Practical exploration of artificial intelligence-empowered hybrid 5E teaching mode

Abstract: The rapid development of artificial intelligence has given rise to a series of new teaching models supported by artificial intelligence, including the hybrid 5E teaching model, smart teaching platform and information-based teaching environment. Artificial intelligence-based hybrid 5E teaching mode, 5E is Engage, Explore, Explain, Elaborate, EvaluateIt is a new teaching mode that is student-centered, self-directed learning as the main line, and characterized by multiple interactions, which is conducive to promoting the individualized development and all-round development of students.

Teachers' digital and intellectual literacy training

Digital literacy is a comprehensive concept that integrates "digital literacy" and "intelligent literacy", which mainly refers to the knowledge, skills, attitudes and values that individuals or groups possess in the environment of digital technology and intelligent technology, so as to effectively respond to and adapt to the needs of a digital and intelligent society.

Build an online smart class system

In the 5E teaching model, artificial intelligence is an important means of support. With the help of artificial intelligence, teachers can build online teaching resources based on technologies such as knowledge graph and data mining, and provide accurate learning path guidance and learning resource push according to students' different learning stages and personalized needs, so as to improve learning effectiveness.Figure 1 shows the construction of online teaching resources.

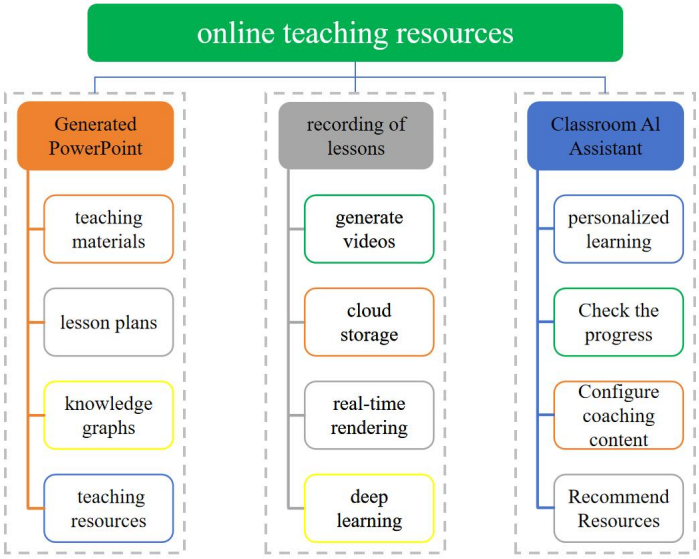

Fig 1 Construction of online teaching resources

Intelligently Generated PowerPoint: Intelligently generated PowerPoint can combine

efficient content generation, professional design capabilities, and flexible usage scenarios to help teachers quickly produce high-quality presentations. It not only saves time and energy, but also improves the effect and attractiveness of the presentation, teachers upload the electronic version of the teaching materials, lesson plans, knowledge graphs, teaching resources, one-click intelligent generation of multi-mode editable PPT, teachers can choose multiple templates for editing.

Building digital teachers: With the development of the digital age, technological advancements will have a great impact on the education industry and teaching models, and digital teachers will inevitably become the standard for the next generation of teachers and students.

Intelligent recording of lessons: The system can automatically generate videos by combining the digital teacher with the intelligently generated PPT. Teaching content is easy to update, through cloud storage and real-time rendering technology, teachers can modify or add knowledge points at any time, and the updated video can be generated within a few minutes. Through deep learning technology, digital teachers can highly restore the teacher's image, voice and movements, and can even adjust their expressions and body language according to the teaching content, which greatly improves the immersion of teaching. Digital teachers can also design diversified teaching scenarios according to the teaching content, such as history class traveling through time and space, science class simulation experiments, etc., to create a new learning experience for students.

