoding). *General English* serves as their foundational compulsory course. The course obtained the title of Hebei Provincial Curriculum-based Ideological-Political Demonstration Course in 2023. Its MOOC resources are available on Xueyin Online and Chaoxing Fanya SPOC platforms. The research spans 12 months, from January 2025 to January 2026.

3.2 Mixed research methods

1. Case-study method: Multiple typical teaching cases are selected throughout two cycles of formal course delivery. Researchers observe classroom implementation of knowledge-graph-oriented teaching activities, including group debates, generative ideological-political case analysis, and knowledge-graph-guided inquiry tasks. Platform-generated learning log data, student assignments and interview records are synthesized to analyze curriculum effectiveness.

2. Iterative development: Adopting design-based-research logic, the project proceeds in two sequential phases: knowledge-graph construction phase (Jan 2025-Aug 2025), curriculum implementation and two-round instructional iteration phase (Sep 2025-Jan 2026). Expert review and student testing are arranged

after each iteration cycle to revise graph nodes, relational edges and attached teaching resources.

3.3 Construction of General English knowledge graph

This study adopts combined top-down plus bottom-up construction workflow, building ontology knowledge layer and data-resource layer respectively.

Ontology knowledge layer (top-down construction). Guided by course syllabus, researchers sort atomic knowledge points across five skill dimensions: reading, listening, speaking, translation and writing. Reading knowledge nodes cover contrast, context clues, argumentation, cause-and-effect exposition and essay-summarizing skills. Listening includes key-point extraction, contextual understanding and attitude identification. Speaking nodes contain abstract-concept expression, complex-idea delivery and coherent-sentence development. Translation covers parallelism, nominalization, concession and cause-and-effect logic conversion. Writing involves paragraph-pattern knowledge such as introductory paragraphs, argumentative paragraphs and cause-effect paragraphs. Researchers define prerequisite relations, inclusion relations and causal relations between nodes. Each knowledge point is annotated with cognitive-dimension tags (remember, understand, apply, analyze, evaluate, create), difficulty tags, examination-focus tags and ideological-political tags.

Data-resource layer (bottom-up construction). Based on existing MOOC videos, courseware, exercises and documents stored in Chaoxing Fanya SPOC platform, the team executes data cleaning, deduplication and formatting. Manual-AI joint labeling connects multi-modal teaching resources to corresponding ontology-layer knowledge nodes. Missing resources are supplemented by AI-digital-human generated micro-lectures and student-co-developed item banks under teachers' guidance.

3.4 “Teacher-student-machine” smart-curriculum implementation framework

The smart-curriculum workflow covers online pre-class preparation, hybrid offline-online in-class teaching and online post-class expansion.

Pre-class phase: Teachers complete intelligent lesson preparation supported by the knowledge graph, designing learning scaffolding and task prompts. Students finish preview tasks on AI-learning space. The knowledge-graph system collects preview feedback and visualizes learner portraits, revealing individual knowledge-mastery status for teachers.

In-class phase: Under offline smart-classroom settings, teachers create situational contexts with ideological-political case libraries. Interactive activities including inquiry, debate, sharing and peer evaluation

are organized. Knowledge-graph visualization displays knowledge networks for whole-class reference. Real-time learning data are synchronously fed back to the platform. Students failing mastery thresholds receive targeted remedial task recommendations.

Post-class phase: The system delivers adaptive resource push according to individual learner portraits. AI teaching assistants provide instant Q&A support. Students participate in reflective sharing and contribute new learning resources or ideological-political cases for curriculum resource library expansion. Teachers analyze aggregated data and carry out whole-course reflection to optimize knowledge-graph structures and teaching designs.

Two key challenges are targeted in practice: (1) improving instructors' digital literacy to fully exploit knowledge-graph and AI-assisted platform functions; (2) maintaining continuous dynamic updating of graph nodes and linked resources responding to real-time learning-data feedback.

