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Research on the Early Warning and Intervention of Learning Crisis Based on Smart Classroom

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Abstract: Under the normal state of online and offline integrated learning of open courses, the low participation of learners and low learning results are hot issues that scholars in the industry pay more attention to. Accurate learning crisis warning and personalized teaching intervention are important measures to solve the above problems and improve teaching quality. Based on the analysis of the shortcomings of the existing learning early warning and teaching intervention, this study constructs a research framework of online open course learning early warning and intervention under the intelligent classroom learning environment. The framework diagnoses and warns learners' learning state from three aspects: knowledge mastery, learning behavior and learning mood. According to the diagnosis and warning report of learners, the corresponding intervention strategies are carefully designed, and learning analysis and data mining are applied to accurately match the implementation of intervention strategies to ensure the intervention effect and finally achieve the purpose of improving the learning effect.

Key words: Smart classroom; Emotional diagnosis; Learn early warning; Learning intervention; Intervention strategy

1. Introduction

There are a large number of online course learners, and the cognitive basis, learning preference and learning ability of learners are quite different, so it is difficult for teachers to accurately analyze their learning situation and teach students in accordance with their aptitude. In addition, learners' negative learning emotions, learning motivation and other factors lead to low completion rate of courses and low learning results. Learning early warning uses appropriate methods and models to evaluate and analyze learners' learning process and learning results, understand their learning process, predict possible learning risks, and send warning signals to teachers and learners in time; Help learners to adjust themselves in time, help teachers to adjust teaching strategies, teaching methods and teaching progress in time, and provide appropriate teaching services for learners to promote their all-round development. Accurate learning crisis warning and individualized teaching intervention are important means to solve the above problems and improve teaching quality. In recent years, learning early warning has been continuously concerned by the educational circles and scholars. Learning early warning has changed from the traditional "post-processing" management control to the "pre-and in-process prevention" guidance service[1]. However, the traditional learning environment is limited by the insufficient application of data acquisition technology in the field of education, the lack of in-depth application of learning analysis and other technologies, the limited means of early warning and intervention, and the complicated intervention process, which leads to the failure of learning early warning and intervention to achieve

people's expectations. With the deep integration of new generation information technologies such as Internet of Things, big data, artificial intelligence, learning analysis and so on in the field of education, it helps to collect online and offline data of learners, analyze their learning process, and provide accurate learning feedback in the intelligent classroom learning environment, which provides the possibility for exploring personalized and accurate learning early warning and intervention.

2. Construction of Early Warning and Intervention Framework for Online Open Course Learning in Smart Classroom Environment

(1) Connotation of Smart Classroom and Teaching Structure Process

Smart classroom uses the new generation of information technology such as Internet of Things, big data, artificial intelligence, etc. to recreate the traditional classroom teaching process, realize efficient interaction and instant evaluation in the whole process before, during and after class, realize smart teaching in the teaching process, and finally achieve individualized learning of students and precise teaching of teachers[2-4]. The intelligent classroom has undergone fundamental changes with the traditional classroom teaching process in the aspects of resource presentation, interaction, evaluation and feedback. At the same time, in the teaching activities, the wisdom classroom records the learning behavior of learners, and also produces massive structured and unstructured data. Collecting, mining and analyzing these massive educational big data in the whole process can provide data support for teaching diagnosis and improvement. On the whole, the intelligent classroom teaching process mainly includes three stages: before, during and after class, and each stage dynamically generates a large amount of data[2,5].

1) Pre-class stage

Teaching presupposition: teachers make a preliminary teaching design based on the analysis of learning objectives, learning environment and initial learning needs of individual/group learners. Pre-class learning: Teachers develop pre-class learning (online autonomous learning) materials, design task lists for guiding learning, and push them to learners. Pre-class assessment: after completing all the learning tasks according to the guidance task list, conduct pre-class assessment and record the existing problems. Analysis of learning situation: Teachers conduct comprehensive research on students' learning situation according to their learning time, resource learning situation, forum comments, interaction, guidance and evaluation, etc. Teaching redesign: according to the accurate analysis of academic situation, such as personality differences, pre-study evaluation before class, etc., the hierarchical and classified teaching redesign is carried out by learning and teaching[2].