To achieve high-fidelity restoration and real-time interactive teaching by digital instructors, several key technical processes rooted in deep learning are essential. Initially, high-precision 3D scanning with Artec Eva and multi-view cameras is employed to capture visual data of instructors. Concurrently, Vicon, a motion capture system, is utilized to record gestures and subtle facial expressions, while Neumann U87, a high-fidelity microphone, is used for capturing voice samples. The acquired data undergo preprocessing steps such as cleaning, normalization, and feature extraction. Simultaneously, a knowledge atlas of the teaching environment is developed, drawing from educational materials, instructional videos, and expert insights. This knowledge atlas is established through ontology definition and relationship extraction. Subsequently, teacher poses are parameterized based on the SMPL model.

$$M(\beta,\theta,\psi) = W(T(\beta,\theta,\psi), J(\beta), \theta, W) \quad (1)$$

The body shape parameter is denoted by β, the joint angle by θ, the facial expression parameter by ψ, and W represents the skin function utilized for image synthesis. To attain high-fidelity dynamic images, StyleGAN3 and Neural Radiance Fields (NeRF) are employed. The equation governing expression control is referred to as Eq. (2).

$$E(\mathrm{t}) = \mathrm{Transformer}(\mathrm{Q(text)}, \mathrm{K(emo)}, \mathrm{V(face)}) \quad (2)$$

Q is encoded by CLIP, with emoticon key-value pairs (K,V) sourced from the emotion classification dataset.

Speech synthesis follows a hierarchical speech generation model incorporating

phoneme duration prediction. DiffWave enhances the model for waveform generation, and the framework of stochastic differential equations is integrated to guarantee generation stability. The stochastic differential equation form is:

$$dx_t = f(x_t, t)d_t + g(x_t, t)dW_t \quad (3)$$

Conduct action generation and use Transformer to identify high-level intentions

$$A(t^{(high)}) = soft\max(QK^T / \sqrt{d})V \quad (4)$$

Q comes from text semantics, K/V comes from action library encoding

Subsequently, physical constraints are imposed to enhance the underlying motion, followed by multi-modal fusion. Graph Attention Networks (GAT) are utilized to synchronize the generation of different modes. Subsequently, system optimization is conducted. Neural Architecture Search is employed to autonomously design the architecture of each module, while the EWC algorithm is utilized to mitigate catastrophic forgetting. Lastly, performance metrics are assessed.

dimension	index	Target value
Visual authenticity	FVD (Frechet Video Distance)	< 25.0
Speech naturalness	MOS (Mean Opinion Score)	> 4.3/5.0
Rationality of action	Gesture-BERT Similarity	> 0.82
System latency	End-to-end build latency	< 200ms

Next, we discuss the implementation of a Progressive Training strategy, where each subsystem undergoes individual optimization followed by joint fine-tuning through comparative learning. The final rendering optimization is carried out in collaboration with Unreal Engine during deployment. Figure 2 illustrates the essential technical process of developing digital teachers using deep learning.

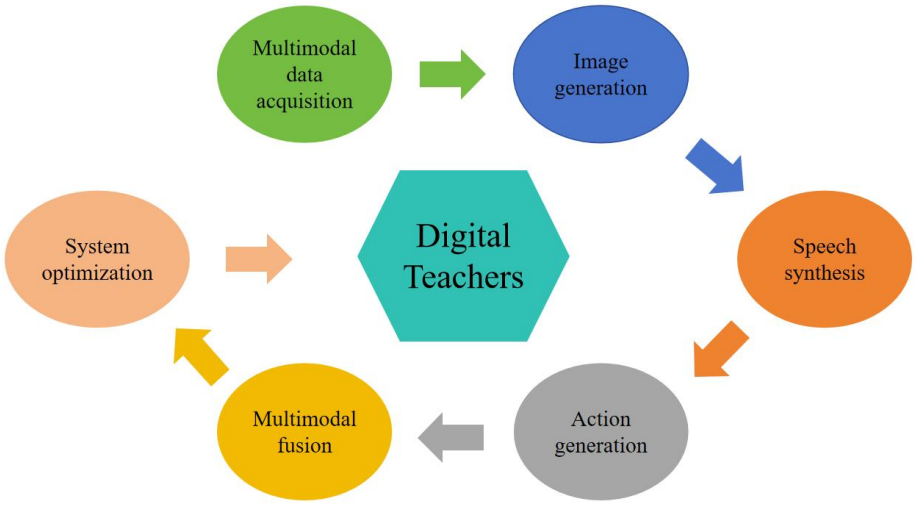

Fig2 Key technical processes for implementing digital teachers

Classroom AI Assistant: As an educational tool based on artificial intelligence

technology, it has many significant advantages, which can provide students and teachers with a more efficient and personalized learning and teaching experience. The classroom intelligent assistant can provide personalized learning support and provide personalized learning paths and tutoring content according to students' learning progress, style, and needs. For example, for students with math learning difficulties, the intelligent assistant can break down the problem step by step and provide targeted answers and suggestions. The intelligent assistant can recommend suitable learning resources, such as video tutorials and practice questions, based on students' learning history and interests, to help students better grasp knowledge.

