Research on the Exploration and Practice of AI Video Analysis Assisting the Improvement of Teaching Quality in Colleges and Universities

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Abstract: With the rapid development of artificial intelligence technology, the application of AI video analysis in the field of education has gradually become an important direction of teaching reform. This paper focuses on the reform of teaching quality in colleges and universities, and deeply explores the application and practice of AI video analysis in improving teaching quality. By introducing the technical foundation of AI video analysis and combining theoretical foundations such as the S-T Teaching Analysis Method, Bloom's Taxonomy of Educational Objectives, McCarthy's 4MAT Question Model, and the Learning Pyramid Model, this paper elaborates on the specific application practices of AI video analysis in teaching situation analysis, learning situation analysis, and classroom analysis. The research results show that AI video analysis technology can accurately quantify the teaching process, provide objective and fair evaluation, realize panoramic data collection and multi-dimensional display, thereby providing strong support for the adjustment of teaching strategies and the optimal allocation of teaching resources, and promoting the continuous improvement of teaching quality.

Keywords: AI Video Analysis; Teaching Quality Improvement; Teaching Evaluation

1. Introduction

In the current era of rapid technological development, artificial intelligence has deeply penetrated into various fields of society, and the education field is also undergoing profound changes[1]. In recent years, the successive introduction of policies such as the "Overall Plan for Deepening the Reform of Educational Evaluation in the New Era" has clarified the development direction and evaluation standards of colleges and universities, emphasizing the improvement of professional practical capabilities and precise teaching evaluation. However, the traditional teaching model faces many challenges in improving teaching quality, such as the difficulty in accurately quantifying the teaching process and the strong subjectivity of teaching evaluation. Against this background, AI video analysis technology, with its powerful functions such as data analysis and real-time monitoring, has brought new opportunities for the improvement of teaching quality in colleges and

universities[2].

AI video analysis can not only accurately quantify the teaching process and objectively evaluate the teaching effect, but also collect teaching data in a panoramic manner and realize multi-dimensional analysis, providing a strong basis for the adjustment of teaching strategies and the optimal allocation of teaching resources. This research aims to explore the specific application of AI video analysis technology in the teaching process of colleges and universities. Through in-depth analysis of each link in the teaching process, it reveals the mechanism of this technology in improving teaching quality, solves problems existing in traditional teaching such as the difficulty in accurately evaluating teaching quality and the difficulty in targeted optimization of teaching methods, and provides scientific basis and practical guidance for teaching reform.

2. Technical Principles of AI Video Analysis

AI video analysis technology relies on cutting-edge artificial intelligence technology systems such as computer vision, natural language processing, and deep learning. By extracting, identifying, and analyzing information such as images and sounds in teaching videos, it realizes intelligent monitoring and evaluation of teachers' and students' behaviors and teaching activities in the teaching scenario.

2.1. Computer Vision (CV)

Computer vision is a core component of AI video analysis technology. By simulating the human visual system, it enables computers to understand and interpret the content in images and videos. In the teaching scenario, face recognition technology can be used to identify and analyze students' attendance; behavior analysis technology can judge students' classroom participation. By recognizing information such as students' facial expressions, body movements, and postures, it captures non-verbal behavior signals of students in the classroom, such as concentration and interest, providing rich data support for teaching analysis[3].

2.2. Natural Language Processing (NLP)

Natural language processing technology is mainly used to process the voice and text information in teaching videos in AI video analysis. It can convert voice information such as teachers' explanations and students' speeches into text and conduct semantic analysis. For example, through the transcription and analysis of teachers' teaching voices, key content of the course and question-asking situations can be extracted; through the analysis of students' classroom speeches, the activity of students' thinking and their mastery of knowledge can be understood, thereby providing a more comprehensive basis for the evaluation of teaching effects.

3. Theoretical Foundations

In the process of teaching reform in colleges and universities, the practice of optimizing teaching with the help of AI video analysis technology is not groundless. It is supported by solid and diverse theoretical foundations. These theories provide ideas and methods for teaching analysis from different perspectives, helping us deeply understand the teaching process, accurately evaluate the teaching effect, and point out the direction for the adjustment of teaching strategies.

3.1. S-T Teaching Analysis Method

The S-T Teaching Analysis Method is based on teaching behavior data, which quantifies student behavior (S) and teacher behavior (T). It judges the type of teaching model by calculating the teacher behavior occupancy rate (Rt) and the behavior conversion rate (Ch)[4]. The application of the S-T Teaching Analysis Method in AI video analysis can accurately calculate the Rt and Ch values through the identification and statistics of teachers' and students' behaviors in teaching videos,

helping teachers understand their own teaching models, evaluate teaching effects, and provide a scientific basis for the adjustment of teaching strategies.