2) Stage in class

Situation creation and problem introduction: Teachers create appropriate learning situations according to the learning content, the selected teaching mode and other factors, and introduce the learning tasks in this section in an appropriate way to inform students of the important and difficult points, learning objectives and relevant matters needing attention. Inquiry learning: this link is an important part of the middle-class stage, which is related to the learning effect. After clarifying the learning task, students can explore independently or explore and solve problems in groups to complete the learning task. Real-time evaluation: immediately evaluate the learning effect after completing the learning task. Summary and

promotion: After the presentation of the learning results, the teachers summarize and reflect on the completion of the learning tasks and the remaining questions.

3) After-class stage

After-class extension: according to the completion of learning tasks and the performance of learning process in class, teachers design and expand advanced learning projects to improve students' application of knowledge and skills. Resource recommendation: Use data mining, learning analysis and other technologies to analyze students' learning process data and evaluation data, diagnose their weaknesses and push appropriate personalized learning resources to students. Fine guidance: under the empowerment of intelligent technology, students' difficult points can be diagnosed and targeted guidance can be given to improve their learning effectiveness. Evaluation: Teachers and learners reflect on the deficiencies in the teaching and learning process that need to be improved, so as to adjust the corresponding teaching strategies and learning strategies in time.

(2) Design of Early Warning and Intervention Framework for Online Open Courses in Smart Classroom Environment

The process of learning early warning usually includes the steps of determining the purpose of early warning, data collection, data analysis, visualization of learning information, push of early warning information and implementation of intervention[6-7]. With the help of the new generation of information technology, the intelligent classroom learning environment collects students' online and offline multi-mode heterogeneous data concomitantly, which provides holographic data foundation for learning early warning and teaching intervention. On the basis of the existing research on learning early warning and intervention, combined with the teaching structure process of smart classroom, this study constructs the learning early warning and precise intervention framework of online open courses in smart classroom environment from data collection, data processing, early warning data mining and analysis, diagnosis early warning and teaching intervention, as shown in Figure 1.

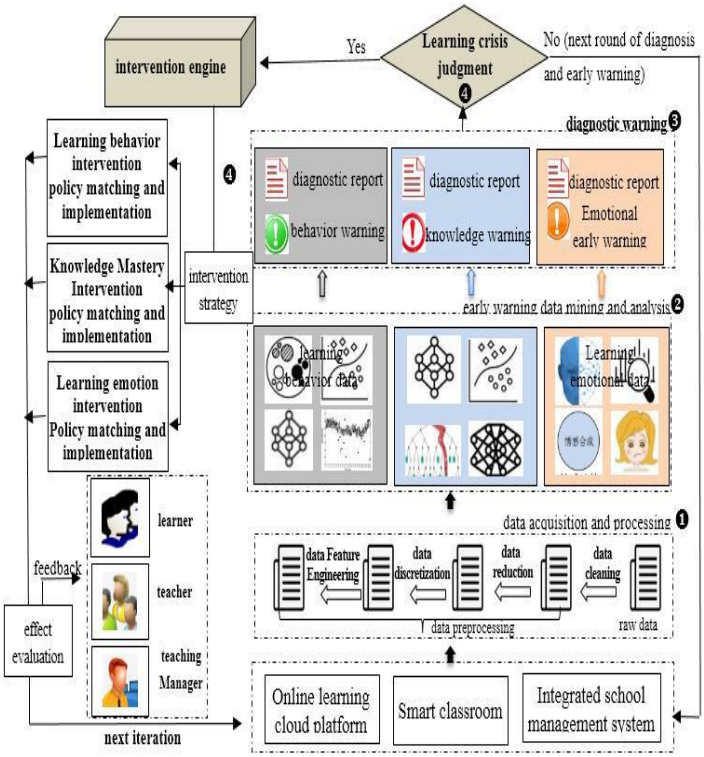

Fig 1 Early warning and intervention framework for online open course learning in smart classroom environment

