

Curriculum Reform of Advanced Algebra in the AI Era: Dilemmas, Correlations and Restructuring

Debiao Li*

School of Mathematics, North University of China, Taiyuan 030051, Shanxi, China

**Author to whom correspondence should be addressed.*

Copyright: © 2026 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: As the mathematical cornerstone of cutting-edge technologies such as artificial intelligence and big data, the Advanced Algebra course is confronted with challenges including disconnection between theoretical teaching and practical application demands, rigid teaching modes and insufficient practical training in the AI era. Based on the dual demands for students' mathematical literacy and interdisciplinary capabilities in the AI era, this paper combines the existing dilemmas of curriculum teaching and restructures current teaching paths driven by AI application demands, so as to provide solid support for cultivating high-quality interdisciplinary talents with solid mathematical foundations and innovative practical capabilities.

Keywords: AI era; Advanced algebra; Curriculum reform; Teaching innovation; Mathematical application

Online publication: August 13, 2026

1. Introduction

As the core driving force leading a new round of scientific and technological revolution and industrial transformation, artificial intelligence is reshaping human production modes, lifestyles and knowledge dissemination forms with unprecedented depth and breadth ^[1]. From the training and optimization of deep learning models to feature extraction and dimensionality reduction in big data analysis ^[2], from image transformation and pattern recognition in computer vision to semantic vector representation and similarity calculation in natural language processing, the theories and methods of Advanced Algebra run through all links and form an indispensable mathematical logical foundation of the AI technical system ^[3]. The value of the Advanced Algebra course lies not only in imparting abstract concepts and logical reasoning paradigms such as polynomials, linear spaces and linear transformations, but also in cultivating students' practical ability to convert real-world problems into algebraic models for solutions ^[4].

Nevertheless, an examination of Advanced Algebra teaching practices in domestic universities reveals that the prevalent teaching modes are obviously misaligned with talent training standards in the AI era. In terms of

teaching content, teaching focus leans excessively on rigorous deduction of theoretical systems, while in-depth correlations between various knowledge modules and AI application scenarios are insufficiently explored, leading students to fall into the cognitive dilemma of “learning without practical use”^{[5][6]}. In terms of teaching methods, one-way knowledge indoctrination suppresses students’ enthusiasm for inquiry and stimulation of innovative potential. Practical sessions are mostly limited to basic software command operations, lacking comprehensive and design-oriented training targeting real-world problems, and fail to cultivate students’ ability to solve complex interdisciplinary problems. Assessment and evaluation systems merely test the reproduction of declarative knowledge, and cannot effectively measure practical capabilities and innovative literacy. With the accelerated iteration of AI technologies, society has an increasingly urgent demand for interdisciplinary talents with solid mathematical and physical foundations and proficient application skills. Systematic reform of the Advanced Algebra course has become an inevitable choice for higher education to keep pace with the development of the times.

2. Core value and reform demands of advanced algebra in the AI era

Centered on polynomial theory, basic linear algebra and abstract linear spaces, the knowledge system of Advanced Algebra shares an isomorphic relationship with the AI technology stack ^[7]. Polynomial theory provides basic algorithm models for data fitting, regression prediction and cryptography; determinants, matrices and linear equations constitute core toolkits for data representation and large-scale numerical solutions; quadratic form and eigenvalue theories reveal the mathematical essence of classification decision boundaries and data dimensionality reduction; linear spaces, linear transformations and Euclidean spaces are highly abstract generalizations of neural network architectures, feature mapping and similarity measurement. Therefore, the core value of this course lies in shaping mathematical thinking, enabling students to acquire core literacy in describing the world with algebraic language and solving complex system problems through rigorous logical deduction.

