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A Comparative Study of Domestic and International Linear Algebra Curriculum Design and Application Orientation

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Abstract: This paper presents a systematic comparison of the curriculum design and application orientation of the linear algebra curriculum in our country and abroad. It explains mainly differences in course objectives, teaching content, approaches, and feedback mechanisms, reflecting divergent understandings of the discipline's value within distinct educational ecosystems. Forward-looking and practical conclusions are proposed across five main directions: optimizing course structure, strengthening practical components, deepening interdisciplinary integration, building faculty capacity, and developing teaching resources. The aim is to provide strong conceptual help and realistic guidance for getting real progress in linear algebra education in China.

Keywords: Linear algebra; Curriculum design; Application orientation; Teaching reform

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1. Introduction

Linear algebra, as one of modern mathematics, is an important course for principles such as computer science, but also plays an indispensable role in cutting-edge fields. However, the teaching of the linear algebra curriculum has universally faced certain challenges [1].

Currently, there is a phenomenon in the teaching course: a neglect of practical applications. A lot of courses still focus on proofs of abstract concepts, for example, matrices, vectors, systems of equations, and transformations, with teaching methods mainly focused on teacher-led lectures. This causes many students, those majoring in non-mathematical fields, to find the subject difficult to understand. They struggle to understand the same points between these mathematical tools and their future professional fields or daily life, which often makes them in feelings of intimidation and a lack of interest.

Simultaneously, more and more diversification in teaching methods is also being explored. Including the introduction of flipped classrooms, project-based learning (PBL), and group collaboration, all aimed at stimulating students' learning initiative and creativity. Cross-cultural comparative studies have also revealed differences in the understanding of the value of algebra and the divergences in course design and feedback systems [2].

The teaching of the algebra curriculum is undergoing a critical period of transformation. Although some teaching models remain prevalent, a wave of reform emphasizing application orientation and talent development is gaining momentum. The goal is to make linear algebra a truly handy "innovation practice platform" for students in future studies and work, rather than just an intimidating "mathematical tool course."

2. Comparison of teaching content and textbook systems

2.1. Selection of textbooks

In China, most universities adopt nationally unified textbooks or versions compiled by university professors themselves. The representative textbook is Linear Algebra (6th Edition, Tongji University Press). These textbooks are defined by structure, logic, and a complete theoretical framework, reflecting a progressive writing style that moves "from the simple to the complex." Such textbooks generally lack sufficient case studies, especially those with interdisciplinary backgrounds, which weakens their ability to stimulate students' interest in learning and awareness of real applications. Moreover, the exercises are mostly computational in nature, with few open-ended problems, which is not conducive to developing students' critical thinking and creative abilities.

Textbooks used in foreign universities place greater emphasis on the practice. For instance, Linear Algebra and Its Applications [3] not only covers the main abstract content of the curriculum but also presents difficult mathematical concepts in a concrete and visual manner through rich tables, models, and interdisciplinary application cases. This method could make students master complex theoretical structures.

The textbook also pays special attention to students' cognitive methods. Each chapter includes content, such as "Explore" and "Modeling Exercises," which guide students to consolidate their knowledge through experimentation, programming, and modeling. Similarly, Introduction to Linear Algebra [4] has a distinctive feature, its use of engineering problems—such as picture understanding, network flow, and the Google PageRank algorithm—as contextual backgrounds for introducing linear algebra theory. This greatly improves students' interest in mathematics applications and their practical problem-solving abilities.

Currently, some Chinese universities have begun to introduce foreign textbooks or adopt bilingual teaching methods. For example, Peking University uses Strang's textbook alongside MIT video lectures in their linear algebra course, supplemented with MATLAB-based experiments. This approach has received positive feedback from students, indicating that the choice of textbook has a profound impact on teaching quality.

2.2. Organization of content

Regarding the content organization structure of linear algebra, we can get the differences between Chinese and foreign approaches in **Table 1** below.

Table 1. Main differences between Chinese and international textbooks.

Aspect	Chinese textbooks	Foreign textbooks
Chapter organization	Primarily adopt a traditional, deductive structure: “definition-theorem-proof-example-exercise.”	Often adopt an inductive structure, starting with practical problems, then deriving concepts and methods.
Pedagogical philosophy	Emphasizes systematic knowledge building and rigorous foundational understanding.	Focuses on problem-solving, practical application.
Motivation	Sometimes, lacking sufficient motivation for students.	Often provide more vivid motivation and practical examples, better linking theory with application.
Teaching resources	Relatively scarce in terms of rich, integrated digital resources.	Generally more abundant in rich, integrated digital resources.
Overall impression	Strong in building fundamentals, but may need improvement in a useful context.	Perceived as engaging, application-oriented, and rich in resources.
Consequence/need	Enhancing applicability, openness, and interdisciplinary integration is seen as an urgent task for reform.	Serve as methods for incorporating modern pedagogical tools and resources.