1) Data Acquisition And Processing

The data system of online open courses in the smart classroom environment involves teachers, learners, learning platforms and various modal data generated in the process of teaching implementation among them, including data collected by online learning platforms and offline smart classrooms (see Figure 1). In addition to online platform and offline classroom data, the data collected in this study should also include data of school

performance management system, history and studies, etc. Online learning platform data collection uses platform data collection tools to collect learners' online learning trajectory data, resource learning behavior data, learning interaction data, homework and evaluation data, etc. Using web crawler tools and learning analysis technology to crawl and mine hidden learning emotion data such as forum interaction. Intelligent classroom data collection collects heterogeneous multi-modal data such as learners' facial expressions, body movements, voice features, eye movement signal physiological data, etc. through technologies such as perception technology, video surveillance and language recognition of the Internet of Things. Data such as students' basic information and historical academic achievements are collected by learning various management systems. In the aspect of data processing, the collected data is processed through data cleaning, data specification, data conversion, data specification, data feature engineering, etc., which provides the data foundation for subsequent data mining, early warning and diagnosis.

2) Mining and analysis of early warning data

The framework of learning early warning and intervention constructed in this study aims at accurately warning the possible learning crisis of students and providing individualized teaching intervention in time by using educational data mining and learning analysis, so as to improve the learning effect[8]. On the basis of basic processing of early warning data, cluster analysis is made on the data to form data clusters such as learners' basic information, learning behaviors, learning emotions and knowledge points. On the premise of maintaining the integrity of the original data, a simplified data set of learners is obtained from massive data. Next, the data set is mined and analyzed from three dimensions: knowledge, behavior and emotion. The key technologies involved are educational data mining and learning analysis. The commonly used analysis methods of educational data mining include statistical analysis, classification, clustering (clustering, outlier analysis), prediction (Bayesian network, decision tree, regression analysis, time series analysis), relationship mining (association rules mining, sequential pattern mining, social network analysis) and text mining [6]. Analysis methods commonly used in learning include network analysis, discourse analysis and content analysis[9-10].

Data mining analysis of knowledge point mastery: ① extract the learning process data of students' practice/evaluation/measurement of knowledge point mastery for mining, in which "practice" of learning process data refers to data such as the number of times, practice duration, completion degree, etc. of a certain knowledge point; "Evaluation" refers to the data such as mutual comments between forums or learning partners after learning a certain knowledge point; "Test" mainly focuses on the data such as the situation of test questions, including the speed of doing the questions, the correct or incorrect situation, the results, the ranking, etc. ② Q matrix of knowledge points in the test questions: firstly, mark the types of knowledge points involved in the test questions as conceptual knowledge, factual knowledge, procedural knowledge, etc. Divide the types of questions into fill-in-the-blank questions, multiple-choice questions, essay questions, answer questions and calculation questions; The difficulty marks are difficult, difficult, medium, easy and easy. Secondly, the relationship between knowledge points in the test questions is marked as hierarchical relationship (parallel, brother, father and son), dependent relationship (predecessor, successor) and related relationship (loose relationship between main knowledge points and related knowledge points). Finally, each row (also called row vector) in the Q matrix X×Y represents a test question, and each value in the row vector has two values (0 and 1). When the value of xy of Qxy is 0, it means that the test question X has not investigated the knowledge point Y; When the value of xy of Qxy is 1, it means that the test question X examines the

knowledge point Y. ③ comprehensively judge learners' mastery of knowledge points from the aspects of Q matrix associated with knowledge points of test questions and learners' personal practice/evaluation/evaluation data.