3.2. Bloom's Taxonomy of Educational Objectives

Bloom's Taxonomy of Educational Objectives divides educational objectives into three domains: cognitive, affective, and psychomotor. Among them, the "cognitive level" is divided into memory, understanding, application, analysis, evaluation, and creation from low to high. In AI video analysis, with reference to Bloom's "cognitive level" classification, the types of questions raised by teachers in teaching videos are classified. This helps teachers understand whether their questioning strategies are reasonable and whether they cover cognitive objectives at different levels, thereby adjusting teaching methods and promoting the all-round development of students' cognitive abilities.

3.3. McCarthy's 4MAT Question Model

McCarthy's 4MAT Question Model divides questions into four types, namely the "Four What Questions": "What is it" questions that point to factual knowledge, "Why is it" questions that point to principled knowledge, "How to do it" questions that point to strategic knowledge, and "What if" questions that point to transferable knowledge. By applying this model in AI video analysis, the frequency of different types of questions raised by teachers, as well as key data such as the accuracy rate of students' answers, answer duration, and thinking time, are counted, providing more comprehensive and in-depth teaching feedback for teachers and students.

4. Application Practice of AI Video Analysis in Teaching Reform

This research adopts the case analysis method, selecting a normal class of the "Linear Algebra" course in Minjiang University as the research object, and uses AI video analysis technology to record and analyze the entire teaching process. Combining the above theoretical foundations, the course research team has actively explored and practiced, deeply integrating these theories with AI video analysis technology, and carried out the following innovative and practical applications:

4.1. Teaching Situation Analysis

4.1.1. Teacher's Speech Rate Analysis - Optimizing Teaching Rhythm and Improving Knowledge Absorption Efficiency

Whether the teacher's speech rate is reasonable and scientific directly affects the teaching effect. Generally speaking, the recommended standard average speech rate for teaching is 200-250 words per minute. A too fast speech rate will leave students with insufficient time to think, absorb, and memorize knowledge, thereby affecting the learning effect; a too slow speech rate may cause students to lose focus and reduce classroom efficiency. The AI video analysis system counts the teacher's average speech rate through language recognition and analysis. Based on the data feedback, combined with factors such as the actual age of the teaching objects and the teaching content, teachers can reasonably adjust the speed of their teaching language, thereby optimizing the teaching rhythm and ensuring that students can absorb knowledge more effectively.

4.1.2. Teacher's Questioning Analysis - Optimizing Questioning Strategies and Promoting the Cultivation of In-depth Thinking Abilities

In order to conduct an in-depth and comprehensive analysis of the actual effectiveness of teachers' questioning in teaching, the AI video analysis system identifies and counts the frequency, content, and types of questions raised by teachers in the classroom. It also incorporates Bloom's Taxonomy of Educational Objectives and McCarthy's 4MAT Question Theoretical Model to perform multi-dimensional analysis. By classifying and counting these questions, the system determines the

quantitative distribution of different types of questions. This enables the assessment of whether teachers ask questions effectively in alignment with teaching objectives and whether they reasonably guide students to engage in thinking that corresponds to the intended teaching goals. If it is found that the proportion of questions related to a specific cognitive level or a certain type of knowledge is relatively low, teachers can adjust their questioning strategies in a targeted manner and increase the design of relevant questions, thereby promoting students' in-depth thinking.

4.1.3. Teacher's Vocabulary Analysis - Standardizing Language Expression and Improving the Accuracy of Content Expression

In order to comprehensively evaluate the effect of teachers' language use in classroom teaching, the AI video analysis system conducts an in-depth analysis of teachers' vocabulary from two key dimensions: high-frequency words and modal particles. By counting and analyzing high-frequency words, it is judged whether the classroom teaching is closely centered on the established teaching objectives and teaching focuses. By counting and analyzing modal particles, it is judged whether teachers overuse ineffective high-frequency modal particles or pet phrases, thereby urging teachers to consciously control the frequency of using modal particles, improve the standardization and professionalism of language expression, and ensure the accuracy of teaching content.

