

Exploring the Teaching Path of the Systems Engineering Course Empowered by Generative Artificial Intelligence

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Abstract: The rapid growth of generative artificial intelligence (GenAI) has created both new opportunities and problems for instructional change in higher education. Systems Engineering, a key methodology course for “engineering management” postgraduates, aims to develop students’ abilities to understand and solve complex engineering problems using systematic thinking. However, persistent obstacles in teaching practice have long existed, including abstract theoretical concepts, methodologies with limited transferability to real-world circumstances, insufficient customized assistance, boring teaching forms, and strict evaluation practices. Taking the course of Systems Engineering as the research object, this study analyzes the course’s characteristics and teaching pain points. An overall framework is proposed, which centers on “human-machine collaboration”, with “pre-class, in-class, post-class” as the main line, and encompassing the dimensions of “teacher, student, and course assessment”. Based on this approach, we explain how GenAI might be integrated into the teaching of Systems Engineering from each of the three perspectives of teacher, student, and course assessment. This investigation is expected to serve as a reference for teaching reform in engineering management courses, aid in the development of compound engineering talents with systematic thinking ability, and contribute to the development of “new business” talents in the digital economy.

Keywords: Generative artificial intelligence; Systems engineering; Teaching path; Curriculum reform

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1. Introduction

Generative Artificial Intelligence (GenAI) technologies such as ChatGPT, Pangu Large Model, and DeepSeek have resulted in a global rebuilding of cognitive paradigms^[1,2]. Compared to standard AI technologies, GenAI has several distinguishing features, including natural interaction, active creation, and tailored adaptation, all of which play a vital role in redefining teaching processes, reconstructing instructional content, and transforming learning modes^[3]. Furthermore, “The Outline of the 15th Five-Year Plan for National Economic and Social Development” clearly proposes to fully implement the “Artificial Intelligence+” action, promote artificial intelligence to empower the reform of educational models, advance the construction of a modern vocational education system, and implement an industry-education integrated talent training model^[4]. As a result,

research into the use of GenAI in classroom reform is both important and in high demand.

“Systems Engineering” is an obvious choice as a basic methodological course for postgraduate engineering management students. It is an interdisciplinary subject based on system theory, management science, operations research, and other disciplines, bringing together information from these fields. On the other hand, this course teaches students how to analyze problems from a broad viewpoint and solve difficulties using engineering approaches, which is important in forming systematic thinking and boosting comprehensive decision-making capacity. However, traditional teaching encounters numerous challenges in the “Systems Engineering” course^[5-10]. In terms of teaching content, overemphasis on theoretical teaching is a major feature of the traditional education model, which differs significantly from practice. This results in a lack of systematic discussion on real engineering problems, making it difficult for students to apply classroom knowledge to practical engineering scenarios. In terms of teaching methodologies, the course incorporates many disciplines and is primarily theoretical in nature, with more abstract content than other courses. Students struggle to instinctively comprehend the practical aspects of systems engineering in class, resulting in poor learning enthusiasm and increased learning difficulties. From the standpoint of teaching mode, the typical “cramming” teaching technique results in limited student participation, which is detrimental to encouraging students’ enthusiasm for learning and inventive thinking. Students differ primarily in their knowledge foundation, cognitive style, and learning needs, and personalized guidance has become the focus of current teaching, but the traditional teaching mode struggles to meet this point, failing to respond to students’ diverse needs. Examination scores have always been the primary criterion for teaching evaluation, ignoring the systematic evaluation of students’ learning processes and comprehensive abilities, making it difficult to comprehensively and objectively assess students’ learning effectiveness.

The rapid development of GenAI technology has reshaped the functions and optimized the relationships of teaching elements, such as teaching subjects, teaching content, and teaching environment, breaking the one-way and isolated interaction mode among elements in traditional classroom teaching and thus creating a new teaching structure with multi-directional linkage and dynamic collaboration. It can be used not only as an additional tool to improve training efficiency, but also as the primary engine to transform teaching procedures and ability training paradigms. It not only increases the implementation efficiency and effectiveness of instructors and students in specified teaching tasks, but it also opens up a brand-new education and teaching space for teachers and students, and can even replace teachers and students in performing part of teaching activities^[11,12]. In light of this, this paper intends to investigate the design ideas and practical paths of GenAI empowering the teaching of “Systems Engineering,” and construct a teaching empowerment system from the dimensions of teachers, students, and course assessment, so as to provide a reference for the teaching reform of engineering management specialty courses, help cultivate compound engineering talents with systematic thinking ability, help solve the pain points of “emphasizing theory over technology, emphasizing classroom over practice” in traditional engineering management education, and make valuable contributions to the cultivation of “new business” talents in the digital economy.

