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Research on Empowering Mathematics Classrooms and Constructing an AI-Enhanced Teaching Evaluation System

Junyang Xia*

Jinhua Open University, Jinhua, Zhejiang, China

Author to whom correspondence should be addressed.

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Abstract: This paper focuses on AI technology empowering open education mathematics classrooms and the construction of a teaching evaluation system, which is oriented toward the digital empowerment of open education mathematics teaching applications. Aiming at the core problems of "evaluation failure" (adult learners are geographically dispersed and dominated by independent learning, while the traditional "one final examination determines the grade" model emphasizes results over processes and cannot capture learning trajectories) and "inefficient learning" (adult learners have weak mathematical foundations, heavy mathematics anxiety, and fragmented learning time, lacking personalized learning support and interesting learning scenarios) existing in open education mathematics teaching, this paper proposes AI-driven solutions and implementation paths. Specifically, it includes constructing a "cognition-behavior-emotion" multimodal evaluation system integrating learning behavior analysis, homework trajectory analysis, and emotion state identification to drive the reform of educational evaluation; creating a learning ecology of "game clearance + adaptive push" to support learners' personalized learning through the development of mathematical mini-games and collaborative learning communities; meanwhile, building a dedicated data middle platform for the mathematics discipline with student portraits, a teaching strategy library, and a learning early-warning mechanism to realize tool collaboration and data closed-loop. The research aims to break through the bottleneck of traditional open education teaching, improve teaching quality and course pass rate, promote learners' all-round development through the deep integration of AI technology and open education mathematics teaching, and provide theoretical and practical references for the modernization reform of open education and the AI-empowered education teaching reform.

Keywords: AI technology; Open education; Mathematics classroom; Teaching evaluation system

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1. Introduction

Under the global wave of digitalization, artificial intelligence technology has deeply integrated into all fields of society with an unprecedented momentum, and the education field has also ushered in unprecedented

opportunities for reform [1]. As an important support of the lifelong education system, open education mainly serves working adults and undertakes the mission of serving lifelong learning for all. As a basic discipline with strong logic and high abstraction, the improvement of mathematics teaching quality and the perfection of the evaluation system are crucial to cultivating learners' thinking ability, application ability, and core literacy.

Different from full-time school education, learners in open education are mostly working adults who are geographically dispersed, rely mainly on online independent learning, and have obviously fragmented learning time. The traditional mathematics classroom teaching mode is often teacher-centered, with learners in a passive state of receiving knowledge, lacking teaching interaction, and making it difficult to fully stimulate learners' learning interest and initiative. Meanwhile, the traditional teaching evaluation system has obvious limitations, paying too much attention to result evaluation such as final examination scores, ignoring process performance such as learners' thinking trajectories and emotional attitudes in the learning process, leading to evaluation failure and being unable to provide an accurate and effective basis for teaching improvement.

Against this background, under the framework of the school's quality professional group construction "unveiling and commanding" action and oriented to the achievement project of digital empowerment of open education mathematics teaching application, this research focuses on the construction of an AI technology-empowered open education mathematics classroom and teaching evaluation system. By deeply analyzing the core problems existing in current open education mathematics teaching, this paper explores how to deeply integrate AI technology with open education mathematics teaching and build a scientific and efficient teaching evaluation system, covering AI-empowered teaching innovation, AI-supported personalized learning, and AI-driven educational evaluation reform, so as to break through the bottleneck of traditional teaching, improve mathematics teaching quality, and promote learners' all-round development [2].

The theoretical significance of this research lies in enriching and developing the interdisciplinary research of educational technology and open education, filling the gap in process evaluation research in open education mathematics teaching, and providing a new theoretical perspective and practical paradigm for the application of AI technology in adult distance education. The practical significance lies in providing front-line teachers of open education with operable teaching modes and evaluation tools, helping to improve teachers' teaching efficiency and digital literacy; meanwhile, it can provide learners with personalized learning support and scientific evaluation feedback, alleviate mathematics anxiety, cultivate independent learning ability, and promote the modernization reform of open education.

2. Core problems existing in open education mathematics teaching

2.1. Evaluation failure: Traditional evaluation "emphasizes results over processes," making it difficult to capture learning trajectories

Open education mathematics evaluation has long been plagued by the drawback of "emphasizing results over processes." Learners are scattered in different regions and mostly learn independently online, while the focus of evaluation is mainly on the results of final examinations and homework scores [3]. This evaluation method cannot comprehensively record and analyze learners' learning processes, and cannot identify learning difficulty nodes and thinking obstacles. Relevant survey data show that more than 65% of teachers evaluate students only by homework and final examinations. Facing a large number of dispersed adult learners,

teachers are unable to perceive the "falling behind" signals in the learning process in time, resulting in the failure of timely intervention for at-risk learners.

Taking the online teaching of the unit "Concept of Limit" in the course "Advanced Mathematics" of an open university as an example, the learning platform logs show that some learners repeatedly paused and replayed the micro-lecture videos of key knowledge points, made repeated mistakes in the same type of exercises, and rarely participated in forum discussions. However, under the traditional evaluation model, the teacher could only see the cold final scores, could not perceive these obvious learning difficulties, and the intervention for at-risk learners often came too late.