4. RESULTS

Pilot implementation for *General English* was completed with 1855 first-year undergraduates at North China Electric Power University. Preliminary output data were collected from the Chaoxing Fanya platform, questionnaire feedback, classroom observation records, providing foundational empirical evidence for subsequent full-scale curriculum iteration. Results are organized into four themes: knowledge-graph pilot construction outcomes, platform-based learning behavioral metrics, questionnaire feedback on "teacher-student-machine" interaction, and existing defects identified from the pilot practice.

4.1 Outcomes of preliminary knowledge-graph construction

Knowledge-graph modules of the smart curriculum were implemented on the Xueyin Online platform. Up to the statistics snapshot, 50 curriculum knowledge points and 5 566 knowledge fragments have been defined and structured to build the semantic network of *General English*. Driven by the knowledge-graph framework, the platform has generated 914 AI-supported teaching resources linked to knowledge nodes. A total of 563 test items have been analyzed and mapped onto corresponding knowledge entities for intelligent diagnosis. Furthermore, 2831 AI-tutoring dialogue records were accumulated, which reflect learners' interactive behaviors with the graph-empowered intelligent agent. These structured outputs lay a data foundation for knowledge visualization, personalized resource recommendation and fine-grained learning-mastery diagnosis in the "teacher-student-machine" teaching ecosystem.

4.2 Learning-behavior statistics from the smart-teaching platform

Platform log data recorded student engagement metrics during pilot teaching. Among the 1855 participants, the average knowledge-point completion rate reached 96.98%, while the average resource-learning completion ratio stood at 71.54 %. The system generated individual learner portraits for every student, quantitatively displaying mastery level for each knowledge node. The data demonstrated distinct gaps across different knowledge dimensions. Mastery rates for receptive-skill nodes (reading context clues, listening key-point identification) were generally higher, whereas productive-skill nodes (complex oral-idea expression, translation of concession logic, cause-and-effect paragraph writing) showed substantially lower mastery indicators. This finding aligned with practical teaching experience: productive language competence constitutes the main difficulty for this student cohort.

In terms of conventional course resources, the curriculum contains 35 lecture videos with a total duration of approximately 300 hours. It is equipped with 28889 exercises for quizzes and assignments, alongside 1020 items in the examination question bank. Supplementary non-video learning resources reach 128 units, and 795 official course announcements have been released throughout implementation.

Regarding interactive learning performance, a total of 587 classroom activities have been launched, attracting 28951 participations. In the discussion zone, 6363 posts have been contributed, including 258 posts released by teachers, with 1 132 participants involved in forum-based interaction. These platform statistics reflect large-scale resource accumulation and active learner engagement within the "teacher-student-machine" collaborative smart-curriculum ecosystem.

4.3 Outcomes of preliminary ideological-political and discipline-feature practice

During pilot teaching, teachers organized group tasks for students to co-construct ideological-political case resources. Students submitted case analysis focusing on themes including mission awareness, professionalism and international communication, forming the initial fragment of generative ideological-political case library. However, in the pilot knowledge-graph, these case resources were mostly attached to chapter-level entries instead of fine-grained knowledge nodes. Consequently, the intelligent system could not trigger corresponding value-oriented learning materials automatically when students encountered specific knowledge-points. In terms of electric-power disciplinary characteristics, only a small quantity of industry-related reading excerpts were added as supplementary materials. Specialized knowledge-node design and matched multi-modal industry resources had not yet been systematically integrated into the graph framework. These results illustrated that curriculum-

ideological-political embedding and school-based disciplinary feature development require long-term iterative construction rather than one-off completion in pilot testing.

5. DISCUSSION

Drawing upon the pilot results above, this section conducts multi-faceted discussion covering knowledge-graph construction quality, “teacher-student-machine” smart-community bottlenecks, integration of curriculum ideological-political education and disciplinary features, limitations of evaluation instruments, teacher digital-literacy challenges, and implications for popularization and future research directions. All discussion points are closely grounded on the original research design and expected difficulties presented in the project declaration.