4.1.4. Teacher's Behavior and Trajectory Analysis - Balancing Spatial Attention and Optimizing Teaching Interaction Modes

Teacher's behavior analysis covers many behaviors such as stating questions, moving around, writing on the blackboard, going up to the platform, and coming down from the platform. These behaviors directly reflect the activity mode and teaching method of teachers in the teaching process. The AI video analysis system can identify and count various behaviors of teachers, providing key reference bases for the subsequent optimization and improvement of teaching strategies. At the same time, the system can record the number of times the teacher patrols, the duration of patrolling, and the time spent teaching on the platform, and form a point map of the teacher's activity trajectory. The coverage of the teacher's trajectory largely reflects whether the teacher makes full use of the classroom space and whether the attention to all students is balanced. (**Figure 1**)
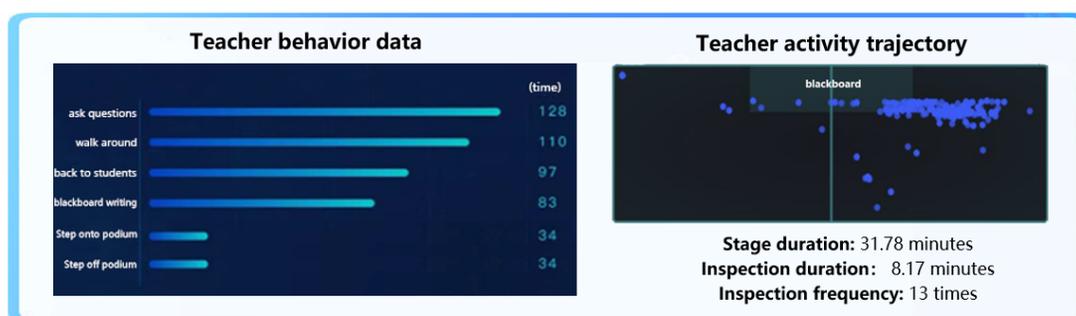

Figure 1. Teacher's Behavior and Trajectory Analysis

4.2. Learning Situation Analysis

4.2.1. Students' Attendance Rate Analysis - Accurate Attendance and Improving the Efficiency of Student Attendance Management

The attendance rate is an important indicator to measure students' attendance, which directly reflects students' attention to the course and their participation in teaching activities. The AI video analysis system adopts the "non-sensing attendance" method through face recognition technology. Without the need for students to take the initiative to operate, the system will automatically complete the dynamic attendance record during the students' class. This not only reduces the queuing time and human errors caused by traditional attendance methods (such as signing in, swiping cards, etc.), but also can identify

the identity information of students in the classroom and compare it with the class student list, improving the accuracy of attendance and the efficiency of student attendance management.

4.2.2. Students' Front-row Seating Rate Analysis - Stimulating the Willingness of Active Learning and Enhancing the Effectiveness of Classroom Interaction

The front-row seating rate reflects students' willingness and attitude to actively participate in the classroom and actively acquire knowledge. The AI video analysis system counts the number of students in the front-row seats and calculates the front-row seating rate by identifying the classroom seating area and detecting the students' positions. Generally speaking, students in the front row are more likely to have eye contact and interaction with the teacher, can see the teaching display content more clearly, and their learning enthusiasm and participation are relatively higher. By analyzing the front-row seating rate, teachers can take measures to encourage students to actively participate in the classroom and improve their learning initiative.

4.2.3. Students' Head-up Rate Analysis - Monitoring Students' Concentration and Optimizing Teaching Design

The students' head-up rate can directly reflect the degree of students' attention in the classroom to a certain extent. The AI video analysis system identifies the students' head posture. When the student's head is in a normal raised state and faces the teacher or the teaching display area, it is determined as a head-up state, and the head-up rate is calculated based on this. The system generates a head-up rate analysis curve for the entire class according to the preset analysis granularity (such as analyzing once every 5 seconds), helping teachers understand the periods when students' concentration is focused or distracted. At the same time, by calculating the concentration (number of students with heads up) and the degree of concentration (number of students with heads up/total number of attending students), the system provides a concentration curve, providing teachers with more comprehensive classroom concentration data. (**Figure 2**)
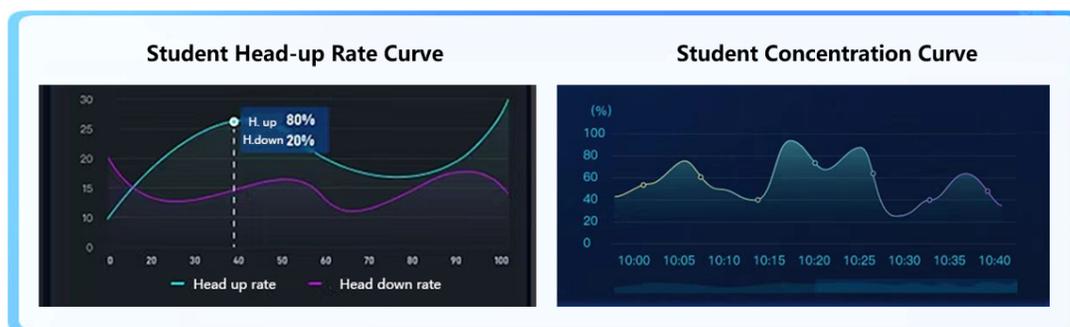

