Article

Construction Mode and Operation Mechanism of Intercollegiate Collaborative Curriculum Community Among Heterogeneous Universities

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Abstract: In response to the current landscape of intercollegiate cooperation in Chinese higher education, which is predominantly dominated by alliances of homogeneous institutions and frequently suffers from a lack of deep collaboration in curriculum development among heterogeneous universities, this paper explores the construction mode and operation mechanism of an intercollegiate collaborative curriculum community. Taking three heterogeneous but homologous universities—North University of China, Taiyuan Institute of Technology, and Shanxi College of Technology—as a pilot program and utilizing the Principles of Circuit Analysis course as a primary case study, a comprehensive digital curriculum resource ecosystem was developed based on a faculty-student crowd-sourcing approach. Through off-line practical modeling and assistance, online distinct-pedagogy for identical-courses, and the detailed decomposition of course objectives, substantial equivalence in teaching cross-campus identical courses was successfully achieved. Furthermore, cross-institutional and diversified academic tutoring was implemented to promote personalized cultivation within the broader context of large-scale education. Regional characteristic elements, such as the local power industry culture, alongside fundamental engineering ethics, were integrated into classroom teaching to significantly enhance the overall educational impact of the curriculum. Additionally, an objective achievement evaluation method based on a combined Visual Analog Scale and Incremental Evaluation approach was proposed. Practical implementation indicates that this innovative mode effectively narrows the gap in intercollegiate learning outcomes and improves the teaching proficiency and professional competence of young faculty, providing a replicable paradigm for the collaborative development of regional heterogeneous universities and the modernization of New Engineering curricula.

Keywords: heterogeneous universities; intercollegiate collaboration; curriculum community; engineering education; teaching equivalence

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1. Introduction

Intercollegiate cooperation in higher education refers to activities in which two or more universities establish cooperative relationships to optimize resource integration and achieve specific educational objectives through methods such as joint faculty appointments, resource sharing, mutual credit recognition, and collaborative research projects. Currently, the primary form of intercollegiate cooperation among Chinese universities consists of autonomous alliances between institutions with similar characteristics, while collaboration between universities with differing profiles remains limited. The content of this intercollegiate cooperation is predominantly focused on scientific research and academic exchanges [1]. Specifically, fields of science and engineering emphasize laboratory collaboration and joint research projects, whereas fields of humanities and social sciences prioritize academic exchanges and seminars. The proportion of intercollegiate collaboration dedicated to curriculum development and pedagogical research remains relatively low. Furthermore, the functions of experimental teaching centers at various levels largely remain confined to exhibitions, observations, and study visits, limiting their broader impact on educational innovation and curriculum enhancement.

As a high-level, teaching-and-research-oriented university with distinct national defense characteristics, North University of China (NUC) is actively striving toward the objective of institutional excellence and development. Taiyuan Institute of Technology, formerly the Branch Campus of North China Institute of Technology (the predecessor of NUC), is a regional first-class applied undergraduate college characterized by strong engineering application features. Shanxi College of Technology is a provincial public undergraduate institution established in 2021 through the restructuring of the Modern Science and Technology College of Taiyuan University of Technology, with its foundational faculty drawn from NUC's Shuozhou Campus [2]. This institution carries the vital mission of cultivating local applied talents and serving regional economic and social development. These three universities are heterogeneous yet share historical connections. Consequently, North University of China possesses a high sense of responsibility and a strong mission to drive the collaborative development of its affiliated institutions, while Taiyuan Institute of Technology and Shanxi College of Technology share a sincere aspiration and an urgent desire to align with high standards and strive toward greater educational quality.

Through the construction of the Principles of Circuit Analysis course community based on intercollegiate collaboration among regional universities with differing profiles yet historical connections, the three universities have translated traditional intercollegiate cooperation into concrete, meticulous, and practical actions. This initiative explores a new path to enhance the quality of talent cultivation by leveraging intercollegiate cooperation for deep curriculum development [3]. By focusing on the integration of resources and expertise, this collaboration aims to address existing gaps in curriculum innovation and pedagogical research, thereby fostering a more comprehensive and effective educational framework. The initiative not only strengthens academic ties but also sets a precedent for future cooperative efforts that prioritize curriculum advancement and the holistic development of students.

