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Research on the Construction of Multi-dimensional Teaching Evaluation System for Advanced Mathematics Based on AI under the Background of Digital-Intelligent Transformation

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Abstract: **Driven by digital intelligence technologies, reforms have been advanced in higher education evaluation. Traditional courses of Advanced Mathematics generally suffer from drawbacks including single-dimensional evaluation, difficulties in recording process-based learning data, and delayed evaluation feedback. As a mainstream intelligent teaching platform in China, ChaoXing Learning integrates curriculum development, in-class interaction, AI homework grading, learning situation statistics, learning behavior tracing and other functions, providing platform support for full-process and multi-dimensional teaching evaluation of Advanced Mathematics. Taking ChaoXing Learning as the carrier and relying on the platform's AI modules and multi-source data collection capabilities, this paper constructs a multi-dimensional three-dimensional teaching evaluation system for Advanced Mathematics featuring "multi-stakeholder participation, full-process coverage and human-machine collaboration". It closes the teaching loop covering pre-class preview, in-class interaction, after-class consolidation and final assessment, and realizes the organic integration of process-based evaluation and summative evaluation. Practical results demonstrate that carrying out three-dimensional teaching evaluation supported by the Learning Platform can effectively mine students' learning behavioral data, reduce teachers' workload in process evaluation, accurately identify deficiencies in students' learning, implement individualized teaching and personalized learning, and improve the educational effectiveness of the Advanced Mathematics course.**

Keywords: **Digital intelligence, artificial intelligence, Advanced Mathematics, multi-dimensional three-dimensional evaluation, teaching evaluation system.**

I. INTRODUCTION

As a compulsory public basic course for science, engineering, economics and management majors in universities, Advanced Mathematics is characterized by abstraction, logicality and applicability, and plays a vital role in cultivating students' logical thinking, mathematical modeling and problem-solving abilities. For a long time, the assessment of Advanced Mathematics in most universities has centered on closed-book final examinations. Evaluation focuses excessively on the assessment of knowledge outcomes, while insufficient attention is paid to learning processes, thinking development, inquiry and practical capabilities. The evaluation model that "prioritizes summative assessment over process assessment" fails to fully reflect students' true mathematical literacy and restricts the improvement of curriculum teaching quality.

The Ministry of Education has repeatedly proposed deepening reforms in educational evaluation, advocating the use of information-based teaching tools to optimize full-process evaluation and break the "score-only" evaluation orientation. With the continuous advancement of intelligent teaching construction, the ChaoXing Learning has been widely adopted in the teaching of public mathematics courses across universities nationwide. Built into the platform are functions such as automatic AI grading, class sign-in, in-class quizzes, discussion boards, task points, error archives and learning situation analysis, which can completely retain full-chain data of students' curriculum learning and lay a data foundation for conducting process-based evaluation. Nevertheless, in actual teaching practice, many teachers only use the Learning Platform to upload courseware and release assignments, while underutilizing the platform's evaluation functions including AI learning situation analysis and behavioral data mining. Realistic problems such as superficial data utilization, fragmented evaluation indicators and disconnection between online and offline evaluation exist, failing to form a systematic three-dimensional teaching evaluation model.

How to fully leverage the data collection and AI analysis strengths of the ChaoXing Learning, deeply integrate platform functions with the characteristics of the Advanced Mathematics course, build a matched multi-dimensional three-dimensional teaching evaluation system for public mathematics courses, and shift evaluation from "outcome judgment" to "promoting learning and teaching through evaluation" has become an important research topic for the digital intelligent teaching reform of Advanced Mathematics. Taking the ChaoXing Learning as the carrier and drawing on its AI capabilities, this paper constructs a complete evaluation system from the perspectives of evaluation subjects, evaluation indicators, implementation procedures, feedback mechanisms and supporting conditions, providing practical references for the assessment reform of Advanced Mathematics courses in universities.