The practice process of the blended 5E teaching model

Engage

This is the beginning of the "5E" teaching model, which aims to attract students' interest in learning tasks and stimulate students' active inquiry. Online, you can learn through the smart class teaching platform, and the AI learning assistant refines personalized student learning information according to the student's viewing time, questions and other information, customizes and pushes teaching resources that can arouse students' curiosity and desire for knowledge, and organizes and sends them to the teacher. Offline, teachers can have a preliminary understanding of students through the information sent by the smart lesson teaching platform, and create problem situations according to students' interests and learning difficulties, such as asking a challenging question or telling a related story to stimulate students' interest and answer students' confusion.In the realm of online intelligent learning, an AI learning assistant is developed using an integrated algorithm module. Student behavior sequences are represented using a time convolution grid (TCN) to derive implicit indicators like students' attention patterns and cognitive load. A hybrid recommendation model is devised for personalized suggestions, and a multi-task learning framework is employed for simultaneous predictions.

Explore

This session is the central part of the "5E" teaching model, which requires students to explore independently based on existing knowledge and given materials. AI learning assistants, online discussion forums and other links can be used online to allow students to conduct independent exploration and exchange and discussion. Teachers need to fully observe the students' inquiry process in the process, and provide some help and guidance in the form of questions and suggestions online and offline.

Explain

This session is a key part of the "5E" teaching model, and students are required to analyze and interpret the results of the inquiry session and explain them in their own words. Online through the smart learning platform, students can show their own research results and explanations. In offline classes, students will directly explain orally, and teachers will correct them according to their understanding, give scientific explanations of terms or concepts, and help students establish a correct knowledge system.

Elaborate

In this session, in order to expand the understanding of concepts and improve the

ability to apply new knowledge, teachers need to create new situations online, such as providing some relevant practice problems and case studies, so that students can use new concepts to solve problems and explain phenomena, and encourage students to think differently about the application of new knowledge in life. Group activities and project practices can be organized offline, so that students can further deepen their understanding and application of knowledge in practical operations, such as organizing students to conduct social surveys and use what they have learned to analyze.

Evaluate

The evaluation link can determine the learning effect of students and provide suggestions for subsequent teaching design, which can be teacher evaluation or student self-evaluation and mutual evaluation. Evaluation data can be collected online through online tests, questionnaires, etc., and students can also evaluate their own and their classmates' learning process on the platform. Offline teachers evaluate through classroom questions, homework corrections, exams, etc., while students can also conduct self-reflection and mutual evaluation among classmates to fully understand the learning situation and progress.

Multiple interactive evaluations

On the basis of the traditional evaluation model, artificial intelligence technology is used to introduce process evaluation and value-added evaluation to form a "multi-interaction" evaluation system. Teaching evaluation is changing from the traditional single evaluation method to multiple interactive evaluation, and with the help of artificial intelligence technology, educational evaluation has become more scientific, comprehensive and efficient. The following are the main features and practice paths of multiple interactive evaluation in AI teaching, integrated with relevant algorithm applications:

1. Diversification of evaluation content

AI technology can break through the traditional single evaluation model based on academic performance and achieve a comprehensive evaluation of students. The evaluation content includes not only knowledge acquisition, but also learning attitudes, emotional values, critical thinking, creativity and collaboration skills. The AI intelligent course platform can intelligently analyze the classroom teaching content and generate multi - subject and multi - dimensional evaluation reports for students, teachers, courses, etc.In this process, natural language processing (NLP) algorithms, such as BERT (Bidirectional Encoder Representations from Transformers), are used to analyze students' written work, like essays and reports, to evaluate their knowledge understanding, critical thinking, and language expression abilities.Convolutional neural networks (CNNs) can be applied to analyze students' creative works, such as paintings and designs, to assess their creativity. Sentiment analysis algorithms are employed to understand students' emotional values and learning attitudes from their online discussions and comments.