Figure 2. Students' Head-up Rate and Concentration Curve

4.3. Classroom Analysis

4.3.1. Analysis of the Proportion of Teaching Subject Behaviors - Balancing Teaching Interaction and Optimizing Classroom Structure

In the teaching process, teacher behaviors mainly include teacher lecturing, teacher questioning, writing on the blackboard, teacher patrolling, multimedia operation, etc., while student behaviors include teacher-student interaction, student presentations, student-student interaction, etc. The AI video analysis system makes accurate judgments and in-depth comprehensive analysis on the two video images recording the teacher's panorama and the student's panorama, counts the duration of various behaviors, and forms an analysis chart of the proportion of teaching subject behaviors. Through this analysis chart, teachers can intuitively understand the proportion of the duration of various teaching behaviors in the classroom. If it is found that there is a deviation in the proportion of the duration of certain behaviors, such as the teacher's lecturing time is too long while the students' interaction time is insufficient, teachers can adjust the duration of teaching behaviors, optimize the teaching design, balance classroom interaction and knowledge imparting, thereby improving the teaching quality.

4.3.2. S-T Teaching Analysis - Accurately Evaluating Teaching Models and Optimizing Teacher-student Interaction

The AI video analysis system automatically samples the classroom content in detail at a preset fixed interval of 5 seconds. At each sampling point, according to the subject and type of behavior, it is recorded with the symbol S (representing student behavior) or T (representing teacher behavior), forming S-T time series data and drawing an S-T chart. (**Figure 3**) The proportion of teacher and student activities in the classroom is judged according to the deviation of the curve. When the curve deviates towards the T-axis, it indicates that teacher activities are in the majority; when the curve deviates towards the S-axis, it indicates that student activities are in the majority; when the curve is generally parallel to the 45-degree line, it indicates that teacher-student interaction is sufficient and the participation of both parties is basically balanced. Through S-T teaching analysis, teachers can accurately evaluate the teaching model and optimize teacher-student interaction.
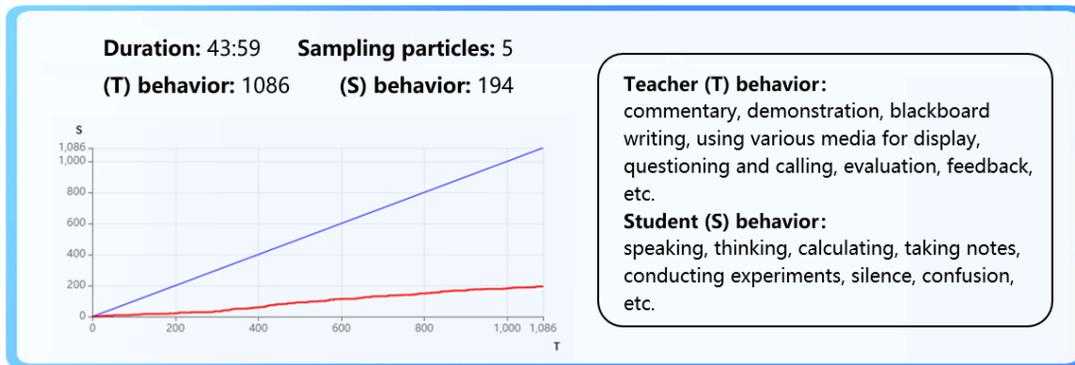