II. EXISTING PROBLEMS IN TRADITIONAL ADVANCED MATHEMATICS TEACHING EVALUATION AND THE APPLICATION OF CHAOXING LEARNING

2.1 Inherent Drawbacks of Traditional Advanced Mathematics Teaching Evaluation

(1) Single-dimensional evaluation. Traditional evaluation relies heavily on final exam scores, focusing on the assessment of formula computation and theorem memorization, while neglecting the evaluation of logical reasoning, mathematical application, learning attitude, collaborative inquiry and other literacies. This easily breeds exam-oriented learning, where some students achieve high paper scores yet lack mathematical thinking and practical capabilities.

(2) Difficulties in implementing process-based evaluation. Advanced Mathematics is taught to large class cohorts, imposing an enormous manual workload on teachers to document classroom performance, homework revisions and error records. Process materials such as class presentations and group seminars are hard to preserve, rendering process assessment a mere formality with strong subjectivity and arbitrariness.

(3) Severe delays in evaluation feedback. A prominent feature of Advanced Mathematics is the interconnection of knowledge points: contents such as limits, derivatives and integrals are closely linked sequentially. Under the traditional model, feedback on homework and unit tests has a long cycle, causing students' knowledge gaps to accumulate continuously and making it difficult for teachers to conduct timely intervention and personalized tutoring.

(4) Single evaluation subjects dominated by teacher evaluation. Effective channels for student self-evaluation and peer evaluation are lacking, leading to limited evaluation perspectives that cannot fully depict students' overall learning status.

2.2 Practical Pain Points in Applying ChaoXing Learning to Advanced Mathematics Evaluation

Although numerous universities have adopted the ChaoXing Learning for Advanced Mathematics courses, the platform's evaluation functions are underutilized in practice. First, platform application remains superficial: teachers mostly use it to upload courseware and release notifications, while evaluation modules including task points, discussion forums, AI homework and learning situation reports see low utilization rates. Second, the problem of data silos persists: many teachers analyze scattered data from sign-ins, quizzes and homework separately without integrating multi-source data from the Learning Platform into comprehensive curriculum evaluation, creating a disconnect between online data and offline classroom teaching. Third, insufficient exploitation of the platform's AI capabilities: the Learning Platform supports automatic marking of objective questions and error statistics, yet it cannot fully judge a large number of subjective proof and derivation questions in Advanced Mathematics. Some teachers directly adopt AI grading results as final scores without secondary professional review by instructors. Fourth, a lack of supporting evaluation indicators matching Learning Platform data: metrics such as task point completion duration and video viewing progress are equated with learning effectiveness, leading to invalid learning behaviors like "brushing task points" and distorting evaluation results.

III. FEASIBILITY OF EMPOWERING MULTI-DIMENSIONAL THREE-DIMENSIONAL EVALUATION OF ADVANCED MATHEMATICS WITH AI ON CHAOXING LEARNING

Integrated with an artificial intelligence learning situation analysis module, the ChaoXing Learning enables non-intrusive automatic collection of learning behavior data, serving as a technical carrier for multi-dimensional three-dimensional evaluation.

(1) The platform supports automatic full-process data collection of teaching activities. Data including pre-class task point completion progress, answers to preview quizzes; in-class sign-ins, in-class exercises, screen-cast responses and forum discussions; after-class homework submissions, AI grading results, error archives, chapter test scores and group task completion status can all be automatically stored. This replaces massive manual recording work for teachers and addresses the practical challenge of collecting process data for large-sized classes.

(2) AI learning situation analysis on the platform generates learning portraits for classes and individual students. The backend of the Learning Platform automatically calculates task point completion rates, exercise accuracy, frequently missed questions and weak knowledge modules, outputting class-wide learning situation reports and personal student learning files, helping teachers quickly identify common errors across the cohort and students with learning difficulties. For objective computational questions, the platform's AI delivers instant automatic grading; for subjective derivation questions, the AI can identify solution steps and mark error links, offering references for further manual re-evaluation by teachers.

Furthermore, the platform facilitates the implementation of multi-stakeholder evaluation. The group task and peer assignment modules on the Learning Platform directly support student self-evaluation and group peer evaluation. Objective data output by the platform serves as the basis for intelligent evaluation, combined with teachers' offline classroom observations to form a multi-party collaborative evaluation model involving "Superstar AI, teachers, individual students and learning groups".