The advent of the AI era puts forward four urgent reform requirements for the Advanced Algebra course. First, the reconstruction of teaching contents: teaching shall shift from self-consistent pure theories to the organic integration of theories and applications. On the premise of guaranteeing the rigor of core theories, specific application scenarios such as SVD decomposition in image compression and eigenvectors in data dimensionality reduction shall be systematically embedded to bridge the gap between theories and practices. Second, the paradigm shift of teaching methods: teaching shall transform from passive reception to active inquiry. Blended online-offline teaching, AI auxiliary tools and flipped classrooms shall be widely introduced to reshape teacher-student interaction and stimulate students’ internal cognitive drive and critical thinking. Third, hierarchical reconstruction of practical systems: practical training shall shift from single verification to comprehensive innovation. Multi-level practical projects covering basic operations, comprehensive applications and frontier exploration shall be constructed to help students internalize knowledge and improve interdisciplinary transfer ability when solving real problems. Fourth, systematic optimization of assessment mechanisms: evaluation shall shift from knowledge-oriented to competence-oriented. The evaluation system shall incorporate multi-dimensional indicators including process evaluation, project achievements and teamwork to exert positive guiding effects on students’ all-round development.

3. In-depth correlation between core knowledge modules and AI as well as teaching restructuring paths

The inherent logical connections between each core module of Advanced Algebra and AI provide clear guidance and basis for precise reconstruction of teaching contents. The core reform strategy is to optimize and integrate teaching contents of each module driven by AI application demands, and strengthen direct docking and two-way mapping between theoretical knowledge and engineering application scenarios.

3.1. Polynomial theory and data fitting

Traditional teaching of polynomial theory, the opening chapter of Advanced Algebra, focuses on theoretical deduction such as algebraic operations, divisibility, factorization and root properties of polynomials, while ignoring its application value as a basic tool for function approximation. Teaching restructuring shall focus on explaining the functional mechanisms of polynomial interpolation and polynomial regression in the AI field. When elaborating on Lagrange interpolation and Newton interpolation, teachers can naturally extend to the basic ideas of linear regression and polynomial regression^[8], and illustrate their practical applications in data completion and trend prediction. When discussing the relationship between polynomial roots and coefficients, connections can be made to the principles of RSA encryption and decryption algorithms based on the difficulty of large integer factorization in cryptography. Through Python programming experiments for simple curve fitting and numerical prediction, students can intuitively perceive the specific forms and efficiency of abstract algebraic structures in data modeling and pattern recognition^[9].

3.2. Determinants, linear equations and large-scale numerical solutions

Determinants and linear equations are core models for dealing with linear problems. Traditional courses focus on manual calculation skills of low-order determinants and exact solution methods such as Cramer's rule and Gaussian elimination, which are obviously inconsistent with the demand for solving large-scale sparse linear systems in the AI field. On the basis of retaining the theoretical essence of classical elimination methods, teaching reform shall appropriately introduce numerical calculation ideas such as Jacobi iteration, Gauss-Seidel iteration and conjugate gradient method, and clarify their key roles in parameter optimization of deep neural networks and numerical solutions of partial differential equations. Meanwhile, students shall be guided to solve large sparse linear equations using scientific computing libraries such as NumPy, shifting the cognitive focus from cumbersome manual calculations to macro grasp and strategic selection of problem solvability conditions and algorithm convergence and efficiency.

3.3. Matrix theory and feature extraction

Matrix theory is the core hub of Advanced Algebra and the most widely used universal language in AI computing. However, traditional teaching often fails to elaborate advanced matrix decomposition technologies such as singular value decomposition (SVD) and principal component analysis (PCA) in sufficient depth. Teaching reform shall elevate SVD and PCA to the same core teaching status as basic matrix operations, and thoroughly analyze their mathematical essence of dimensionality reduction and denoising from a theoretical perspective. Combined with comprehensive experiments including image compression and reconstruction, dimensionality reduction visualization of the Iris dataset, and scoring matrix completion in recommendation systems, the powerful efficiency of matrix decomposition in feature engineering and data preprocessing can be intuitively demonstrated. During teaching, efforts shall be made to cultivate students' structured thinking

of constructing matrix models to describe practical problems, enabling them to consciously convert issues such as network weight updating, image transformation and collaborative filtering into matrix operations and decomposition for solutions.