BERT's attention mechanism:

$$Attention(Q,K,V) = soft\max(\frac{QK^T}{\sqrt{d_k}})V \quad (5)$$

where $Q=W_qH$, $K=W_kH$, $V=W_vH$, and H are the input text embedding matrix

2. Intelligent evaluation methods

AI technology collects and analyzes multimodal data (such as classroom behavior, language expression, emotional state, etc.) in the teaching process to achieve real - time monitoring and dynamic evaluation of the teaching process. For example, AI can monitor students' emotional changes through affective computing technology to provide teachers with timely feedback to adjust teaching strategies.To analyze classroom behavior, computer vision algorithms, like YOLO (You Only Look Once) for object detection, can be used to track students' body movements, such as sitting postures and hand - raising frequencies. Recurrent neural networks (RNNs) and their variants, such as LSTM (Long Short - Term Memory) and GRU (Gated Recurrent Unit), are suitable for analyzing sequential data, like students' language expressions in class discussions, to evaluate their thinking logic and communication skills. Affective computing often uses machine learning algorithms, such as support vector machines (SVMs), to classify students' emotional states based on facial expressions, voice intonations, and physiological signals.

3. Personalized reviews

AI can provide customized evaluations and feedback based on students' learning progress, cognitive characteristics, and personalized needs. This individualized assessment focuses not only on the student's academic performance, but also on their emotional and psychological state during the learning process. For example, AI tools can generate personalized learning paths and improvement plans based on student learning data.Reinforcement learning algorithms can be used to design personalized learning paths. The algorithm learns the optimal actions (such as recommending specific learning materials or exercises) based on the student's learning state (input) and the feedback (reward) of the learning outcome. Clustering algorithms, such as k - means clustering, can group students with similar cognitive characteristics, and then different evaluation models can be applied to each group. Bayesian networks can be used to predict students' future learning performance and emotional states based on their historical learning data, enabling more accurate personalized feedback.

4. Multi - agent interactive evaluation

AI technology supports the participation of multiple subjects, including teachers, students, parents, and even members of the public. This kind of multi - agent interactive evaluation enhances the reliability and validity of the evaluation, and makes the evaluation more comprehensive and objective. The AI technology of the smart class platform builds a multi - dimensional evaluation and supervision scenario to support the interactive evaluation between supervisors, teachers and students.Graph neural networks (GNNs) can be used to model the relationships between different evaluation agents. For example, the nodes in the graph can represent teachers, students, and parents, and the edges can represent their interactions, such as teacher - student feedback, parent - student communication, etc. The GNN can analyze the influence of these interactions on the evaluation results. Social network analysis algorithms can also be applied to understand the information flow and power structure

among different agents in the evaluation process, ensuring the fairness and comprehensiveness of the evaluation.Graph neural network (GNN) is used to process graph structure data. In multi-agent interactive evaluation, we can construct the evaluation subject and its relationship into a graph G= (V, E), where V is a set of nodes representing teachers, students, parents and other evaluation subjects;E is a set of edges that represents the interaction between subjects. Assuming that the eigenvector of node Vi is $h_i^{(0)}$, in the L-layer GNN, the feature update formula of node Vi can be expressed as:

$$h_i^{l+1} = \sigma(W^{(l)}) \sum_{j \in N(i)} \frac{1}{d_i d_j} h_j^{(l)} \quad (6)$$

Ni is the set of neighbors of node Vi
di and dj are the degrees of nodes vi and vj, respectively.
W(l) is the learnable weight matrix of the lth layer.
σ is an activation function, such as the ReLU function.

5. Visualization of evaluation results

AI technology can transform complex evaluation data into intuitive visualization charts, such as radar charts and heat maps, to help teachers and students quickly understand evaluation results. For example, AI systems can generate portraits of students' learning behaviors to show their performance in different dimensions, thus providing a basis for teaching improvement.Dimensionality reduction algorithms, such as PCA (Principal Component Analysis) and t - SNE (t - Distributed Stochastic Neighbor Embedding), can be used to reduce the high - dimensional evaluation data to a lower - dimensional space, which is more suitable for visualization. These algorithms can help extract the most important features from the data and represent them in a more intuitive way. Data interpolation and smoothing algorithms can be used to make the visualization results more continuous and interpretable, especially when dealing with sparse or noisy data.

