

Research on Teaching Reform and Innovation in a Time Series Analysis Course Based on Artificial Intelligence

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Abstract: Artificial intelligence is developing rapidly, and its applications in the field of education are becoming increasingly widely popular. As a core course in statistics, economics, finance, and related disciplines, the time series analysis course is characterized by its strong theoretical and practical dimensions. This study explores teaching reform and innovation in a time series analysis course based on artificial intelligence. It optimizes teaching content, methodologies, and assessment systems by integrating artificial intelligence tools and techniques. The aim is to enhance students' learning engagement and practical application skills, cultivate their innovative thinking, and strengthen their ability to solve real-world problems. Furthermore, this study provides valuable insights for teaching reforms in related academic fields.

Keywords: Time series analysis; Artificial intelligence; Intelligent tutoring; Evaluation system

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1. Introduction

The time series analysis course serves as a core course across multiple disciplines, including statistics, economics, finance, etc. Its goal is to systematically study observation data arranged chronologically, reveal the inherent patterns of phenomena evolving over time, and this foundation enables the establishment of predictive models to support decision-making ^[1]. With the rapid advancement of big data and artificial intelligence (AI), the application of time series analysis has deepened and expanded across numerous domains, including macroeconomic forecasting, financial market modeling, industrial Internet of Things monitoring, smart medical diagnostics, and climate and environmental monitoring ^[2]. This trend places increasingly urgent demands on universities to cultivate high-caliber talents equipped with solid theoretical foundations, proficient technical tool usage, and interdisciplinary innovative thinking.

However, the traditional teaching of the time series analysis course still faces significant challenges.

In terms of content, instruction often emphasizes theoretical derivations of classical statistical models while failing to effectively integrate emerging time-series models from machine learning and deep learning ^[3-4]. This disconnect leaves students' knowledge systems out of step with industry frontiers. Teaching methods predominantly rely on a one-way lecture format where instructors deliver content and students passively absorb it, which makes it difficult to inspire students' enthusiasm for exploration and innovation. In practical sessions, constrained by limited class hours and software tools, experiments often remain confined to simple modeling of outdated datasets. Students lack experience handling real-world, massive, and high-dimensional time series data. Furthermore, course assessments typically rely heavily on written examinations, which fail to comprehensively evaluate students' model application skills, critical thinking, and practical problem-solving capabilities ^[5].

Therefore, in the current era of AI, teaching reform and innovation for time series analysis courses have become imperative. This study explores teaching reform and innovation in a time series analysis course based on AI. It optimizes teaching content, methodologies, and assessment systems by integrating AI tools and techniques. The aim is to enhance students' learning engagement and practical application skills, cultivate their innovative thinking, and strengthen their ability to solve real-world problems. Furthermore, this study provides valuable insights for teaching reforms in related academic fields.

2. Current applications of AI in education

AI can provide personalized learning paths and content recommendations based on students' learning progress and styles, which help them learn more effectively ^[6-10]. For example, through data analysis within learning management systems (LMS), AI can identify where students struggle with specific knowledge points and recommend relevant learning resources and practice exercises.

With natural language processing and machine learning technologies, intelligent tutoring systems can provide real-time answers to student questions and immediate feedback to resolve learning challenges. For instance, such systems can interact with students via chatbots to address specific course-related queries.

Furthermore, AI can automatically evaluate student assignments and exams, generating detailed analytical reports to help educators better understand learning outcomes and adjust teaching strategies. For instance, machine learning algorithms can automatically grade programming assignments and suggest code optimizations.

In addition, with virtual reality (VR) and augmented reality (AR) technologies, AI creates virtual labs where students perform practical operations to enhance hands-on skills. For example, VR enables students to visually track trends in time-series data, while AR allows them to build models and make predictions directly on real-world data.

3. Teaching reform of the time series analysis course based on AI

3.1. Optimizing teaching content

Systematically integrating AI tools into curriculum reform is a crucial pathway to enhancing students' practical skills. As shown in **Figure 1**, optimizing teaching content involves introducing artificial intelligence tools and integrating real-world case studies. Centered on the Python ecosystem, this course progressively integrates modern machine learning and deep learning toolchains. At the foundational level, it first establishes students' Python programming fundamentals, emphasizing the data processing capabilities of the Pandas library (including

resampling time series data, sliding window operations, and handling missing values) and the numerical computation basics of the NumPy library, laying a solid technical groundwork for subsequent analysis.

At the machine learning application level, the course strategically introduces the scikit-learn library. It not only covers common regression and classification models but also incorporates time series analysis characteristics, specifically designing teaching content that encompasses feature engineering, cross-validation strategies, and model evaluation methods. Through this module, students will proficiently master standardized processing of time series data, feature extraction, and the construction workflow of traditional machine learning models.

To further address complex time series forecasting demands, the advanced section introduces TensorFlow and PyTorch—two major deep learning frameworks. Through detailed explanations of the structural principles and implementation methods for models like Recurrent Neural Networks (RNN), Long Short-Term Memory Networks (LSTM), and Gated Recurrent Units (GRU), students are guided to build end-to-end deep learning prediction models. The course places particular emphasis on hands-on practice, requiring students to independently complete the entire workflow from data preprocessing, model construction, training optimization, to prediction evaluation.