3.4. Quadratic forms, linear spaces and model optimization

Quadratic forms, linear spaces and linear transformations constitute the most abstract modules in Advanced Algebra. The theories of standard form transformation and positive definite discrimination of quadratic forms provide direct mathematical explanations and geometric intuitions for constructing optimal classification hyperplanes in support vector machines, defining Mahalanobis distance and data whitening preprocessing. Although linear spaces and linear transformations are generally regarded as the most obscure chapters, they serve as the theoretical foundation for affine mapping between neural network layers, feature representation learning and query-key mapping in attention mechanisms. Teaching shall resolve cognitive barriers to abstract concepts through geometric intuition. For instance, rotation, scaling and projection transformations on two-dimensional planes can be used to interpret the essence of linear transformations, which can be further extended to weight matrix updating and basis transformation dimensionality reduction strategies in deep learning. The key to reform this module lies in converting abstract algebraic definitions into perceptible geometric operations and computable engineering processes, helping students build a cognitive bridge from formal definitions to practical applications.

3.5. Jordan canonical form, Euclidean spaces and system analysis

Jordan canonical form and Euclidean space theories contain abundant AI application interfaces. As the simplest form of matrices under similarity transformation, Jordan canonical form possesses unique value in analyzing the stability, controllability and observability of linear dynamic systems. Teaching can link it with long-term dependency problems, model compression and network pruning technologies in recurrent neural networks, and illustrate its potential applications in simplifying complex model structures and improving training efficiency. Euclidean spaces define geometric metrics such as vector length, included angle and distance through inner product operations, providing strict mathematical criteria for measuring similarity between data objects. Teaching contents shall highlight the application principles of Euclidean distance, Manhattan distance, cosine similarity and Mahalanobis distance in cluster analysis, image retrieval, face recognition and personalized recommendation systems. Corresponding algorithm implementation projects shall be designed to guide students to convert abstract vector-included angle and spatial distance calculations into operable technical schemes for solving practical recommendation and retrieval problems.

4. Integrated innovation of teaching methods and hierarchical construction of practical systems

Innovation of teaching methods serves as a key carrier for the implementation of curriculum reform^[10]. Advanced Algebra classrooms in the AI era shall realize the organic integration of multiple teaching modes. Blended teaching and AI-assisted learning can break time and space limitations, realize personalized learning path planning through MOOC platforms and intelligent teaching systems^[11], and deliver real-time learning situation feedback^[12]. Flipped classrooms and project-based learning shift knowledge imparting to pre-class preparation, reserving valuable class hours for teacher-student discussions, case analysis and collaborative

problem-solving^[13]. Design project tasks covering multiple knowledge points such as “image compression based on matrix decomposition”^[14], which can effectively drive students to deepen theoretical understanding and exercise knowledge transfer and innovative capabilities during practice.

Matching the innovation of teaching methods, a well-structured practical teaching system shall be built^[15]. Basic experiment level: Targeted at mastering tools and methods. Students complete tasks such as polynomial fitting and basic matrix operations via Python or MATLAB. Comprehensive experiment level: Focused on the integrated application of multi-module knowledge. Students are required to solve relatively complex application problems such as image compression and data classification, cultivating their system analysis and scheme design capabilities. Innovative project level: The highest tier of practical systems. Students are encouraged to carry out exploratory research on self-selected topics such as image style migration and social network analysis based on personal interests and disciplinary frontiers, stimulating original innovative thinking and cultivating comprehensive literacy for interdisciplinary research and solving cutting-edge problems.

5. Optimization and restructuring of multi-dimensional evaluation mechanisms

As the “baton” of teaching activities, assessment and evaluation directly affect the actual effectiveness of reform. A multi-dimensional, three-dimensional evaluation system matching competence cultivation objectives must be constructed.