(3) The platform enables real-time two-way feedback. Students can access error archives and prompts for weak knowledge points on their terminals; teachers receive early warnings on learning situations to quickly locate struggling students, adjust teaching designs in a timely manner and push targeted learning resources, laying foundations for layered teaching and personalized tutoring.

It must be clarified that the AI functions of the Learning Platform act merely as auxiliary tools. Machine intelligence cannot fully judge logical speculation and innovative problem-solving ideas in Advanced Mathematics; human-machine collaboration must be upheld, with platform output data serving only as evaluation references and teachers' professional judgment occupying a dominant position.

IV. CONSTRUCTION OF MULTI-DIMENSIONAL THREE-DIMENSIONAL TEACHING EVALUATION SYSTEM FOR ADVANCED MATHEMATICS BASED ON CHAOXING LEARNING

Adhering to the principles of fostering virtue through education, human-machine collaboration, integration of online and offline teaching, full closed-loop teaching processes and promoting teaching via evaluation, this system takes the ChaoXing Learning as the foundation and consists of five components: multi-stakeholder evaluation subjects, three-dimensional evaluation contents and indicators, full-process evaluation implementation paths supported by the platform, a two-way dynamic evaluation feedback closed loop, and operational guarantee mechanisms, covering pre-class, in-class, after-class and final assessment stages.

4.1 Four-party Collaborative Multi-stakeholder Evaluation Subjects

Supported by functional modules of the ChaoXing Learning, a four-party collaborative evaluation framework is constructed, involving intelligent evaluation by Superstar AI, teacher evaluation, student self-evaluation and group peer evaluation.

(1) Intelligent evaluation by Superstar AI: Collects all objective learning behavioral data within the platform, completes automatic grading of objective questions, and compiles statistics on task point completion, quiz accuracy and error distribution to output quantitative learning situation data. Such data only acts as reference materials for evaluation and does not directly generate final course scores.

(2) Teacher evaluation: Occupies a dominant position in the evaluation system. Teachers synthesize platform data from the Learning Platform, combined with offline classroom observations, performance on subjective assignments and proof/derivation tasks, and completion quality of curriculum expansion tasks to comprehensively assess students' mathematical thinking, logical deduction and innovative thinking, fulfilling evaluation of subjective dimensions.

(3) Student self-evaluation: Via discussion boards and assignment reflection modules on the Learning Platform, students conduct self-review against curriculum objectives, evaluating their fulfillment of preview requirements, error revisions and knowledge mastery to cultivate autonomous reflective abilities.

(4) Group peer evaluation: Leveraging the group task and peer assignment functions of the Learning Platform, group members complete online mutual evaluation targeting mathematical inquiry and mathematical modeling group assignments, assessing each member's division of labor, communication and collaboration, and contribution to group tasks.

Reasonable weight coefficients are assigned to each evaluation subject to avoid platform data dominating overall assessment scores, and online platform data is integrated with offline classroom performance.

4.2 Three-dimensional Evaluation Contents and Indicator System

Combining the curriculum objectives of Advanced Mathematics and data sources collectible via the ChaoXing Learning, evaluation is divided into four dimensions: knowledge mastery, mathematical capabilities, learning process and literacy, and innovative practice, balancing process-based evaluation and summative evaluation.

TABLE I: THREE-DIMENSIONAL EVALUATION CONTENTS AND INDICATOR SYSTEM FOR ADVANCED MATHEMATICS SUPPORTED BY CHAOXING LEARNING