Learning behavior data mining analysis:① Extracting learning behavior data, including explicit behavior data and implicit learning behavior data. Explicit behavior data can be recorded by online learning platform and intelligent classroom IoT sensing devices, such as landing platform, browsing resources, editing resources, video-on-demand drag and drop, offline classroom discussion and communication, etc. Implicit learning behavior data, such as learning motivation, reflection, learning satisfaction and other psychological activities. In this study, learning behaviors are roughly divided into track learning behaviors, social behaviors, resource learning behaviors and evaluation and reflection behaviors. Trajectory learning behavior refers to learners' behaviors such as logging in, logging out, and jumping on the web page in the online learning platform, and behaviors such as offline class attendance rate, answering questions, etc. belong to trajectory behavior. Social behavior refers to learners' real-time/asynchronous communication and discussion communication in the online platform forum module, Q&A module and personal space module, as well as the face-to-face communication between teachers, students and students in offline smart classroom, such as inquiry and collaborative problem solving. Learning behavior refers to learners' behaviors of accessing, learning, editing and publishing information on learning resources in the resource module and forum module of the online learning platform, and also includes a series of activities such as searching and sharing resources in offline classroom when teams collaborate to complete specific learning tasks. Reflective behavior belongs to implicit learning behavior, which refers to the learning behavior of homework/exercises module, evaluation module, project works display evaluation and other links. ② Using clustering, classification, association rules, sequential pattern mining, text mining, Web mining and other methods to mine the learning behaviors, what types of learners there are, and what characteristics each type of learners has, etc. ③ Using clustering, outlier analysis and other methods to comprehensively analyze learners' learning behavior from the aspects of attendance, learning progress, learning participation, learning task contribution and learning task completion.

Data mining and analysis of learning emotion: ① Firstly, get the relevant data of learners' learning emotion. Learning emotion measurement usually adopts two ways: physiological measurement and behavioral measurement. Physiology measurement uses intelligent wearable devices (physiological recorder, eye movement meter, brainwave meter, VR helmet, etc.) to collect data; Behavior measurement uses video recording, speech recognition and web crawler to collect learners' facial expressions, body movements, speech features and forum text information. ② Using expression recognition technology, NLP language understanding technology, soma to sensory technology, text mining, emotion computing technology, etc. to comprehensively recognize learners' emotions.

3） Diagnostic warning

Diagnosis and early warning can be made from three aspects: learning behavior, knowledge mastery and learning mood. Learning behavior diagnosis: Comprehensive diagnosis is mainly made from the aspects of learning progress, interaction frequency, learning engagement, completion of learning tasks, attendance and punching, etc., to identify which learning type learners belong to and what characteristics each learning type has, and form a learning behavior diagnosis report. Learning state diagnosis: comprehensive analysis is mainly made from the aspects of learning duration, learning frequency, interaction frequency, timely submission of homework and attendance, etc., so as to evaluate

whether learners are in a good learning state or a bad learning state.

Evaluation of learning emotion: using emotion recognition technology and text mining technology to evaluate the learning emotion of video, voice, posture, physiology, forum text and other data, so as to identify the state of learning emotion and form a diagnosis report of learning emotion. Evaluation of knowledge mastery: You can make diagnosis from the aspects of homework completion, evaluation results, evaluation duration, evaluation times, resource learning, learning path, etc., predict learners' learning needs and possible learning difficulties, and form a knowledge mastery diagnosis report. Finally, considering these diagnosis reports and learning state diagnosis comprehensively, we can judge whether students have learning crisis, whether they need early warning, and what kind of early warning methods are adopted.

4) Teaching intervention and strategies

Teaching intervention in intelligent classroom learning environment refers to the collection of multimodal data of learners in different learning scenarios, the diagnosis and analysis of their learning problems, and the provision of differentiated and scientific decision support and targeted teaching guidance activities for different types of learners[11]. According to the diagnosis report of early warning of learning situation (early warning of learning behavior, early warning of knowledge mastery and early warning of learning emotion), targeted teaching intervention is adopted to help students solve their learning difficulties. At present, the most commonly used intervention model is "Response to Intervention" (RTI) three-level model. The first level of intervention is aimed at all students, and the intervention mode is all intervention, with the lowest intervention intensity. The intervention goal is to carry out early prevention for students with learning difficulties. The second-level intervention is aimed at some students who still have learning difficulties after the first-level intervention. The intervention mode is group intervention, and the intervention intensity is strong. The third-level intervention, the intervention target is a small number of students with learning difficulties who need further close monitoring and individual in-depth intervention after the first and second-level intervention. The intervention mode is individual guidance, and the intervention intensity is the strongest. Based on RTI theory, this study will carefully design intervention strategies from three dimensions: learning behavior, knowledge mastery and learning emotion, apply learning analysis and other technologies, and accurately match the intervention strategies according to the learner's diagnosis and early warning report to ensure the intervention effect and improve the learning effect.