2. Construction of a Course Resource Ecosystem Based on Faculty-Student Crowdsourcing and Intercollegiate Sharing

As a foundational course in engineering education, Principles of Circuit Analysis possesses a relatively rich repository of course resources and materials. However, precisely due to the foundational nature of its curriculum attributes, these course resources tend to be relatively outdated and slow to update, failing to meet the demands of New Engineering program construction that faces industry frontiers and technological cutting edges. Guided by the concept of "resource ecologization," this course community has constructed a curriculum resource ecosystem based on faculty-student collaboration and intercollegiate sharing. Progressing from resource standard formulation, content acquisition, and structured management to dynamic iterative updates, a multi-dimensional resource framework has been established, comprising knowledge graphs, engineering case libraries, experimental project repositories, extracurricular resource banks, and exercise-and-examination databases. This approach ensures that the course resources remain relevant and adaptable to the evolving needs of both academia and industry, fostering a more integrated and forward-looking educational experience.

The course knowledge graph achieves an overarching presentation of the Principles of Circuit Analysis knowledge units, facilitating students' understanding and transfer of complex knowledge systems. The engineering case library has undergone multiple rounds of refinement in alignment with regional industrial characteristics, rendering theoretical learning closer to engineering practice. The update rate of experimental projects has exceeded 30%, achieving deep integration with industry technological trends [4]. Extracurricular resources are proactively collected by students and incorporated into the database after being screened by faculty, which enhances the adaptability of resources to contemporary digital media. Furthermore, the construction of the examination database strengthens the reliability of cross-campus identical-test testing, unified evaluation, and precision analysis. Through collaborative efforts, faculty members from participating universities contribute classroom videos, exercises, cases, experimental materials, and graphic resources. This joint effort drives the transformation of resources from fragmented to systematic, and from static to dynamic, effectively addressing the challenges of inadequate course resources, intercollegiate imbalance, and sluggish iterative updates.

The construction of the curriculum resource ecosystem has significantly enhanced students' learning structures and cognitive depth. The course is no longer presented in a traditional linear fashion, and students have tangibly perceived that the curriculum has become "increasingly accessible" and that they are "increasingly capable of discerning the interconnections between prior and subsequent knowledge." The knowledge graph assists students in understanding conceptual relationships within an overarching framework, while the engineering cases ground abstract theories into real-world contexts. The multi-dimensional resources provide personalized entry points for students with diverse learning styles. Faculty members from the participating universities report that students' classroom questions have become more insightful, and their understanding of knowledge is no longer confined to the level of formulas; instead, they are now able to proactively establish connections across different problems. This shift reflects a deeper engagement with the material and a more comprehensive grasp of the subject matter, which aligns with the overarching goals of modern engineering education.

3. Substantial Equivalence in Cross-Campus Identical-Course Teaching within the Course Community

Engineering Education Accreditation establishes a framework to ensure that engineering graduates from various universities achieve a standardized set of eleven core graduate attributes, which serve as a baseline for their professional competencies. This accreditation process incorporates mechanisms for evaluating achievement levels and implementing continuous improvements, thereby enabling students with varying academic foundations to meet unified competency benchmarks by the time they graduate [4]. This approach facilitates the realization of intercollegiate substantial equivalence, ensuring that graduates from different institutions possess comparable skills and knowledge, regardless of their initial disparities in preparation or institutional resources. Such standardization is critical for maintaining consistency in the quality of engineering education across diverse academic environments.

Substantial equivalence emphasizes achieving relative consistency and maintaining high-quality learning outcomes rather than enforcing identical instructional content or uniform teaching methodologies [5]. Within this framework, the Principles of Circuit Analysis course community has implemented specific strategies to ensure substantial equivalence in the delivery of identical courses across multiple campuses. These strategies include the alignment of core learning objectives, the development of shared assessment criteria, and the establishment of collaborative teaching practices. By focusing on these measures, the course community ensures that students, regardless of their campus location, receive an education that meets the same rigorous standards and prepares them equally well for professional engineering challenges.

3.1. Offline Instructional Demonstration and Assistance

Given the varying levels of teaching expertise among faculty members across the universities participating in the course community, North University of China (NUC) has implemented a structured initiative to enhance instructional quality. Distinguished provincial-level university educators and accomplished young lecturers from NUC are regularly assigned to Taiyuan Institute of Technology and Shanxi College of Technology. These educators provide comprehensive, offline instructional support, including practical demonstrations, theoretical teaching, experimental guidance, tutoring sessions, examination preparation, and pedagogical workshops [6]. This initiative, which emphasizes collaborative learning and skill development, has substantially improved the instructional design proficiency and classroom management skills of young faculty members at partner institutions, fostering a more robust academic environment.