Evaluation Dimension	Secondary Evaluation Indicators	Primary Data Sources
Knowledge Mastery	Concept comprehension, formula computation, theorem application, knowledge system construction	Chapter tests on Superstar Platform, AI-graded homework, final exam paper analysis
Mathematical Capabilities	Logical reasoning, abstract generalization, theorem proof, problem transformation and solving	Subjective assignments and in-class exercises on Superstar Platform; teachers' re-evaluation combined with AI records of student responses
Learning Process & Literacy	Completion of preview task points, participation in in-class interactions, error revision, learning reflection	Task points, class sign-ins, forum discussions and error archives on Superstar Platform; student self-evaluation; teachers' classroom observations
Innovative Practice	Multiple solutions to single problems, mathematical modeling inquiry, extended assignments of mathematizing real-world problems	Group tasks and extended assignments on Superstar Platform, short curriculum reports, group peer evaluation

Weight allocation for comprehensive assessment: Process-based evaluation accounts for 40%, and summative final examination accounts for 60%. Within process-based evaluation: objective data collected by the Superstar Platform accounts for 25%, comprehensive teacher evaluation accounts for 10%, and student self-evaluation plus group peer evaluation jointly account for 5%. Weight coefficients of each indicator can be adjusted in the backend of the Superstar Platform for economics & management and engineering majors to match talent training requirements of different disciplines.

4.3 Full-process Evaluation Implementation Paths Supported by ChaoXing Learning

(1) Pre-class Preview Evaluation Stage

Teachers release micro-lesson videos, electronic courseware and preview quizzes as task points on the ChaoXing Learning. The platform automatically records students' video viewing progress and answers to preview exercises. The AI generates a preview learning situation report in advance, allowing teachers to identify common conceptual misunderstandings among students and adjust key and difficult teaching points for offline classes accordingly, realizing evaluation in advance. Pure video playback duration is not taken as the sole judgment criterion for preview quality; teachers integrate preview quiz accuracy to assess preview completion, eliminating the phenomenon of passively brushing task points.

(2) Real-time In-class Evaluation Integrating Offline Classroom and Platform

Offline classroom teaching adopts screen casting, in-class quizzes, rush-to-answer and voting functions of the Superstar Platform to carry out in-class interactions. Objective questions in in-class exercises are instantly graded by platform AI, outputting real-time answer accuracy to quickly identify common problems across the class. For in-class exercises involving theorem proofs and derivations, students upload responses to the Superstar Platform; the AI marks error segments in solutions, while teachers conduct offline classroom observations to document students' speculative performance and complete subjective in-class evaluation, achieving deep integration between online platform data and offline classroom teaching.

(3) After-class Consolidation Evaluation Stage

After-class homework and chapter tests are released on the Superstar Platform. Objective exercises are automatically graded by AI; for computational and proof-based subjective questions, the AI identifies solution steps and marks error locations, followed by secondary manual re-evaluation by teachers focusing on assessing students' problem-solving ideas and logical rigor. The platform automatically generates personal error archives for each student, with AI summarizing frequently missed knowledge points. Mathematical modeling and inquiry assignments are submitted via the platform's group task module, with the peer evaluation function activated for intra-group assessment, followed by final quality grading by teachers. Students may submit learning reflections on the platform to complete the self-evaluation component. Teachers regularly review learning situation early warnings on the platform and conduct timely communication and tutoring for students with declining learning status.

(4) Summative Final Evaluation Stage

Scores of the final examination are incorporated into comprehensive evaluation yet no longer serve as the sole assessment criterion. Final exam papers are imported into the Superstar Platform for paper analysis, with AI calculating score loss distribution across knowledge points to cross-verify with full-semester process data from the platform. Teachers generate overall comprehensive course grades by integrating full-process online platform data, offline classroom performance and final exam scores, and export complete evaluation archives from the Superstar Platform.

4.4 Two-way Dynamic Evaluation Feedback Closed Loop Supported by the Platform

Targeted at "promoting teaching and learning through evaluation", a two-way feedback channel for teachers and students is established.

- For teachers: The Superstar Platform regularly outputs class-wide learning situation analysis reports displaying weak knowledge points, stratified student groups and a list of students flagged by learning situation early warnings. Teachers reflect on teaching design based on the reports, adjust teaching rhythms, implement layered teaching and provide targeted support for students under early warning.
- For students: Students access personal learning profiles, error archives and evaluation feedback on the Superstar Platform terminal. The system pushes micro-lesson resources and variant exercises targeting weak knowledge points to guide students in reviewing errors; students also view teacher comments and feedback from self and peer evaluations to reflect on their own learning methods.

