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Research on the Application of Brain-Computer Interface in Intelligent Classroom Teaching

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Abstract

With the rapid development of information technology, the field of education is undergoing profound changes, and intelligent classroom teaching has become an important development direction of educational modernization. As a cutting-edge technology enabling direct communication between the brain and external devices, Brain-Computer Interface (BCI) technology has gradually attracted the attention of educational researchers. It can real-time monitor students' learning status, provide teachers with precise teaching feedback, help teachers adjust teaching strategies in a timely manner, and realize true teaching students in accordance with their aptitude. This paper aims to explore how to deeply integrate BCI technology with the teaching process and design application schemes suitable for different disciplines and teaching scenarios.

Keywords

Brain-Computer Interface (BCI); Intelligent Classroom; Teaching.

1. Introduction

With the rapid development of information technology, the field of education is undergoing profound changes, and intelligent classroom teaching has become an important development direction of educational modernization. In this context, Brain-Computer Interface (BCI) technology, as a cutting-edge technology enabling direct communication between the brain and external devices, has gradually entered the vision of educational researchers [1]. It can real-time monitor students' learning status, such as attention concentration, cognitive load, emotional changes, etc., provide teachers with precise teaching feedback, help teachers adjust teaching strategies in a timely manner, and realize true teaching students in accordance with their aptitude. For example, by analyzing students' electroencephalographic (EEG) signals, teachers can understand students' comprehension and interest in different knowledge points during the learning process, thereby optimizing teaching content and methods in a targeted manner and improving teaching effectiveness. In addition, BCI technology can provide unique support for special education groups, helping them overcome learning and communication barriers and better integrate into the educational environment.

2. Feasibility and Advantages of the Application of BCI Technology in Intelligent Classroom Teaching

BCI technology has made remarkable progress in key aspects such as signal acquisition and processing accuracy, showing high technical maturity and laying a solid foundation for its application in intelligent classroom teaching [2]. In terms of signal acquisition, the continuous development of various acquisition technologies has greatly improved the convenience and comfort of wearing, allowing students to use BCI devices more naturally in class. In terms of

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signal processing and analysis, the application of machine learning and deep learning algorithms has significantly enhanced the ability of BCI systems to understand and interpret brain signals. This enables BCI systems to convert brain signals into operable instructions more quickly and accurately, providing technical support for real-time interaction in intelligent classroom teaching. In intelligent teaching, through integration with technologies such as artificial intelligence and big data, BCI systems can realize intelligent push of teaching content, automatic adjustment of teaching strategies, and real-time evaluation of learning effects, accurately pushing learning resources that meet students' needs. During the teaching process, the system can automatically adjust teaching strategies according to students' real-time learning status to improve teaching effectiveness. BCI technology can also real-time evaluate students' learning effects. By analyzing students' EEG signals and learning behavior data, it can timely identify problems and difficulties encountered by students in the learning process, and provide targeted suggestions for teachers to help them improve teaching methods and quality.

3. Research on the Framework of Intelligent Classroom Teaching System Based on BCI

3.1. System Architecture

Intelligent classrooms need to rely on technology-supported educational measurement, establish rich and in-depth cognitive and learning models, and promote students to improve their ability to solve complex tasks and realize personalized learning [3]. This paper explores an intelligent classroom teaching application model based on BCI learning evaluation and intelligent classroom teaching, realizing teacher-student classroom interaction, explicit learning status measurement, and implicit factor measurement through BCI technology. By measuring students' explicit behaviors in classroom activities combined with implicit state measurement, it realizes the identification of teaching and learning styles, the measurement and analysis of complex learning abilities, achieves intelligent support for teachers' teaching behaviors and students' intelligent learning behaviors, and provides data support for teaching effect evaluation. Integrating BCI technology into the teaching process is the key to realizing intelligent classroom teaching, which requires careful design and implementation in various links such as lesson preparation, teaching, and after-class tutoring to give full play to the advantages of BCI technology and improve teaching quality and effectiveness.

3.2. Adaptation to Disciplines and Scenarios

Different disciplines and teaching scenarios have their own unique characteristics and needs. Adapting BCI technology to them requires in-depth analysis of the differences in disciplinary characteristics and teaching scenarios, and formulating targeted application strategies to realize the organic integration of technology and teaching and improve teaching effectiveness.

In terms of disciplinary adaptation, the application of BCI technology should be adjusted according to the knowledge system, thinking mode and teaching objectives of different disciplines. For mathematical and physical disciplines such as mathematics, physics, and chemistry, which focus on the cultivation of logical thinking and problem-solving abilities, BCI technology can play a role in problem-solving thinking analysis and experimental operation assistance. In mathematics problem-solving teaching, teachers can use BCI technology to monitor changes in students' EEG signals during the problem-solving process and analyze their thinking processes and strategies. When students encounter difficulties, BCI data can show their thinking bottlenecks and confusion points. Teachers can use this information to guide students to think from different perspectives, provide targeted problem-solving ideas and methods, help students break through thinking barriers, and improve their problem-solving abilities. In physics experiment teaching, BCI technology can be combined with experimental

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equipment to real-time monitor students' operation processes and attention concentration. When students operate improperly or are distracted, the system can issue timely reminders to avoid experimental accidents, and at the same time help students better master experimental skills and principles..

4. Application of BCI Technology in Teaching Evaluation

Teaching evaluation is the "baton" of the teaching process. Traditional teaching evaluation mostly relies on result-oriented indicators such as exam scores and classroom performance ratings, which are difficult to fully reflect process-oriented information such as cognitive changes and learning engagement during teaching. It also has drawbacks such as "valuing results over processes" and "valuing knowledge over abilities". By capturing learners' physiological and neural activity data during the teaching process, BCI technology can realize the transformation of teaching evaluation from "result-oriented" to "processresult dual-oriented" and the expansion from "single indicator" to "multi-dimensional indicators" [4].

4.1. Learning Status Indicators

Learning status is an important dimension to evaluate students' learning process and effects. Through BCI technology, various learning status indicators can be obtained to provide comprehensive and accurate information for teaching evaluation. Attention and concentration are key indicators reflecting students' learning engagement. In classroom learning, students with focused attention can better receive and understand the knowledge taught by teachers. BCI devices can accurately judge students' attention levels by monitoring brain electrical activities. When students are in a focused state, specific areas of the brain will generate EEG signals of specific frequencies. Quantifying students' attention and concentration can help real-time understand their attention status and provide a basis for teachers to adjust teaching strategies.

4.2. Knowledge Mastery Indicators

BCI technology provides a new method for evaluating students' understanding and memory of knowledge. By analyzing brain activity signals, we can deeply understand students' knowledge mastery and provide a more accurate basis for teaching evaluation. In terms of knowledge understanding, when students are exposed to new knowledge, the brain will carry out a series of cognitive processing activities, which will be reflected in changes in EEG signals. By monitoring students' EEG signals during the learning of new knowledge and combining with machine learning algorithms, we can judge their understanding of the knowledge..

5. Conclusion

This paper focuses on the application of BCI technology in intelligent classroom teaching, exploring the integration of BCI technology with educational neuroscience, educational psychology and teaching theories. By real-time collecting students' brain signals through BCI technology, it reveals the neural mechanisms in the learning process and provides a neuroscientific basis for optimizing teaching methods. The research on teaching theories based on BCI technology promotes the transformation of teaching theories from teacher-centered to student-centered, pays more attention to students' subject status and individual differences, and promotes the innovative development of teaching theories.

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