3.2. Online Pedagogical Research via Distinct-Pedagogy for Identical-Courses

On a monthly basis, instructors within the course community engage in online pedagogical research and academic exchanges centered on delivering the same instructional content through varied teaching methods and strategies. This approach, referred to as "distinct-pedagogy for identical-courses" (Same Course with Diversified Teaching Designs), allows educators to tailor their teaching styles to their individual strengths and the unique needs of their students [7, 8]. For instance, one instructor might employ traditional methods such as structured lectures and detailed explanations, while another might adopt more interactive techniques like case studies, collaborative group discussions, or educational games to foster engagement and critical thinking. This structured framework for online pedagogical research not only facilitates the sharing of innovative teaching practices but also encourages instructors to refine their methodologies by learning from their peers. By fostering a culture of collaboration and continuous improvement, this model has significantly enhanced the instructional quality and learning outcomes of Circuit Analysis-related courses across participating institutions, ensuring that both educators and students benefit from a dynamic and adaptable educational environment.

3.3. Collaborative Formulation of Curriculum Standards

Curriculum standards are explicit, standardized, or guiding documents that formalize the objectives, content, assessment frameworks, and instructional requirements of a course. These standards define the essential knowledge, skills, and competencies that students are expected to acquire upon completing the course, while also outlining the teaching methodologies and evaluation strategies necessary to achieve these objectives. By establishing a unified framework, curriculum standards promote consistency across the instructional process, ensuring that students—regardless of their institution or geographic location—receive an education of comparable quality. The collaboratively developed curriculum standards within this course community provide a detailed pedagogical blueprint, offering comprehensive guidance for every stage of the instructional lifecycle. This structured approach serves as a foundational directive to enhance learning outcomes, particularly in scenarios involving identical courses taught across multiple campuses, thereby fostering uniformity and academic excellence.

3.4. Detailed Decomposition of Course Objectives

Engineering Education Accreditation plays a pivotal role in ensuring that engineering programs meet international standards of quality and achieve mutual recognition across borders. This system, widely adopted in global engineering education, is underpinned by the Outcome-Based Education (OBE) philosophy, which emphasizes measurable outcomes as a foundation for curriculum design and evaluation. Within this framework, courses such as Principles of Circuit Analysis typically establish three to five broad course objectives. However, these objectives, while comprehensive in scope, often remain overly generalized. Their macroscopic nature, though beneficial for overarching guidance, lacks the granularity required for precise evaluation of achievement. This lack of specificity can hinder the ability to assess whether students have effectively met the intended learning outcomes, thereby limiting the operational feasibility of the accreditation process. Addressing this challenge necessitates a more detailed and structured approach to defining and evaluating course objectives, ensuring alignment with both educational goals and accreditation standards [9].

To address the limitations of generalized course objectives, the academic community has undertaken a systematic decomposition of these objectives into more specific and actionable sub-objectives. This process involves breaking down the overarching goals into distinct knowledge units that align closely with the curriculum content. By constructing a Principles of Circuit Analysis Course Objective Tree, educators have created a hierarchical framework that maps the relationship between high-level objectives and their corresponding sub-objectives. This detailed structure facilitates a full-process evaluation of sub-objective achievement, enabling a more granular and accurate assessment of student learning outcomes. The implementation of this framework has significantly enhanced the precision of evaluations and has contributed to a measurable improvement in the overall attainment rate of course objectives. This approach not only strengthens the alignment between course design and accreditation requirements but also fosters continuous improvement in teaching and learning practices within the discipline.

3.5. Cross-Campus Synchronous Online Testing with Identical Test Items

Cross-campus synchronous online testing with identical test items represents a structured assessment approach designed to ensure uniformity and standardization across diverse student groups within the course community [10]. By requiring all participants to engage in examinations simultaneously and respond to identical questions under standardized conditions, this method facilitates a robust framework for evaluating student performance objectively. Such uniformity minimizes discrepancies that could arise from variations in test administration, thereby enhancing the reliability of comparative analyses of student competencies. Furthermore, this approach supports the equitable treatment of all examinees, fostering a consistent academic environment that prioritizes fairness and transparency in assessment practices.

The course community conducts these online examinations through a centralized open curriculum platform, which serves as a unified interface for managing the testing process. To uphold the integrity and fairness of the assessments, advanced technical measures are employed, including the randomization of question sequences, shuffling of answer options, and the implementation of strict time constraints. These mechanisms are meticulously designed to mitigate risks such as academic dishonesty and ensure that the testing conditions remain consistent for all participants. By leveraging these tools, the platform not only enhances the validity of the examination outcomes but also reinforces the credibility of the overall assessment framework [11].