Similar dilemmas are also common in other mathematics courses of open education, such as Linear Algebra and Probability and Statistics. The pass rate of open education mathematics courses is generally lower than that of humanities courses. The "one final examination determines the grade" evaluation mode further weakens learners' learning motivation, forms a vicious circle of "unpaid process → poor results → heavier anxiety," and seriously restricts the improvement of open education talent cultivation quality.

2.2. Inefficient learning: Adult learners lack intelligent support in independent learning, limiting learning confidence and persistence

Open education learners are mostly working adults with weak mathematical foundations, strong fear of difficulty, and fragmented learning time. Traditional mathematics learning activities face many problems in the implementation process, resulting in poor independent learning effect [4]. Due to the lack of timely feedback and intelligent guidance in the online learning environment, learners often fall into a "stuck" state when encountering problems, and it is difficult to obtain effective help in time, resulting in frustration and even learning abandonment.

Taking the unit "Linear Equation with One Variable" as an example, in the traditional online homework arrangement, learners can only passively complete the exercises; teachers cannot grasp learners' problem-solving ideas, time consumption, and error types, and homework feedback often lags behind for several days. Some adult learners study in fragmented evening time. When their questions cannot be answered in time, they gradually lose learning confidence, and their learning persistence is difficult to guarantee.

On the other hand, the lack of interaction in distance learning also limits the development of learners' cooperative inquiry ability to a certain extent. Open education learners are physically dispersed, lack face-to-face communication scenarios with classmates and teachers, and online discussions are often mere formalities. Learners' innovative ability and team spirit are difficult to cultivate, and the learning atmosphere and emotional support of the learning community are obviously insufficient.

3. AI-driven solutions and implementation paths

3.1. Constructing a "cognition-behavior-emotion" multimodal evaluation system to solve "evaluation failure"

Process Capture: To achieve comprehensive capture of learners' learning process, this research plans to develop an AI learning analysis system integrating three modules, so as to realize the transformation of open education mathematics evaluation from "result orientation" to "process orientation" and drive the reform of educational evaluation.

The learning behavior analysis module is based on the LSTM (Long Short-Term Memory) neural

network, which analyzes learners' online learning trajectories such as video watching, homework submission, and forum discussion, identifies learning engagement and weak knowledge points, and provides data support for process evaluation [5].

The homework trajectory analysis module has developed a mathematics-specific AI engine, which parses learners' solution paths and mind map logic chains, captures the mathematical thinking process, and locates conceptual understanding deviations, so that evaluation can reach the level of thinking.

The emotion state recognition module indirectly infers learners' learning interest and anxiety levels based on learning behavior data, and generates learning state early warnings, making up for the deficiency that open education cannot directly observe learners' emotional states.

On this basis, the system automatically generates the "Personalized Learning Diagnosis Report," which is visually presented on both the learner side and the teacher side. Learners can clearly understand their own weak knowledge points and learning states, and teachers can grasp the learning situation of the whole class and each learner as a whole, so as to achieve precise teaching.

Dynamic Evaluation Model Training: To improve the accuracy and scientificity of evaluation, this research adopts the TensorFlow framework to build a dynamic evaluation model and determines the weights of multi-dimensional indicators of cognition, behavior, and emotion through expert consultation. In view of the characteristics of open education, process data such as video watching, discussion participation, and game completion are given higher weights, so that evaluation can truly reflect the learning process of adult learners.

Application Process: The application process of the AI learning analysis system is clear and efficient. Firstly, it collects data such as video watching, homework, discussion, and game clearance; secondly, the AI engine analyzes and generates diagnosis reports; thirdly, teachers intervene with at-risk learners in a targeted manner according to the early warning information, and learners adjust learning strategies according to the reports; finally, the intervention effects are fed back into the model to realize the dynamic iteration of evaluation. Taking the evaluation of "probability model construction" as an example, the system can automatically identify learners with obstacles in the concept of classical probability according to wrong answers and playback trajectories, and push targeted micro-lectures and exercises to achieve timely intervention.

3.2. Creating "game clearance + adaptive push" inquiry ecology to support "personalized learning"

Developing Mathematical Mini-Games: To stimulate learners' learning interest and alleviate mathematics anxiety, this research has developed a WeChat mini-program-based mathematical gamified learning platform [6]. Mathematical knowledge points are embedded in clearance mini-games, so that learners can study in fragmented time, which greatly lowers the learning threshold and reduces the fear of difficulty.

For example, after learning "Linear Equation with One Variable," push the "Equation Treasure Hunt" game. In the game, learners need to list linear equations to solve problems such as "chicken and rabbit in the same cage" to unlock new levels. The system records the time consumption and error types of each level in real time, and the gamified incentive mechanism significantly improves the learning persistence of adult learners.