Figure 3. S-T Teaching Analysis

4.3.3. RT-Ch Teaching Analysis - Quantifying Interaction Modes and Optimizing Teaching Interaction Rhythm

On the basis of S-T teaching analysis, the Rt (teacher behavior occupancy rate) and Ch (behavior conversion rate) indices are calculated to further understand the interaction mode and interaction rhythm between teachers and students in the teaching process. The Rt index represents the proportion of teacher behavior (T) in the teaching process, and a larger value indicates more teacher behaviors. The Ch index represents the ratio of the number of conversions between teacher behavior (T) and student behavior (S) to the total number of behavior samples, and a larger value indicates more conversions between teacher and student behaviors. According to the Rt and Ch indices, the teaching models can be divided into the following four types: exercise type, lecture type, dialogue type, and mixed type. Through real-time monitoring and calculation, the AI video analysis system will determine which teaching mode the class tends to on the Rt-Ch chart, providing teachers with intuitive teaching behavior analysis. (**Figure 4**)
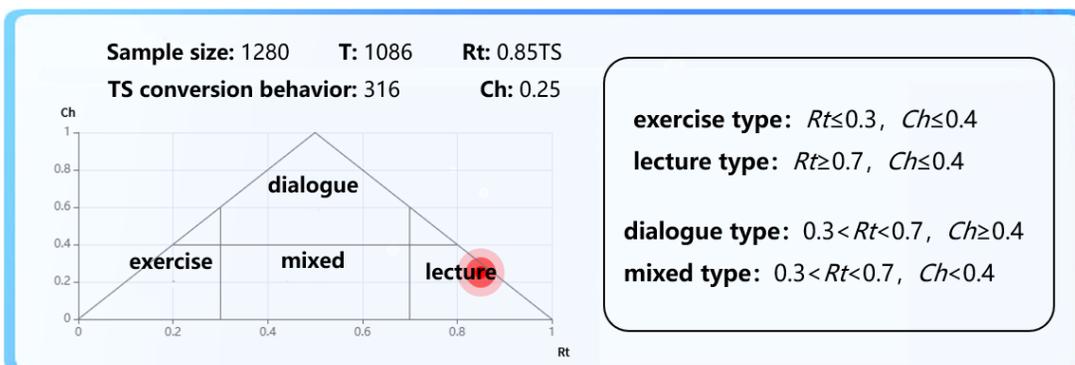

Figure 4. RT-Ch Teaching Analysis

4.3.4. Summary of Teaching Content Transformation - Generating Multi-dimensional Learning Resources and Assisting the Structured Construction of Knowledge Systems

AI video analysis technology uses an advanced speech recognition model to transcribe the classroom teaching audio and generate a detailed text record. On this basis, the AI system further extracts the teaching summary and accurately refines the core points of the course. These summaries not only cover key knowledge points, but also are presented in a concise form, facilitating students to quickly grasp the key points of the course. At the same time, AI video analysis can also generate learning resources such as knowledge mind maps and question chains. The knowledge mind map presents the structure and connection of teaching content in a visual way, helping students build a systematic knowledge system. The question chain generates a series of related questions around the teaching content, guiding students to think in depth and explore, and enhancing the initiative and depth of learning.

4.3.5. Generation of Teaching Evaluation and Teaching Suggestions - Providing Data-driven Feedback and Assisting the Iterative Improvement of Teaching

Relying on the powerful data analysis capability of the AI video analysis system, the system conducts a comprehensive and in-depth analysis of the overall teaching quality of each video-analyzed class based on the multi-dimensional data mentioned above, including teaching situation analysis, learning situation analysis, and classroom analysis. The system comprehensively considers the teacher's teaching performance, such as whether the speech rate is properly controlled, whether the questions are accurate and effective, and whether the vocabulary use is standardized and reasonable, as well as the students' learning status, including attendance rate, head-up rate, and behavior performance. Using a scientific algorithm model, it assigns an objective and fair score to the course. At the same time, the system also provides highly targeted teaching suggestions for each specific part of the teaching process.

5. Conclusion

The research shows that AI video analysis technology has significant application value in the teaching reform of colleges and universities. It can accurately quantify the teaching process and provide objective data support for the improvement of teaching quality; realize panoramic collection and multi-dimensional display, helping teachers fully understand the teaching situation and optimize teaching strategies; through real-time feedback and continuous monitoring, timely find and adjust problems in teaching, and improve teaching quality; the visualized and quantifiable index early warning realizes the all-round and refined digital supervision work of "supervising teaching, supervising learning, and supervising management". Although AI video analysis technology has achieved certain results in teaching reform, it still faces some challenges. For example, the scientificity of the theoretical model needs to be further improved, and the granularity of teaching behavior recognition needs to be more refined. In the future, with the continuous development and improvement of technology, AI video analysis technology is expected to play a greater role in the teaching reform of colleges and universities, providing stronger support for the cultivation of high-quality applied talents.

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