3.6. Dynamic Feedback via Process Evaluation

Traditional course achievement analysis is generally conducted after the completion of a course. While the results of this analysis are of paramount significance for continuous program construction and the improvement of faculty instructional strategies, the phenomenon of "assessment without feedback" remains widespread during the active instructional lifecycle. This course community extends the continuous improvement philosophy of Engineering Education Accreditation from the traditional inter-cycle (semester-to-semester) iteration down into the active, ongoing course delivery process [12, 13]. By dynamically collecting, analyzing, and providing feedback on the achievement status of course sub-objectives in real-time, the community actively guides student learning and progression. Concurrently, it provides actionable instructional references for faculty, enabling them to evaluate learning outcomes and the efficacy of their teaching strategies. This approach allows instructors to optimize instructional designs and enhance teaching quality by addressing gaps and adapting to the evolving needs of students during the course delivery phase. Such real-time feedback mechanisms ensure that both students and faculty benefit from a more responsive and adaptive educational environment.

Supported by this collaborative teaching mechanism, the curriculum has gradually transitioned from its initial state of "isolated governance" to a cohesive "community-style instruction." Practices such as instructional showcases, differentiated pedagogy for identical courses, cross-institutional collaborative lesson planning, and periodic synchronous testing with identical test items have fostered a higher level of pedagogical interaction among instructors. These practices have driven the steady alignment of instructional strategies, ensuring consistency and quality across different teaching teams. By fostering a culture of collaboration and shared responsibility, this approach has also encouraged the exchange of innovative teaching methods and the refinement of instructional techniques. The resulting synergy among educators has contributed to a more unified and effective teaching framework, benefiting both faculty and students alike.

Over more than two years of the course community's operation, the gap in student learning outcomes has narrowed significantly. Statistical fluctuations in final grades have decreased, classroom interaction metrics have become more balanced, and the instructional pacing has grown increasingly synchronized [10, 14]. The professional growth of young faculty members, driven by the instructional showcases, has been particularly pronounced. In their reflective reports, they have repeatedly noted that they "have begun to understand how to design courses from a student-centric perspective" and are "now capable of planning instructional objectives as a systematic whole." This transformation highlights the effectiveness of the community's collaborative approach in fostering a deeper understanding of pedagogical principles and enhancing the overall quality of education. By emphasizing systematic course design and student-focused strategies, the initiative has not only improved learning outcomes but also cultivated a more cohesive and skilled teaching workforce.

4. Cross-Institutional, Personalized, and Diversified Academic Tutoring by Faculty

Under the traditional model, students' learning support relies primarily on their own course instructors, which often results in fragmented resources and limited learning scenarios. The cross-institutional, personalized, and diversified academic tutoring model addresses these limitations by enabling students to access tailored guidance and support from faculty members of other universities within the course community [15]. This innovative approach allows students to benefit not only from the expertise of their own institution's faculty but also from the diverse perspectives and teaching methodologies of instructors from partner universities. Such interactions enrich students' academic experiences by exposing them to varied pedagogical styles, encouraging broader intellectual engagement, and fostering innovative thinking. Additionally, this model expands students' cognitive horizons and provides them with a more comprehensive and diversified curriculum learning experience, which is particularly valuable in developing interdisciplinary competencies and adaptability in complex academic and professional environments.

This cross-institutional, personalized, and diversified academic tutoring model is implemented through a blended approach that combines online and offline activities. The online component serves as the primary medium for interaction, offering flexibility and accessibility, while offline activities provide opportunities for deeper engagement and collaboration. The core content of this tutoring model includes course Q&A sessions, guidance for disciplinary competitions, support for innovation and entrepreneurship projects, and coaching for postgraduate entrance examinations targeted at upper-level students. By integrating these elements, the model ensures that students receive comprehensive academic support tailored to their individual needs and aspirations, thereby enhancing their overall learning outcomes and preparing them for future academic and professional challenges.

Student feedback highlights the transformative impact of cross-institutional tutoring on their learning experiences. Through interactions with instructors from diverse academic backgrounds, students reported gaining insights into varied thinking patterns and learning multiple approaches to solving engineering problems. This exposure not only supplements their understanding of course content but also broadens their perspectives, enabling them to develop a more holistic and innovative approach to problem-solving. Furthermore, cross-institutional tutoring serves as a gateway for students to explore new ways of understanding the world and constructing engineering mindsets, which are essential for addressing complex challenges in their academic and professional journeys. By fostering intellectual diversity and encouraging interdisciplinary collaboration, this model significantly contributes to the cultivation of well-rounded and forward-thinking individuals [13].