5.1 Trade-offs between knowledge-graph completeness and iterative construction in language curriculum

Pilot outcomes show that even with mature syllabi and existing MOOC-SPOC digital resources, it is impossible to build a fully-completed, defect-free General-English knowledge graph in a single developmental cycle. Different from STEM disciplines with relatively fixed objective knowledge systems, foreign-language curriculum knowledge possesses obvious openness, contextual dependency and skill-oriented characteristics. Language competence development cannot be exhaustively described merely by static entity nodes and relational edges. Therefore, static one-time graph construction is not suitable for language courses. Instead, dynamic iterative updating should be adopted, which corresponds exactly to the research scheme in the application: completing primary graph construction in phase one; building question graph, competence graph and ideological-political sub-graph in the 2026 spring-summer optimization stage; and further revising node relations and associated resources in the second round of formal teaching practice.

From theoretical perspective, our practice provides real-world evidence for Mu et al. (2023)’s three-dimensional dynamic knowledge-graph theory. Subject knowledge, teaching activities and individual-learner status must evolve synchronously. If the knowledge graph is separated from authentic classroom feedback, it will gradually deviate from actual instructional requirements. Practically, this means that resource co-construction mechanism between teachers and students becomes essential. As observed in the pilot, students can contribute ideological-political case drafts and exercise items. Under teachers’ guidance, these outputs can be filtered, labelled and connected to graph nodes, easing the heavy workload of resource production borne solely by teaching staff. Still, quality-control standards must be established for student-generated resources, including cognitive-level tagging, difficulty grading and accuracy auditing, to prevent low-quality

content from entering the formal smart-curriculum resource pool.

5.2 Bottlenecks restricting the performance of “teacher-student-machine” smart community

The “teacher-student-machine” collaborative smart community constitutes one core research objective of this project. Pilot results reveal two layers of bottleneck: technical-resource limitation and human-subject limitation. At the technical-resource level, incomplete knowledge-node-resource association directly weakens adaptive recommendation and intelligent diagnosis functions. When learning resources corresponding to certain weak knowledge points are absent, even perfect algorithm logic cannot realize personalized remediation. This warns researchers that knowledge-graph construction is not only work of building node-edge networks; matching multi-modal teaching resources is equally critical. Many existing academic studies focus excessively on graph ontology modelling while ignoring the labour-intensive resource-linking procedure, which partially explains why quite a few educational-knowledge-graph research outputs remain at theoretical demonstration stage and are hard to deploy in real university classrooms.

At the human-subject level, teacher digital-literacy emerges as a prominent constraint. Questionnaire and interview data from project teachers indicate that knowledge-graph-driven smart teaching brings new work-load demands: ontology reviewing, resource annotation, learning-portrait data interpretation, and adjustment of classroom activities according to machine-output diagnostic results. Traditional college-English teachers have received limited systematic training on these digital competencies. Simply opening platform AI authority cannot automatically realize high-quality smart-curriculum application. Targeted supporting measures are required, including expert special lectures, thematic training and peer collaborative workshops, to advance team members’ digital teaching capabilities. On the student side, some participants in the pilot were unfamiliar with knowledge-graph visual interfaces. Brief orientation and learning scaffolding should be arranged at the beginning of formal courses to lower students’ threshold for engaging with graph-based learning tools.

5.3 Integration mechanism of knowledge graph, curriculum ideological-political education and electric-power disciplinary characteristics

One major innovation of this project lies in the deep fusion of knowledge-graph technology, curriculum ideological-political education and school-specific talent-training requirements for electric-power international-program students. Pilot practice demonstrates that simply adding ideological-political reading materials into resource libraries cannot achieve fine-grained value-shaping effects. In the trial, ideologica-political cases were only attached at chapter

level, so the intelligent system could not trigger value-oriented learning in alignment with specific knowledge-point learning progress. Accordingly, in subsequent optimization work, the ideological-political sub-graph will be constructed independently. Value-education themes will correspond to fine-grained language knowledge nodes, so that when students study reading argumentation, translation concession logic or argumentative-paragraph writing, matched ideological-political cases can be adaptively pushed. In this manner, value shaping will no longer be isolated from language-skill training, realizing the integration of knowledge transmission, ability cultivation and value guidance.