- (1) Diversified evaluation contents serve as the core. Comprehensive assessment shall cover the mastery of theoretical knowledge, operational skills in experiments, innovative performance in project research and teamwork literacy, with evaluation running through the whole learning process.
- (2) Diversified evaluation methods are essential. The single model of closed-book final exams shall be transformed, with reasonable weight allocated to daily assignments, class participation, experimental reports, project presentations and final assessments, so that capabilities of different dimensions can be effectively measured.
- (3) Diversified evaluators shall be introduced, integrating teacher evaluation, student self-evaluation and group mutual evaluation, which helps improve the objectivity and fairness of evaluation and cultivates students’ reflective learning habits and critical thinking in the process.

6. Conclusion

Against the backdrop where AI technologies thoroughly reshape the modes of knowledge production and dissemination, systematic reform of the Advanced Algebra course is both an urgent proposition of the times and an inevitable path to improve the quality of basic mathematics education. Based on the compound demands for students’ mathematical literacy and practical capabilities brought by the AI industry, this paper explores a reform path that deeply integrates abstract algebraic theories with cutting-edge AI applications through comprehensive analysis and restructuring of four pillars: teaching contents, teaching methods, practical systems and assessment mechanisms. Looking ahead, curriculum construction shall continuously deepen the cross-integration of theories and applications, strengthen the cultivation of interdisciplinary teachers, and jointly build and share teaching resources, so that this classic basic course can glow with new vitality in the intelligent era and cultivate more high-quality talents with solid foundations and innovative spirits for the country.

Disclosure statement

The author declares no conflict of interest.

References

- [1] Li D, 2018, Introduction to Artificial Intelligence. China Science and Technology Press, Beijing.
- [2] Zhou Z, 2016, Machine Learning. Tsinghua University Press, Beijing.
- [3] Li H, 2019, Statistical Learning Methods (2nd Edition). Tsinghua University Press, Beijing.
- [4] Algebra Group of School of Mathematical Sciences, Peking University, 2019, Advanced Algebra (5th Edition). Higher Education Press, Beijing.
- [5] Zhang H, Hao B, 2007, Advanced Algebra (5th Edition). Higher Education Press, Beijing.
- [6] Li G, Ma C, Han S, 2023, Exploration of Teaching Methods to Resolve the Abstractness of Advanced Algebra. *Studies in College Mathematics*, 26(4): 34–37.
- [7] An R, 2021, Reform and Practice of Research-Oriented Teaching in Advanced Algebra Course. *Journal of Science of Teachers' University*, 41(6): 75–77.
- [8] Chen X, 2007, Introduction to Mathematical Statistics. Science Press, Beijing.
- [9] Zhu D, et al., 2003, Selected Cases of Mathematical Modeling. Science Press, Beijing.
- [10] Liu Y, Zhang L, Zhang G, Li T, 2022, Exploration of Online-Offline Blended Teaching Mode for Advanced Algebra. *Journal of Daqing Normal University*, (6): 114–125.
- [11] Zhang G, Pang S, 2022, Research on Curriculum Ideological and Political Construction of Advanced Algebra Based on Blended Teaching. *Journal of Guangdong Polytechnic Normal University*, 43(3): 106–112.
- [12] Zhang G, Pang S, 2023, Exploration and Practice of Blended Teaching of Advanced Algebra Based on MOOC and Rain Classroom. *Journal of Guangdong Polytechnic Normal University*, 43: 84–89.
- [13] Liu J, Lin F, 2024, Exploration of Daily Performance Evaluation System of Rain Classroom Blended Teaching—A Case Study of Advanced Algebra. *College Mathematics*, 40(2): 13–18.
- [14] Shu A, Guo W, Wang P, 2025, Integrated Application of Curriculum Ideological and Political Concept and BOPPPS Model in Advanced Algebra Course. *Journal of Anqing Normal University (Natural Science Edition)*, 31(4): 116–121.
- [15] Cui Y, Jiang X, Jiang J, Hu Z, 2022, Research on Online Teaching Organization and Implementation Strategies of Curriculum Ideology and Politics for Advanced Algebra. *Journal of Higher Education*, 8(7): 68–71.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.