5. Mining of Regionally Characteristic Ideological and Political Elements and Their Effectiveness Evaluation

Compared to other provinces in eastern and central China, the development level of higher education in Shanxi Province is relatively underdeveloped, and its higher education resources are comparatively limited [16, 17]. Consequently, institutions face a dual challenge: they encounter difficulties in attracting high-quality applicants from outside the province and experience a significant outflow of talented local university graduates. This critical shortage of skilled professionals imposes substantial constraints on Shanxi's economic growth and development.

Adopting a tri-university collaborative approach, the course community explored a rich repository of curriculum elements rooted in Shanxi's history as a leader in power and energy development. These elements highlight the province's historical journey, from lighting its first electric lamp in 1908 to its significant contributions in "providing electricity to a substantial portion of China and heating homes across northern regions." Additionally, they emphasize Shanxi's transition from traditional coal-fired thermal generation to a diversified energy matrix that includes wind, thermal, hydro, hydrogen, and photovoltaic power, reflecting the province's commitment to clean energy development. By integrating these elements into the Principles of Circuit Analysis course, the community achieved a seamless combination of knowledge acquisition, value alignment, skill development, and cultural appreciation. This approach has significantly enhanced students' confidence in their regional culture and inspired a strong sense of responsibility to contribute to their local communities [7].

This regionally tailored curriculum framework has facilitated a meaningful integration of academic learning with value-based education, resulting in notable changes in students' cognitive and value systems [11]. Key dimensions such as "professional identity," "understanding of regional culture," and "commitment to local development" have shown significant improvement. Furthermore, students now demonstrate more sophisticated perspectives during classroom discussions. For example, they are able to connect circuit-related knowledge with broader themes such as energy transition, workplace safety, and national development strategies, showcasing a deeper understanding of the interplay between their academic discipline and societal progress.

Building on this regionally focused educational framework, the course community has also prioritized the integration of engineering ethics into the teaching process, thereby amplifying the curriculum's educational impact. Through activities such as analyzing typical failure cases, simulating scenarios involving electrical incidents, and engaging in discussions about the boundaries of engineering responsibility, the abstract concept of engineering ethics has been transformed into tangible, experiential, and relatable scenarios. During failure case analyses, students shifted their focus from merely identifying technical errors to critically examining chains of responsibility, decision-making processes, and systemic risks. Similarly, in scenario simulations, students exhibited a heightened sense of accountability and a deeper emotional connection to issues such as workplace safety and the broader implications of their professional decisions on public welfare [3].

To address the common challenge in value-based education, where objectives are often defined but rarely assessed, the course community developed an evaluation methodology that combines a "Visual Analog Scale (VAS)" with an "Incremental Evaluation" approach. The Visual Analog Scale allows for more detailed and precise measurements by enabling respondents to select values along a continuous spectrum, thereby improving the accuracy of data analysis [9]. Incremental evaluation involves comparing survey results collected at the beginning and end of the course, enabling a quantitative assessment of students' growth in areas such as local identity, regional cultural confidence, and awareness of engineering ethics. This dual-method approach ensures that the educational outcomes are not only well-defined but also effectively measured, providing valuable insights into the impact of the curriculum.

6. Conclusion

The chairing responsibility for this intercollegiate collaborative course community is undertaken by the participating universities on a rotating basis. After more than two years of sustained coordination, iterative adjustment, and joint practice, a systematically organized blueprint for course community development has been formed. This blueprint clarifies the operational structure, division of responsibilities, mechanisms for resource sharing, and procedures for continuous quality improvement, thereby providing a stable institutional foundation for long-term collaboration among regional universities. It also demonstrates that cross-institutional coordination can move beyond short-term project cooperation toward a more mature and normalized model of curriculum co-construction.

In response to the major challenges commonly encountered by regional universities, including outdated curriculum resources, uneven teaching capacity among faculty members, marked differences in student learning outcomes across institutions, and insufficient integration of value-oriented educational elements, the community has developed a collaborative model featuring crowdsourced resource development, substantial equivalence in teaching implementation, and cross-institutional academic tutoring. Through continuous exploration, this model has gradually evolved into a replicable and transferable paradigm for intercollegiate curriculum construction that is well aligned with the conditions and developmental needs of regional universities. Its practical significance lies in improving the quality of undergraduate teaching across heterogeneous institutions, promoting a more balanced distribution of educational resources, supporting greater educational fairness, and advancing ongoing curriculum system improvement within the context of New Engineering Education. Overall, the experience of this course community offers a useful reference for similar institutions seeking coordinated, sustainable, and quality-oriented curriculum development.

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