To integrate theoretical instruction with practical skill development, the course incorporates multiple real-world case projects. In finance, students utilize real-time stock price data from the New York Stock Exchange to predict stock price trends and analyze market volatility patterns by building Autoregressive Integrated Moving Average models (ARIMA) and LSTM neural networks. In meteorology, students utilize multi-year observational data from the National Meteorological Center to perform seasonal decomposition and periodic forecasting, mastering seasonal adjustment techniques in time series analysis. For macroeconomic analysis, students access GDP, Consumer Price Index, and inflation rate data released by the National Bureau of Statistics to build multivariate forecasting models, exploring the intrinsic correlations and patterns among economic indicators.

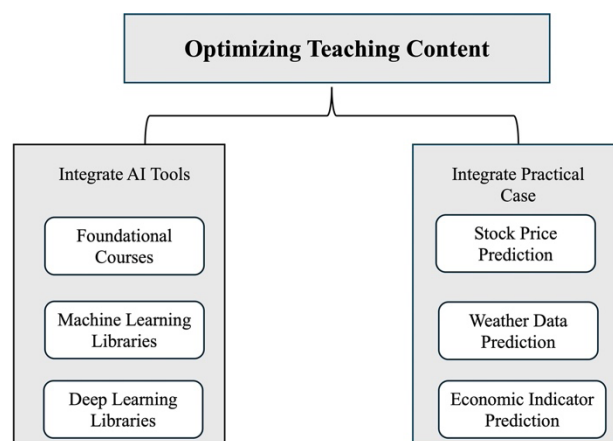


Figure 1. Summary of optimizing teaching content

3.2. Innovative teaching methods

At the pedagogical level, this course actively advances teaching model innovation supported by AI technology, establishing a diversified instructional system that integrates intelligent tutoring, virtual training, and project-based practice. The innovative teaching methods, as shown in **Figure 2**, include an intelligent tutoring system,

virtual laboratories, and project-driven teaching. Firstly, the course incorporates an intelligent tutoring system based on natural language processing technology. This system can automatically identify and categorize questions posed by students, providing precise answers tailored to different question types. For theoretical questions, the system delivers detailed formula derivations, principle explanations, and relevant literature recommendations. For practical questions, it generates concrete code examples and operational guides. Additionally, the system incorporates a robust feedback mechanism that continuously optimizes its knowledge base and response strategies by recording student evaluations of answers, enabling self-evolving teaching resources.

Secondly, the course leverages VR and AR technologies to construct immersive virtual laboratories. Within VR experimental environments, students can use head-mounted displays to enter three-dimensional visualizations, intuitively observing dynamic patterns in time series data—such as tracking real-time stock price fluctuations in simulated financial trading scenarios. In AR environments, students use mobile devices to overlay virtual models onto real-world datasets, enabling interactive analysis and predictive operations within mixed reality. This technology enhances learning engagement and cultivates students’ data perception and spatial reasoning skills.

Finally, the course employs project-driven pedagogy, designing multiple real-world application scenarios. Students select authentic topics based on their interests, such as corporate sales data analysis or financial market forecasting, and undergo the entire process from data collection and cleaning, feature engineering, model building, and optimization, to visualizing results. Throughout project execution, students must prepare technical reports and deliver defense presentations. This process hones their ability to tackle complex problems while simultaneously developing teamwork and academic communication skills. Through this “learning by doing” approach, students gain deep insights into the practical value of time series analysis methods, building solid professional core competencies.

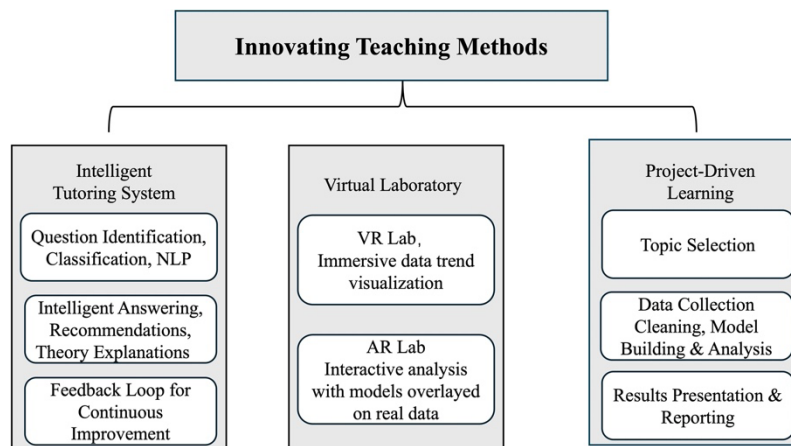


Figure 2. Summary of innovative teaching methods

3.3. Perfecting evaluation systems

Regarding the evaluation system, this course has established a diversified, process-oriented, and personalized comprehensive assessment framework supported by AI technology. **Figure 3** illustrates that the perfecting evaluation system incorporates automated assessment, process evaluation, and personalized feedback. Firstly, an automated evaluation system developed using AI technology enables precise assessment of student learning outcomes. For programming assignments, the system employs machine learning algorithms to perform

static and dynamic code analysis. It not only automatically identifies syntax errors and logical flaws but also provides improvement suggestions in areas such as algorithm optimization, code standardization, and execution efficiency. For theoretical exams, natural language processing technology is employed to perform semantic analysis and knowledge point matching on text-based answers, automatically generating detailed assessment reports that include scoring criteria, error analysis, and knowledge mastery levels, significantly enhancing evaluation efficiency and objectivity.