Therefore, focusing on the ability, openness, and interdisciplinary integration of domestic teaching materials has become an urgent task in China’s university teaching reform.

3. Teaching methods and classroom practices

3.1. Teacher roles and student engagement

In most Chinese universities, the teaching of linear algebra is dominated by a lecture-based approach, where instructors systematically deliver the content from textbooks, and students primarily acquire knowledge through listening, note-taking, and completing exercises after class. While this “knowledge transmission” model helps students systematically grasp knowledge, the tends to result in low student engagement, limited classroom interaction, and a lack of exploratory and innovative learning processes. This is a difficult problem for students with weaker mathematical foundations or low intrinsic motivation, as it fails to stimulate sustained interest in learning.

Universities in developed countries place greater emphasis on active learning and student participation. A lot of strategies are widely adopted, including the Socratic Method, Collaborative Learning, and the Flipped Classroom. Teachers often design courses using a problem-driven approach and real-world problems.

Foreign classrooms emphasize both instructor-student and peer-to-peer interaction. In small-class settings, students are encouraged to present solutions on the board, co-derive theorems with teachers, or use group-based case analysis and role-playing activities. Research shows that such practices significantly enhance students’ sense of participation, belonging, and cognitive engagement. Large-class teaching in China often limits students’ chances for thinking and discussion, thus hindering the development of thoughts and competencies.

3.2. Use of computing and programming tools

A lot of concepts in this course are highly abstract. Students often struggle to build intuitive understanding through symbolic computation and static diagrams alone. In this regard, foreign universities widely use computers as instructional aids. These tools enable conceptual theories to be visualized, animated, and simulated. This graphical and dynamic way enhances students’ depth of understanding and interest in learning all courses.

Furthermore, foreign universities have been focused on the integration of programming skills and mathematical modeling into linear algebra instruction. linear algebra is not only taught as a mathematical foundation also applied through practical programming tasks. Linear algebra courses are supported by the Jupyter Notebook platform, where students can write programs and use computational results and geometric meanings in real time, reinforcing the operability and practicality of the knowledge.

In contrast, some top Chinese universities have begun to explore AI tools in teaching, such as Beihang University and Harbin Institute of Technology. These have been proven effectively and practically. On one hand, limitations in teaching resources, equipment, and instructors' programming skills limited the effective integration of computers into instructional design. On the other hand, the current assessment system still relies heavily on paper-based exams, which reduces the incentive for both instructors and students to actively use these AI tools [5].

4. Course objectives and evaluation systems

4.1. Differences in course objective design

Table 2 illustrates the five main differences in the goal-setting of linear algebra courses between mostly domes-tic universities and some foreign universities, reflecting the teaching philosophies and methods under different educational systems.

Table 2. Differences in course goals: Domestic universities vs. foreign universities.

Aspect	Domestic universities	Foreign universities
Target orientation	Master basic concepts, theories, and methods	Diverse and open, emphasizing practical application skills
Knowledge points	Matrix, determinants, linear equations, and eigenvectors	Understanding theoretical knowledge, practical problem modeling, etc.
Teaching philosophy	Focusing on the completeness and logic of the maths system	Competency-oriented and application-oriented, emphasizing the connection between maths and reality
Application skills development	Relatively neglected	Develop students' capability to use mathematical tools to solve engineering and scientific problems, encouraging understanding through programming, model-ing, and visualization
Other skills development	Not specifically mentioned	Emphasizes thinking, and is achieved through group work, project research, etc.

4.2. Construction and implementation of evaluation systems

The evaluation system is an important part of achieving course aims. For Chinese universities, the evaluation of linear algebra courses is still dominated by a final written exam, which typically accounts for over 70% of the total grade. And mostly exam content mainly consists of computational and proof-based problems, focusing on the reproduction and application of knowledge points.

While the method could, to some extent, assess students' mastery of basic knowledge, it fails to comprehensively provide these students' whole abilities, particularly in areas such as practical application, innovative thinking, and teamwork. In addition, the weight of continuous assessment in the overall grade is relatively low and is often based solely on attendance and homework completion. This lacks an effective evaluation of students' learning growth and engagement. Such a "result-oriented, process-neglected" evaluation approach tends to encourage rote learning and exam-focused strategies.