6. Whole - process evaluation

AI technology can realize the accompanying evaluation of the whole teaching process, from pre - class preview, classroom interaction to after - class homework, and record and analyze students' learning behavior and performance in real time. This kind of whole - process evaluation can identify problems in students' learning in a timely manner and provide immediate feedback.Time series analysis algorithms, such as ARIMA (Autoregressive Integrated Moving Average) and Prophet, can be used to analyze the trends and patterns in students' learning behavior over time. Hidden Markov models (HMMs) can be applied to model the hidden states of students' learning processes, such as their understanding levels and attention states, based on the observable data, like study time and exercise accuracy. These algorithms can help predict future learning performance and detect abnormal learning behaviors in the whole - process evaluation.

7. Promote teaching improvement

The AI - empowered evaluation system can uncover potential educational problems through data analysis and generate customized improvement plans. For example, AI systems can provide teachers with suggestions for teaching improvement based on evaluation results to help teachers optimize their teaching methods.Decision tree algorithms, such as CART (Classification and Regression Trees), can be used to identify the key factors affecting teaching effectiveness and student performance. Based on these factors, the algorithm can generate rules for teaching improvement. Genetic algorithms can be used to optimize teaching strategies. The algorithm evolves a set of teaching strategies over generations, aiming to maximize the teaching effectiveness based on the evaluation results. This process can help teachers find the most suitable teaching methods for different teaching scenarios and student groups.The process of teaching improvement program is shown in Figure 3.The dynamic equations of mathematical model system of teaching improvement process are as follows (7)

$$\frac{dS}{dt} = \alpha \cdot I(t) + \beta \cdot H(t) - \gamma \cdot S(t) \qquad (7)$$

S(t): student knowledge mastery

I (t): The intensity of classroom interaction

H(t): Quality of practice after class

α，β，γ is the strategy impact coefficient

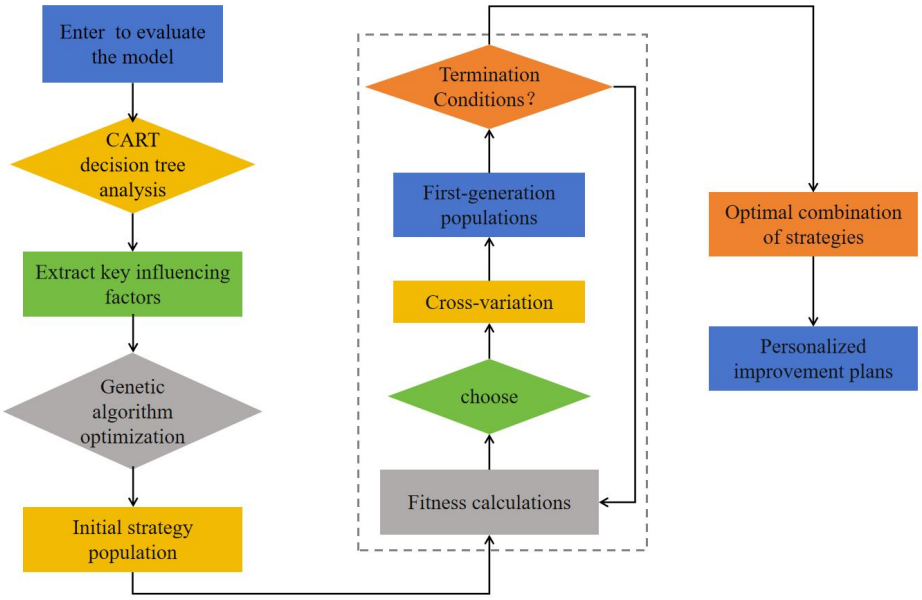

Fig.3 The algorithm process of the teaching improvement scheme

summary

In the AI era, multi-interactive evaluation has comprehensively improved the scientificity and effectiveness of teaching evaluation through intelligent, personalized, multi-subject and whole-process evaluation methods. This evaluation model can not only provide students with more accurate learning support, but also provide teachers with powerful teaching improvement tools to promote the continuous improvement of

education quality.