Beyond focusing on automated assessment of final outcomes, the course places particular emphasis on formative evaluation, comprehensively tracking student performance and development throughout the learning process. Through multidimensional data collection and analysis, the system quantitatively assesses students' classroom engagement, project implementation capabilities, and virtual experiment proficiency. This formative assessment mechanism enables instructors to promptly identify learning challenges and provides data-driven support for instructional interventions.

At the personalized feedback level, the system leverages big data analytics to generate multidimensional learning profiles and diagnostic reports for each student. These reports not only precisely analyze students' mastery across knowledge modules in time series analysis but also reveal their learning behavior patterns and skill development gaps. Based on these analyses, the system intelligently pushes personalized learning recommendations and customized resources. For instance, it recommends classic literature and case libraries to students weak in model selection, and provides specialized training programs for those lacking programming practice skills. This closed-loop evaluation system—"Assessment-Diagnosis-Feedback-Improvement" provides a robust guarantee for cultivating high-caliber data analytics talents.

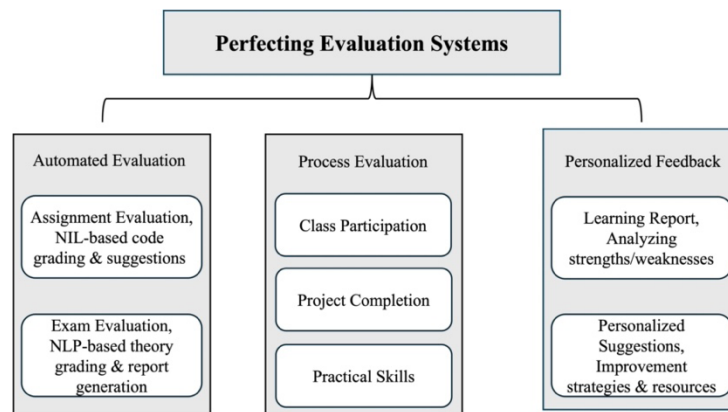


Figure 3. Summary of perfecting evaluation systems

4. Implementation outcomes of teaching reform

4.1. Significant increase in student engagement

The introduction of AI tools and methodologies has markedly heightened student interest in the time series analysis course. Classroom participation has notably increased, with students demonstrating greater initiative in self-directed learning. Specifically, classroom interactions have grown more frequent, with students showing greater willingness to ask questions and participate in discussions, and creating a more dynamic learning environment. Additionally, self-directed study time has expanded significantly, as students now spend considerably more time independently exploring and learning relevant knowledge after class.

4.2. Substantial enhancement in students' practical skills

Through virtual laboratories and project-driven instruction, students' practical operational capabilities have markedly improved. Students can proficiently utilize AI tools for data processing and model analysis, with significantly improved problem-solving capabilities for real-world scenarios. Specifically, firstly, data processing skills have advanced, enabling students to skillfully employ libraries for data preprocessing. Secondly, model construction abilities have improved, allowing students to build and optimize time series forecasting models. Additionally, practical problem-solving capabilities have grown, with students capable of independently completing analyses and predictions for real projects while proposing reasonable solutions.

4.3. Holistic enhancement of student competencies

Through formative assessment and personalized feedback, students not only deepened their theoretical knowledge and practical skills in time series analysis but also cultivated teamwork, innovative thinking, and real-world problem-solving abilities. Specifically, firstly, team collaboration improved significantly, as project-driven learning required students to work collectively with teammates to complete tasks. Secondly, innovative thinking abilities are strengthened, as students must continuously experiment and explore within projects, thereby strengthening and refining their innovative thinking skills. Finally, overall competence is elevated, with students achieving comprehensive enhancement in their comprehensive qualities, laying a solid foundation for future studies and careers.

5. Conclusion

The teaching reform and innovation in the time series analysis course based on AI has effectively enhanced students' learning interest and practical skills by introducing AI tools and methodologies, optimizing teaching content, innovating instructional approaches, and perfecting evaluation systems. This reform has cultivated students' innovative thinking and problem-solving abilities in real-world contexts. This mode of teaching reform offers valuable insights for course instruction in related disciplines and holds significant potential for broader application. In future teaching practices, educators should continuously explore and innovate teaching methods based on students' actual circumstances and course characteristics, further enhancing teaching quality to make contributions toward cultivating high-quality professional talents.

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Disclosure statement

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