2. Analysis of the current teaching situation of the “Systems Engineering” course

As a key course for postgraduate students majoring in engineering management, “Systems Engineering” includes distinct disciplinary qualities, such as interdisciplinarity, methodology, practicality, and systematic thinking cultivation, as mentioned below^[7-10,13]:

- (1) “Systems Engineering” uses large-scale complex systems as a research object, integrating knowledge from system theory, management science, operations research, professional engineering, and other fields,

and is a typical interdisciplinary subject that emphasizes interdisciplinarity.

- (2) The “Systems Engineering” course content focuses on methodology, which includes system analysis, system evaluation, system decision-making, network planning technology, and so on, to provide students with tools and frameworks for analyzing and solving complex engineering problems.
- (3) “Systems Engineering” is derived from engineering practice, and its theories and methods are widely applied in aeronautical engineering, water conservation engineering, transportation engineering, and other domains. Course instruction focuses on merging theory and practice, emphasizing pragmatism.
- (4) The primary purpose of “Systems Engineering” is to develop students’ systematic thinking skills, allowing them to assess issues from a broad viewpoint, understand the relationships between aspects, and seek global optimal solutions, so promoting systematic thinking cultivation.

However, from the standpoint of teaching practice, the “Systems Engineering” course has many issues, primarily the following:

- (1) Theoretical notions are rather abstract, making them difficult for pupils to grasp. “Systems Engineering” requires a great number of abstract concepts, such as system boundary, system environment, and system structure, which causes students to lack intuitive perception and understanding. Mathematical models and quantitative approaches are the primary topics covered in “Systems Engineering” classes, which require students to have a strong mathematical background. As a result, some students have difficulty mastering linear programming, the analytic hierarchy process, and other topics. In addition, systematic thinking is a high-level cognitive ability that can only be gradually constructed in specific problems. However, typical lecture-based education makes it difficult for pupils to develop intuitive cognition.
- (2) It is difficult to apply theoretical methods to real-world problems. The “Systems Engineering” course provides a variety of system analysis ideas and approaches. Students can finish them step by step in classroom exercises, but when confronted with real-world engineering challenges, they lack the knowledge to select acceptable problem-solving strategies. In terms of teaching practice, students have a superficial understanding of data mining, system modeling, and other methods, and they struggle to integrate and flexibly use various knowledge blocks, making it difficult to apply the learned knowledge comprehensively to solve practical problems. As a result, the practical teaching challenge of a significant gap between theory and practice emerges.
- (3) Students have significant individual variances, making tailored guidance challenging to implement. It is challenging to implement individualized advice in the teaching process since students have such big individual differences. For example, disparities in knowledge foundation, learning aptitude, and cognitive style are frequently the most significant characteristics of student differences. Furthermore, throughout the teaching process, it was discovered that certain students had been exposed to important “Systems Engineering” courses as undergraduates, whereas cross-major students lacked relevant prior knowledge accumulation. In general, large-class teaching makes it difficult for teachers to gain insight into each student’s thought process, failing to provide tailored advice. As a result, the unified teaching progression and material cannot suit the diverse learning demands of different pupils.
- (4) The teaching methods are generally simple, and teacher-student contact is inadequate. In the current teaching process, teacher lecturing remains the primary method, and pupils are in a state of passive knowledge absorption, with little engagement in class. As a result, difficulties faced in class are difficult to fix promptly, and students lack adequate supervision after class, resulting in a vicious cycle. As a result, the one-way knowledge transfer approach does not promote students’ enthusiasm and initiative in learning.
- (5) Evaluation procedures are relatively rigorous, making it difficult to reflect overall competencies. In modern teaching, the final score accounts for a large proportion and remains the primary component of students’ marks, whereas the assessment of customary grades accounts for a tiny amount, indicating a

lack of process evaluation in teaching. Classroom discussion, project practice, group collaboration, and other methods are important ways to implement process assessment, but they are difficult to incorporate into current teaching practices, resulting in final evaluation results that do not fully reflect students' knowledge mastery and ability development level.