A complete closed loop is formed: data collection → AI analysis → multi-stakeholder evaluation → two-way feedback → teaching improvement.

4.5 Operational Guarantee Mechanisms for the System

(1) Capacity guarantee for teachers' information-based teaching: Train teachers on advanced applications of the ChaoXing Learning to improve their proficiency in utilizing learning situation reports, group peer evaluation and secondary re-grading of subjective assignments, establish the human-machine collaborative evaluation philosophy, and prohibit directly adopting raw AI grading results as final scores.

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(2) Data standardization and study style guarantee: Standardize assessment rules for Superstar Platform task points, clarifying that video viewing duration serves only as a reference while exercise quality and problem-solving logic act as core evaluation criteria to curb ineffective learning behaviors such as artificially brushing task point viewing hours.

(3) Institutional guarantee: Embed this multi-dimensional three-dimensional evaluation scheme into the curriculum syllabus, specify weight coefficients for each indicator and rules for utilizing Superstar Platform data, and solidify standardized implementation procedures to avoid arbitrary and formalized process evaluation.

(4) Data security guarantee: Strictly protect students' private learning data stored on the Superstar Platform, control access permissions for learning situation data, properly manage student learning archives and prevent information leakage.

V. PRACTICAL REFLECTIONS ON THE SYSTEM

Constructing the multi-dimensional three-dimensional teaching evaluation system for Advanced Mathematics supported by the ChaoXing Learning can fully exploit the platform's strengths in AI learning situation statistics, effectively alleviate teachers' heavy workload in process evaluation for large-sized classes, enable full-process retention of teaching data, and transform the traditional assessment model defined solely by one final exam. Nevertheless, several pitfalls must be avoided in practical implementation.

First, over-reliance on platform data must be avoided. Behavioral data recorded by the Superstar Platform such as task point viewing duration and class sign-ins only reflect tracks of learning behaviors rather than actual learning effectiveness. Some students hang videos in the background to artificially boost platform data yet demonstrate poor knowledge mastery; evaluation must integrate exercise performance and teachers' offline observations comprehensively.

Second, the limitations of platform AI must be recognized. For a large number of subjective proof questions and problems solvable via multiple approaches in Advanced Mathematics, the platform AI can only mark flawed solution steps and cannot fully evaluate the innovativeness of students' thinking. Manual secondary review by teachers must be retained for subjective assignments to adhere to human-machine collaboration.

Third, differentiated treatment should be provided to students with varying foundational levels. For underperforming students, evaluation should focus on progress margins to protect learning enthusiasm instead of judging purely by absolute scores. Meanwhile, the volume of platform tasks should be reasonably controlled to avoid imposing excessive online learning burdens on students, ensuring the online platform serves teaching rather than teaching being subordinate to platform tasks.

VI. CONCLUSION

Under the digital intelligent teaching environment, the ChaoXing Learning provides a practical carrier for reforms in multi-dimensional three-dimensional teaching evaluation of Advanced Mathematics with its functions including AI learning situation analysis, multi-source learning data archiving and multi-stakeholder task interaction. This research constructs a teaching evaluation system supported by the platform with four-party collaborative evaluation subjects and four-dimensional evaluation indicators, running through pre-class, in-class, after-class and final assessment stages. It realizes deep integration of process-based evaluation and summative evaluation, shifting the orientation of Advanced Mathematics curriculum evaluation from outcome-centeredness to full-process developmental orientation.

Technology is a means, while talent cultivation stands as the fundamental goal. In teaching practice, teachers should rationally utilize AI tools on the ChaoXing Learning, balance machine-generated data with teachers' professional judgment, continuously optimize evaluation indicators, break barriers between online and offline teaching, and consistently refine the digital intelligent evaluation model for Advanced Mathematics to better fulfill the fundamental task of fostering virtue through education and improve the teaching quality of public basic courses.

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