In contrast, foreign universities usually adopt a more diversified and process-oriented evaluation system. In the United States, for example, linear algebra courses typically combine formative and summative assessments, emphasizing both the learning process and the final outcomes. Specific evaluation components include: Homework Assignments (20–30% of total grade), Quizzes and Midterm Exams, Projects and Programming Assignments, Class Participation and Group Work, and Final Exam. This diversified evaluation system provides a view of student performance. For example, Freeman *et al.* found that courses with formative feedback and interactive teaching methods significantly improved student performance.

4.3. Teaching feedback

Foreign universities generally place strong emphasis on feedback and course improvement. Many institutions have dedicated Teaching and Learning Centers that regularly organize course evaluations, teaching seminars, and faculty training. For example, there are university that collects anonymous student feedback every semester and uses it to adjust course content and teaching methods. MIT employs video analysis of classroom instruction and focuses on review systems to help teachers change their teaching methods.

In China, although some universities have begun to establish course evaluation theory, they are often administrative in nature and lack sustained implementation. Student feedback is frequently superficial, and instructors may not consistently act according to final results, leading to limited usefulness in making instructional improvement [6].

Through these reforms, it is expected that linear algebra education in China can transition from a "teacher-centered" to a "student-centered" model, truly achieving an integrated "teaching–learning–evaluation" system.

5. Implications of international reform trends for linear algebra education reform in China

The differences between domestic and international linear algebra instruction essentially reflect distinct educational philosophies: while the domestic approach focuses on the "comprehension of knowledge," the international approach prioritizes "problem-solving ability." In light of international reform trends and the current state of linear algebra education in China, Chinese universities should promote teaching reform in the following areas:

Updating teaching philosophy and strengthening application awareness: Chinese universities should shift away from the traditional "knowledge-based" teaching philosophy and adopt a "competency-based" and "application-based" approach to the curriculum plan. It is important to develop localized textbooks that integrate "theory, application, and tools" into a full system. In course development, greater emphasis should be placed on the interdisciplinary integration of linear algebra in areas such as computer methods and economics. Through assimilating real-world cases and projects, students could improve their ability to utilize mathematical methods to solve practical problems.

Innovating teaching methods and emphasizing classroom engagement: There should be a strong promotion of innovative teaching models such as the flipped classroom [7], blended learning, and project-based learning. The method encourages instructors to use in-class time for discussion, hands-on practice, and problem-solving, rather than established knowledge transmission. Through pre-class video lectures, in-class discussions, and post-class project-based activities, students' initiative in learning can be stimulated, thereby enhancing the vitality and effectiveness of classroom instruction.

Integrating information technology to promote smart teaching: Universities should increase expenditure in technology and encourage instructors to integrate computational methods into their classes. The development of visual teaching resources and online experimental platforms should be prioritized. Through the use of technology to dynamize and realize abstract concepts, students may grasp and master linear algebra concepts. AI will be leveraged to personalize studying pathways [5].

Improving the evaluation system and emphasizing process management: A diversified course evaluation system should be established, incorporating components such as regular assignments, project reports, classroom performance, and programs. At the same time, greater attention should be paid to tracking and providing feedback on students' learning processes.

Strengthening faculty training and improvement of teaching competence: Universities should place greater emphasis on the development of instructors' teaching capabilities by regularly organizing teaching seminars, competitions, and training programs. Faculty should be encouraged to participate in domestic and international teaching exchanges and development opportunities.

Strengthening international exchange and collaboration [7,8]: Universities should be encouraged to collaborate with international institutions in areas such as joint course development, faculty exchange. Learning from other countries' practices, we can improve the international competitiveness of our linear algebra education and other curricula. By enhancing instructors' pedagogical literacy and innovative capacity, a solid foundation of talent can be established to support the reform of linear algebra education.

6. Conclusion

International trends in linear algebra education reform are characterized by increasing emphasis on application, interactivity, and process-oriented learning. Chinese universities should follow these trends and promote crucial changes in teaching philosophy, instructional models, technology integration, evaluation systems, and faculty development. Thus, we can build a competency-oriented linear algebra education system for the goals of the course. Only in this way can we get high-quality talent with strong mathematical foundations, strong application ability, and innovative capabilities.

Furthermore, the above education reform measures in linear algebra could be used in other curricula of our country. With the development of AI, more effective methods will be found and applied in mathematical foundations capabilities.

Disclosure statement

The author declares no conflict of interest.

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