3. Framework design of GenAI empowering “Systems Engineering” course teaching

In response to the problems that exist in the teaching of “Systems Engineering” courses, this study intends to incorporate GenAI into teaching to form a teaching framework with “human-machine collaboration” as the core, “pre-class, in-class, post-class” as the main line, and “teacher-student-course assessment” as the dimensions, as shown in **Figure 1**.

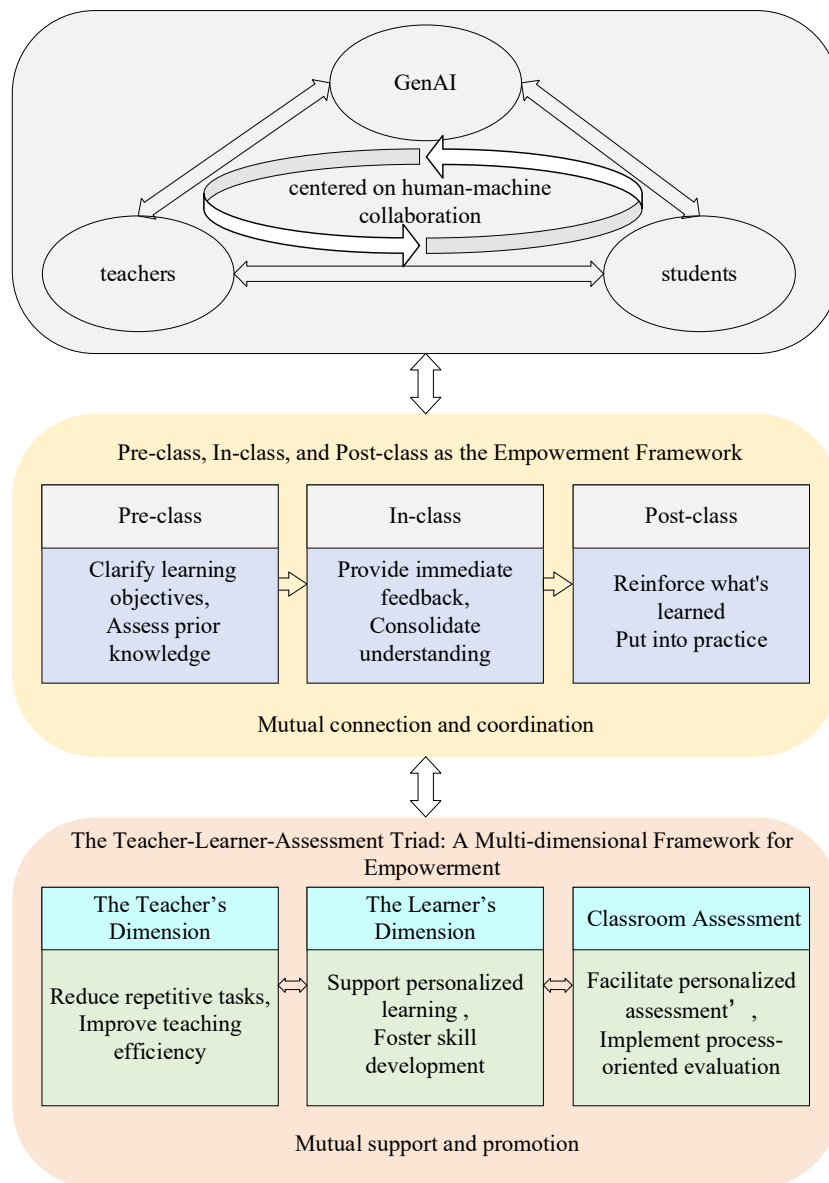


Figure 1. GenAI-Enabled Teaching Framework for Systems Engineering.

3.1. Taking “human-machine collaboration” as the core

The conventional teaching approach involves interaction between professors and pupils. To disrupt this relationship, this study introduces GenAI and expands it into a ternary collaborative interactive relationship of “teacher-student-GenAI”. Each role in the ternary structural connection performs a unique set of tasks. Teachers, as knowledge disseminators, continue to be responsible for creating teaching objectives, designing teaching activities, delivering course knowledge, and leading the learning process. Students, as knowledge recipients, can engage in discussion with the presented GenAI while obtaining knowledge explanations from teachers, sort out knowledge, and build their own knowledge system. As excellent examples of generative artificial intelligence technology, GenAI is mostly employed for auxiliary activities such as information retrieval, resource production, real-time feedback, and learning situation analysis. It is important to note that this ternary structural relationship is dynamic and will be modified in real time as the training process progresses. In the knowledge understanding stage, GenAI acts as an “explainer” and “demonstrator”; in the application practice stage, GenAI serves as a “practice partner” and “feedback provider”; and in the comprehensive innovation stage, GenAI becomes a “thinking inspirer” and “creative collaborator”.