Mastering intervention strategies for knowledge points: designing intervention strategies with different difficulty gradients according to different types of knowledge points (conceptual knowledge, factual knowledge and procedural knowledge). For example, students with poor conceptual knowledge recommend other knowledge or learning materials related to this knowledge point, and design some game-based knowledge concept test questions to mobilize students' learning initiative; For example, students who do not have a good grasp of procedural knowledge are recommended to reduce the difficulty of learning materials, and abstract knowledge is pushed to students in a visual way. At the same time, teachers create process-contextualized learning items in instructional design, so that students can better master the corresponding knowledge in simulation situations. Learning intervention strategy: in the design of trajectory behavior strategy, if students' attendance, times of logging in to the learning platform, times of answering questio

ns and learning progress are lower than or behi nd all the average levels, they will be given vi sual reminders of their learning progress, paths of learning knowledge points/learning companio ns, and sent out e-mail/message reminders or v erbal warnings. In terms of social behavior strat egies, such as online and offline classroom disc ussion and communication, forum interaction, an d collaborative problem solving, if the learning behavior is lower than the average level of the class, send them an email/message reminder or verbal warning, and push their learning partner s. In the aspect of learning behavior strategy de sign, if students' learning behaviors, such as lea rning times, learning duration, forum interaction, etc., are lower than the average level of the c lass, they will be sent e-mail/message reminders or verbal warnings to push the overall picture of students' personal resource learning and rec ommend learning paths.

Learning emotion strategies: according to t he early warning diagnosis report of learning e motions, the corresponding intervention strategie s are designed for different emotions. When stu dents are in good mood, they don't need interv ention. When students are in a state of negative emotions, offline classroom teachers timely adj ust the learning progress, reduce the difficulty o f learning, design interesting interactive links, a nd create aggressive learning situations to stimu late students' positive emotions; On-line learning, the system suspends the current learning tasks, pushes personalized learning resources with lo w difficulty to learners, recommends learning c ompanions to improve learning interest, etc. Aft er the mood improves, the system continues to push follow-up learning tasks to students.

Evaluation of intervention effect: Because l earning is a complex process of dynamic adapt ation, teaching intervention usually needs to be completed many times, so teaching intervention is also a process of it erective and progressi ve optimization. Firstly, the effect of comprehen sive intervention activities is good or bad from the aspects of students' knowledge mastery and learning efficiency, learning behaviors such as learning participation and inquiry interaction, an d improvement of learning mood. Analyze the big data of students' whole learning process, an d comprehensively judge the effect of teaching intervention from the aspects of attendance, lear ning participation, learning task completion, lear ning mood fluctuation and improvement, and pr oblem-solving ability of students with learning difficulties; At the same time, according to the effect of the intervention, it is decided whether to implement the next level or a new round o f teaching intervention, so as to solve the learni ng problems of students with learning difficultie s.

3. Conclusion

Aiming at the shortcomings of existing learning early warning, such as incomplete collection of early warning data, insufficient dimensions of early warning and lack of early warning of learning emotions, this paper studies the learning early warning and intervention framework of online open courses under the intelligent classroom environment. The framework is discussed in detail from the aspects of data collection and processing, early warning data mining and analysis, diagnosis and early warning, teaching intervention and intervention effect evaluation, and comprehensive early warning and intervention are carried out from three dimensions of students' knowledge mastery, learning behavior and learning emotion. Because learning is a process of constant adaptation and dynamic adjustment, there are many factors leading to learning crisis. The learning early warning and intervention framework of online open courses constructed in this paper can solve the learning difficulties to a certain extent, but it can't solve all the learning difficulties. Therefore, the learning early warning and intervention framework studied in this paper needs to be further explored.

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