For electric-power disciplinary characteristics, future iteration will embed authentic industry-related English materials (international energy-industry news, power-engineering popular-science articles) into knowledge-graph resources. For instance, when learning cause-and-effect exposition reading and writing skills, learners can access domain-specific texts discussing global-energy-transition topics. This design responds to the talent-training goal of cultivating engineering talents with global vision and home-country sentiment. It should also be noted that industry-related resources serve language-teaching objectives rather than professional engineering instruction. Material selection difficulty must keep consistent with General-English curriculum requirements, avoiding excessive professional jargon which would overburden language learners.

5.4 Reflection on assessment system: moving beyond knowledge-point mastery toward multi-dimensional generative evaluation

Existing knowledge-graph-oriented English-teaching research mostly takes knowledge-point-mastery indicators as core evaluation metrics (Yang, 2019). Our pilot data show that platform statistics can precisely reflect students' mastery of discrete language knowledge nodes. Nevertheless, language education pursues comprehensive competences including critical-thinking ability, cross-cultural communication awareness and value-identity development. These high-order objectives cannot be fully quantified by node-mastery rates alone. As pointed out in the literature review section, one limitation in current domestic research is the deficiency of long-term tracking and generative multi-agent evaluation.

In the formal two-round teaching implementation phase of this project, evaluation will expand beyond platform-generated quantitative data. Mixed evaluation evidence will include: quantitative knowledge-graph mastery indexes, student generative outputs (ideological-political case reports, argumentative writing assignments, oral-presentation recordings), peer-assessment results, teacher qualitative comments and periodic semi-structured interviews. The combination of machine-generated learning portraits and human qualitative judgement will build a compound

formative-evaluation system for the smart curriculum. This approach may offer practical references for solving the difficulty of curriculum-ideological-political-effect assessment, a widespread challenge in college foreign-language education.

5.5 Limitations of current pilot work

Several limitations of the preliminary pilot must be acknowledged. First, the sample size is limited to one cohort of 1855 students from a single university. No parallel control group was set in the pilot stage, so we cannot make rigorous statistical comparison of learning-effect differences between knowledge-graph-supported teaching and conventional instruction. Formal implementation in 2026-2027 academic year will arrange a control class adopting traditional SPOC-based blended teaching for contrastive analysis. Second, measurement instruments for highorder outcomes (critical thinking development, ideological political educational effect) are still under construction. In followup work, we will refine interview outlines and coding frameworks for qualitative data.

6. CONCLUSION

Driven by educational digitalization strategies, this paper proposes the development path for knowledge-graph-supported *General English* smart curriculum. It combines top-down ontology construction and bottom-up heterogeneous-resource processing, and establishes a closed-loop "teacher-student-machine" interactive instructional workflow covering pre-class, in-class and post-class links. Pilot results verified the feasibility of the overall technical and instructional framework, meanwhile exposing multiple realistic bottlenecks including incomplete resource association, teachers' digital-literacy constraints, and insufficient fine-grained embedding for ideological-political and disciplinary-characteristic resources. These empirical findings are highly consistent with the risk analysis and solving-route design laid out in the original research proposal.

Foreign-language smart-curriculum construction empowered by knowledge graph demands joint efforts of technical platforms, teaching teams and learners. Technology functions as pedagogical instrument rather than ultimate objective. Subsequent two-phase formal research activities will focus on completing full-course knowledge-graph system (including question graph, competence graph and ideological-political sub-graph), carrying out two rounds of comparative teaching practice, improving multi-dimensional formative-evaluation instruments, and continuously optimizing resource co-construction and iterative-update mechanisms. The accumulated practical experience will be disseminated through MOOC resources, virtual-teaching-research communities and teaching-innovation competitions, providing operable references for digital transformation of public foreign-language courses in higher-education institutions.

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