3.2. Taking “pre-class-in-class-after-class” as the empowerment main line

GenAI is utilized to support learning throughout the learning process, rather than simply in a specific link, because GenAI provides distinct services in different links. GenAI offers preview materials, pre-learning assessments, and other services to help students identify learning objectives and understand their own knowledge reserves prior to the start of class. In the classroom, GenAI may give real-time Q&A services and provide multi-scheme comparisons based on the teaching topic, assisting students in deepening their grasp and mastery of knowledge while exploring difficulties. In the after-class stage, GenAI can generate knowledge graphs according to teachers’ teaching content, and after teachers’ verification, accurately push them to each student to help students consolidate the knowledge learned in class; additionally, GenAI can push personalized review content according to students’ mastery of knowledge, and recommend expanded cases to help students transfer theoretical knowledge to practical applications and further master the learned. The preceding information shows that the three steps of “pre-class-in-class-after-class” are linked and coordinated with one another, resulting in a closed-loop teaching process of “diagnosis-intervention-consolidation”.

3.3. Taking “teacher-student-course assessment” as the empowerment dimensions

Because different dimensions have different properties, GenAI performs different functions in each dimension. Because teachers place a higher value on teaching quality and implementation effectiveness, GenAI can provide services to help teachers generate lesson plans, create courseware, build case libraries, compile exam questions, and so on, effectively lowering teachers’ repeated labor burden. At the same time, GenAI may provide learning scenario reports based on students’ classroom performance, assisting teachers in precisely grasping the crucial and challenging aspects of teaching. Furthermore, teaching reflection is an important step for teachers seeking to improve their teaching quality. GenAI can provide a reference base for teachers’ teaching reflection by analyzing numerous data points during the teaching process. For students, the focus is on improving their own learning ability, so GenAI can push differentiated learning resources based on their learning progress and knowledge mastery to enhance their overall development. Conversational thinking is also an important aspect of generative artificial intelligence. Students can engage in numerous rounds of dialogue with GenAI to conduct in-depth thinking, from the surface to the depths of knowledge, and eventually

cultivate their abilities to evaluate and solve problems. GenAI can assist students in understanding their progress and weaknesses based on their learning trajectories. Course assessment is an essential part of the learning process for both teachers and students. Combined with current progress, a diverse assessment and precise evaluation are required. GenAI can create a hierarchical and multi-type test question bank based on teachers' teaching content and students' learning situations, enabling tailored testing and diagnostics. At the same time, it can do process evaluations based on students' behavioral data during the learning process. Furthermore, it may produce visual learning scenario analysis reports to give a diverse foundation for teachers' teaching development.

The three dimensions of "teacher-student-course assessment" complement and enhance each other. Teachers, for example, can design more targeted teaching activities after understanding students' learning situations with the help of GenAI; students will generate learning data during their interactions with GenAI, and the generated data will serve as the foundation for teachers to adjust teaching strategies; and processing data collected through course assessment will feed back into teaching design and learning support. The three complement one another, creating a virtuous loop of mutual promotion of "teaching-learning-evaluation".

4. Exploration of the teaching path of GenAI empowering 'Systems Engineering' course

4.1. Teacher empowerment path

From lesson preparation to teaching reflection, teachers can utilize GenAI to conduct complete data searches in pre-class, in-class, and after-class, as described below:

- (1) Pre-class stage: GenAI assists teachers in preparing instructional materials. Before teaching a course, teachers must look for many relevant resources. With the help of GenAI, teachers' repetitive effort in class preparation can be significantly reduced. For example, depending on the teaching objectives and course syllabus given by teachers, GenAI assists teachers in organizing knowledge frameworks, designing lesson plans, creating multimedia courseware, and so on. Furthermore, teaching situations serve as a link between classroom instruction and practical application. GenAI can assist teachers in searching for different types, levels, and challenges of teaching cases based on teaching topics and case requirements, and updating them in real-time.
- (2) In-class stage: GenAI assists teachers with learning situation analysis. Teachers use learning situation diagnosis to continuously improve their teaching quality. GenAI collects and analyzes data on students' learning processes, allowing teachers to gain a thorough and systematic understanding of their students' learning situations in order to dynamically change teaching tactics and provide differentiated instruction. For example, GenAI records students' question answering, interactive participation in class, homework completion, and error type distribution, allowing teachers to fully understand students' common problems and individual differences, accurately locate teaching difficulties, and finally provide a basis for adjusting teaching rhythm.
- (3) After-class stage: GenAI assists teachers with teaching reflection. GenAI participates in the entire teaching process, allowing it to review and analyze it, assisting teachers in transforming their teaching experiences and providing assistance for systematic teaching improvement measures. Teachers, for example, can input multidimensional data such as students' homework completion, group collaboration records, learning behavior trajectories, classroom performance, and student feedback into GenAI, allowing it to assist teachers in conducting a comprehensive analysis of teaching effects, identifying highlights and deficiencies in the teaching process based on existing teaching experience, reflecting on teaching strategies, and optimizing subsequent teaching design.