Adaptive Push Module: Based on the evaluation data of the multimodal evaluation system, the module intelligently pushes personalized learning resources and exercises, realizing "one thousand learners with one

thousand faces." Learners with weak foundations are pushed with basic micro-lectures and low-difficulty games, while learners with strong abilities are pushed with extended challenge tasks, so that learners at different levels can gain a sense of achievement.

Collaborative Learning Module: An online learning community has been set up to support group discussion and mutual problem-solving, making up for the lack of interaction in distance learning. At the same time, learners are encouraged to participate in the development of mathematical mini-games, so that learners can deeply understand mathematical knowledge through collaborative knowledge creation. In this process, learners can not only improve their ability to apply mathematical knowledge, but also cultivate team spirit and innovative ability.

Application Mode: Adopt the application mode of "after-class push → learner clearance (record time consumption and error type of each level) → data into the evaluation system → adaptive adjustment of difficulty and resources → stage certification." The learning data generated in the game flows into the evaluation system in real time, becoming an important source of process evaluation, and the two systems promote each other to form a joint force.

3.3. Building a data middle platform to realize tool collaboration and data closed-loop

Construct a data middle platform architecture, integrate the data of the evaluation system and the gamified learning platform, and form a dedicated data middle platform for mathematics discipline. The middle platform includes three core components: student portrait library, teaching strategy library, and learning early-warning mechanism.

The student portrait library summarizes various behavior data of learners, such as video watching trajectory, homework quality, game clearance trajectory, and forum participation, forming multi-dimensional learner portraits to support precise teaching and personalized services.

Based on AI cluster analysis technology, the teaching strategy library generates more than 30 types of strategy templates for typical learning situations, such as "Adult Learners with Weak Foundation," "Learners with High Anxiety Level," and "Learners with Insufficient Learning Time," providing a reference for teachers' teaching decision-making.

The learning early-warning mechanism sets risk warning indicators such as "no login for consecutive days," "homework quality decline," and "clearance stagnation," and pushes warning information to teachers in real time, so that teachers can intervene in at-risk learners in time. In terms of technical support, Hadoop is used for data storage, which has the characteristics of high reliability, high scalability, and low cost, ensuring the stable operation of the middle platform, and finally realizing the data closed-loop of "evaluation data → personalized push → learning behavior → optimized evaluation."

4. Conclusion and outlook

This research focuses on the core topic of AI technology empowering open education mathematics classroom and teaching evaluation system construction, deeply analyzes the core problems of "evaluation failure" and "inefficient learning" in open education mathematics teaching, and systematically expounds the AI-driven solutions and implementation paths, which correspond to the achievement project of digital empowerment of open education mathematics teaching application under the school's "unveiling and commanding" action, covering AI-empowered teaching innovation, AI-supported personalized learning, and AI-driven educational

evaluation reform. The research plan is divided into four stages:

Stage 1: Complete demand analysis and system design. Form a professional research team, including mathematics education experts, AI technology experts, and front-line teachers of open education, and complete the overall design of the AI learning analysis system, the gamified learning platform, and the data middle platform.

Stage 2: Carry out system development and data set construction. According to the design scheme, develop the AI learning analysis system and the mathematical mini-game WeChat mini-program, and construct the learning behavior data set to provide data support for model training.

Stage 3: Carry out system testing and optimization. Invite front-line teachers and learners to conduct comprehensive testing, optimize the accuracy of evaluation models and the playability of games, and improve system stability and user experience.

Stage 4: Carry out teaching practice and effect evaluation. Apply the optimized system to the actual open education mathematics teaching of experimental classes, and carry out comparative experiments with control classes to verify the actual effect of the system.

Develop and complete the "cognition-behavior-emotion" multimodal evaluation system, including the AI learning analysis system and the dynamic evaluation model, and generate personalized learning diagnosis reports for both learners and teachers, so as to realize the reform of educational evaluation driven by artificial intelligence.

Build a gamified mathematics learning platform based on WeChat mini-program, develop at least 10 mini-games related to mathematics knowledge points, covering the core mathematics knowledge of open education courses, so that adult learners can learn efficiently in fragmented time and obtain personalized learning support.

Construct a dedicated data middle platform for the mathematics discipline, including a student portrait library, a teaching strategy library (more than 30 types of strategy templates), and a learning early-warning mechanism, so as to realize the data closed-loop of "evaluation → push → learning → optimization."

Form a series of research results, including 1 research report detailing the research process, results, and conclusions, academic papers, and 1–2 software copyrights, forming a replicable open education digital teaching mode, which can be promoted to the provincial open education system and other science courses.

It is expected that through teaching practice, the pass rate of mathematics courses in experimental classes will increase by more than 15% compared with control classes, learners' learning satisfaction will reach more than 85%, mathematics anxiety will be significantly alleviated, and learning persistence will be significantly improved. In the future, with the continuous development of large model technology, the research results will be further extended to intelligent tutoring and learning companionship, providing solid support for the construction of a lifelong learning society.

Disclosure statement

The author declares no conflict of interest.

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