The above analysis shows that in the teacher dimension, GenAI can significantly reduce repetitive labor in the teaching process, not only improving teaching efficiency but also allowing teachers to devote more energy to teaching design and implementation, teaching innovation, and student guidance.

4.2 Student Empowerment Path

Integrating GenAI into pre-class, in-class, and after-class can provide students with diverse knowledge support for their learning, as mentioned below.

- (1) Pre-class stage: GenAI helps students with individualized previews. Preview allows students to gain a general knowledge of the lecture subject. GenAI may offer students individualized preview materials based on their own knowledge background and course learning objectives, such as explanatory films, relevant cases, focused knowledge points, and so on. Furthermore, GenAI may deliver corresponding test questions based on students' preview situations, assisting students in understanding their comprehension of new knowledge, adjusting preview directions, and shifting their listening emphasis in class based on test results.
- (2) In-class stage: GenAI provides interactive learning for students. When students encounter problems in classroom learning, GenAI can provide real-time Q&A and auxiliary discussion for them. For example, in the group discussion link, students can interact and dialogue with GenAI to obtain instant explanations and idea inspiration. In the case analysis link, students can deeply explore the core of the case and compare the advantages and disadvantages of various solutions through multiple rounds of dialogue with GenAI. In addition, GenAI can also provide supplementary knowledge materials according to students' questions on different issues, helping students deeply understand classroom content.
- (3) After-class stage: GenAI helps students consolidate and expand the learned knowledge. After classroom teaching, students can use GenAI to review content. For different students, GenAI can push personalized review content and expanded materials according to students' preferences and classroom performance, to meet the needs of different students. For example, for students with weak knowledge mastery, GenAI can provide targeted knowledge explanations and practice questions to help them consolidate classroom knowledge. For students with spare capacity, expanded knowledge is the focus. GenAI can push cutting-edge literature, expanded cases, etc., to help them conduct in-depth exploration and further learning. In addition, students can use GenAI to generate summary learning reports, so as to master their learning situation and reflect on difficult problems in the learning process.

It can be seen from the above analysis that in the student dimension, GenAI can provide personalized and interactive learning support according to students' learning situation, thus promoting students' understanding of knowledge and helping their ability development, and finally enabling students to transform from passive education to active independent learning.

4.3. Course assessment empowerment path

From the perspective of course assessment, GenAI can also provide full-process services for teaching management and quality improvement in pre-class, in-class and after-class, as detailed below:

- (1) Pre-class stage: GenAI assists in constructing and maintaining an intelligent test question bank. In traditional teaching, teachers need to spend a long time preparing exercises both in class and after class, and sometimes it is difficult to cover all types of exercises. However, GenAI can help teachers build a hierarchical and multi-type test question bank according to the course knowledge system, covering test questions of different difficulty levels and type requirements. For example, GenAI can construct

basic conceptual questions, true-false questions, multiple-choice questions, etc., according to classroom content, and also construct comprehensive application essay questions, design questions, case analysis questions, etc., according to students' learning situation. In addition, the test question bank established by GenAI can not only be dynamically updated based on students' demand feedback, but also identify the use frequency of test questions by teachers, and modify questions with low use frequency or low discrimination according to the actual situation.

- (2) In-class stage: GenAI helps collect and process evaluation data. Since GenAI participates in the whole learning process, it can record students' whole-process learning data. For example, students' pre-class preview, classroom participation, group discussion, after-class homework completion and other situations, these data provide a basis for teaching process evaluation. In addition, GenAI can assist teachers in constructing a teaching evaluation index system, so as to quantitatively analyze the whole learning process of students and generate relevant reports. This method can more comprehensively reflect students' learning investment and effect, helping to make up for the deficiency of "one exam determines the grade" for students in traditional evaluation.
- (3) After-class stage: GenAI provides teaching analysis reports. Since GenAI participates in the whole process of teaching and learning, it can generate a relatively comprehensive teaching analysis report, including students' learning process change trend, knowledge point mastery, comparison between each student and the class average, comparison of teaching situations among multiple classes, etc. For students, the generated report can help them understand their own learning situation and weak links, thus clarifying the direction of future learning; for teachers, the report can help teachers grasp the overall learning situation of the class, helping them adjust teaching strategies.

From the above analysis, it can be seen that, in the course assessment dimension, GenAI can effectively promote the diversification and precision of student evaluation methods and help transform teaching evaluation from "result evaluation" to "developmental evaluation", enabling evaluation to reflect students' learning effectiveness more comprehensively.

In summary, the methods and paths of GenAI empowering the "Systems Engineering" course teaching are shown in **Figure 2**.

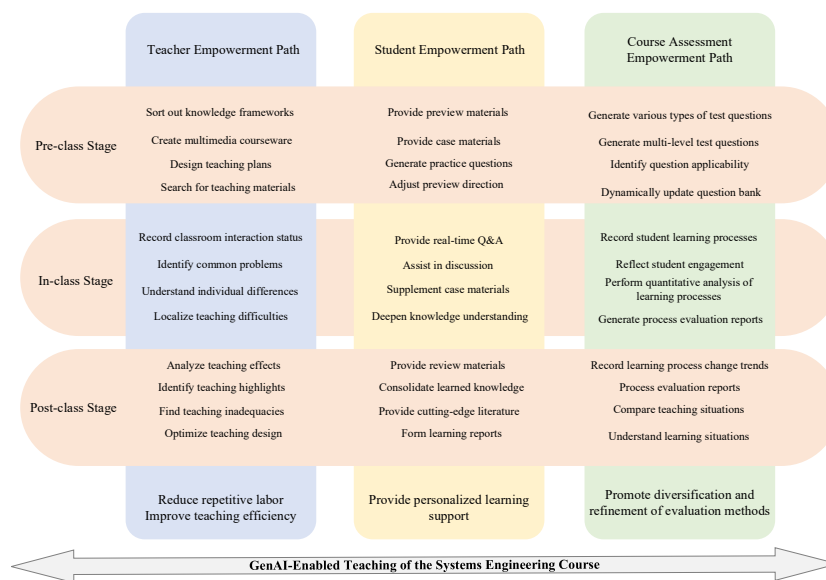


Figure 2. Schematic of GenAI-Empowered Teaching Path in Systems Engineering.

5. Conclusion

Starting from the practical problems faced by the “Systems Engineering” course teaching, based on the analysis of course characteristics and teaching pain points, this paper proposes an overall framework with “human-machine collaboration” as the core, “pre-class, in-class, after-class” as the main line, and “teacher-student-course assessment” as the dimensions. Accordingly, it discusses the teaching path of GenAI empowering “Systems Engineering” from the three dimensions of teacher, student and course assessment. From the perspective of teachers, GenAI can free them from repetitive labor and devote more energy to teaching design and student guidance; from the perspective of students, GenAI can support personalized learning, promote students’ knowledge understanding and ability development, and help students realize the transformation from passive acceptance to active learning; in terms of course assessment path, GenAI can make evaluation more comprehensively reflect students’ learning effectiveness and promote the diversification and precision of evaluation methods.

The GenAI empowerment paths of “teacher-student-course assessment” are interdependent and interrelated, jointly forming a practical system running through the whole teaching process. However, in the implementation process, special attention should be paid to: teachers are always the leaders of teaching, and should review and adjust the content generated by GenAI to avoid deviating from teaching objectives; in addition, students should be helped to cultivate critical thinking and identification ability, maintain active thinking in the interaction with GenAI, and avoid entrusting learning tasks to external tools; schools should provide corresponding technical support and institutional support, and establish norms for GenAI use.

With the rapid development of information technology, GenAI will be further integrated with classroom teaching, and the teaching form will undergo profound changes. The exploration made in this paper on the “Systems Engineering” course may provide a certain reference for the teaching reform of engineering management specialty courses, but how to further promote the in-depth integration of GenAI and classroom teaching to meet the educational needs and career development needs of students in different faculties and stages still needs further exploration.

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