Research on Student Learning Behavior in Smart Classroom Based on Multimodal Data

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ABSTRACT. The smart classroom empowered by intelligent technology provides rich educational multimodal data for monitoring, evaluating, providing feedback, and early warning of students' learning behavior. This study focuses on multimodal data of students' learning behavior in smart classrooms, and constructs a multimodal data analysis framework based on the three-dimensional dimensions of sound data, image data, and text data. Encode multimodal data that reflects the characteristics of students' learning behavior and qualitatively represent it to form an encoding system.

Keywords: Smart Classroom; Learning Behavior; Multimodal Data.

1 Introduction

In today 's education sector, a new round of ' classroom revolution ' is taking place. The application of technologies such as the Internet of Things, big data, cloud computing, and artificial intelligence in educational settings has caused a disruptive impact on traditional education. In the 2021 OECD Digital Education Outlook report released by the Organization for Economic Cooperation and Development, the focus is on the changes in classroom teaching caused by intelligent technology[1]. In recent years, with the development of intelligent perception devices such as intelligent systems, eye trackers, and electroencephalographs, as well as the maturity of intelligent technologies such as human natural language processing, computer vision, speech recognition, and physiological information recognition, new opportunities have been brought to the development of intelligent classrooms[2].

This study is supported by smart classroom intelligent devices for data collection technology, utilizing data mining and machine learning to obtain and analyze data. From the perspective of multimodal learning behavior analysis, based on the constituent elements of student learning behavior, a learning behavior analysis framework with multimodal data is designed and formed. One semester of student behavior data collection is conducted to explore the changes in student learning behavior and explore potential educational value, Promote educational research towards data-driven, dynamic, scientific, and precise development.

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2 Multimodal Analysis of Students ' Learning Behavior in Smart Classroom

In the learning process, students interact with teachers, peers, technological products, traditional learning tools, and other objects through various sensory channels such as visual, auditory, and tactile senses, generating a large amount of multimodal data. The "human machine object" ternary fusion is then completed in the cerebral cortex to construct the meaning of new knowledge[3].

2.1. Research on smart classroom learning behavior

Students ' learning behavior is the behavior feedback of students to classroom activities in the process of classroom teaching, which can show students ' learning state in the classroom. The analysis of classroom student behavior is to systematically collect all information related to classroom student behavior, and use reasonable evaluation methods to measure and value the classroom student learning activities and related factors according to the training objectives and requirements. In the smart classroom, the technical intelligence is used to collect and analyze the information data of multimodal students ' learning behavior, so as to explore the law and potential value of learning behavior[4]. Technology empowerment makes learning behavior analysis more complex and diverse. A large amount of behavior data with rich types needs to form an analysis system for statistical classification[5].

2.2. Multimodal data acquisition

With the development of artificial intelligence technology and the introduction of computer education theory, an intelligent education application mechanism supported by multimodal data is gradually being implemented. Multimodal learning analysis utilizes intelligent technology to collect, analyze, and learn multimodal data such as facial expressions, eye movements, language, gestures, breathing, movements, and electroencephalography. It identifies multiple learning spaces and deeply integrates them to explore learners' cognitive, behavioral, and emotional changes[6].Based on domestic and international research, from the perspective of existing technology, multimodal data collection mainly involves the following methods:

Identify learners' online learning flow data through online learning platforms, and form text for their learning participation and interaction. Utilize natural language processing and speech recognition technologies to collect and recognize speech, intonation, and discourse information data from learners and teachers[7]. Utilizing computer vision technology and 360 panoramic technology to collect classroom behaviors such as learners' facial expressions, movement behavior, body posture, and positional movement, intelligent recognition of learners' classroom learning focus and cognitive emotional changes[8]. Using physiological recognition technology to collect data on learners' electroencephalography, skin electrography, hormone analysis, etc., providing diverse physiological data support for learners' learning behavior research[9].

2.3. Multimodal data analysis framework

The teaching process contains a large amount of multimodal behavior data. In order to reasonably and accurately construct a multimodal analysis framework for smart classroom learning behavior, this study returns to existing learning behavior classification methods, interprets the significance of multimodal learning analysis, comprehensively examines student learning behavior and core features of smart classrooms, in order to determine the multimodal analysis framework for smart classroom student learning behavior.

Firstly, through literature review, it can be seen that the research results on classification of learning behavior are analyzed around teaching activities such as "learning, teaching, management, testing, and evaluation" between teachers and students. Based on multimodal data types, Zhang Lele et al. divided student learning behavior into practice and media use behavior based on text data, listening, questioning, discussing, and media use behavior based on video data, and questioning and discussing behavior based on voice data[10].Secondly, the digital representation of the subject, teaching situation, and teaching environment in classroom teaching activities is carried out, and combined with the human machine object interaction mechanism and behavior mode of smart classrooms, the learner's behavior, physiology, cognition, and emotional changes are deeply revealed[11]. By integrating theoretical knowledge such as brain class and intelligent computing, the potential relationship between explicit behavior characteristics and internal cognitive development is revealed, providing multiple theoretical and technical support for the construction of the smart classroom ecosystem[12].

Based on this, this study divides the multimodal data of student learning behavior into: multimodal sound data (speech based student classroom activities) based on the data type characteristics presented in the smart classroom environment; Multimodal image data Imagedata (a learning activity focused on body movements and positional changes); Multimodal Text Data (a learning activity primarily focused on technology use) constructs a multimodal analysis framework for students' learning behavior in smart classrooms from three dimensions: sound, image, and text. Based on actual observations of classroom learning activities, the author divided the multimodal data under classroom learning activities into"invalid" data and "effective" data from the third gradient, and finally generated a detailed multimodal data framework diagram, as shown in Figure 1.

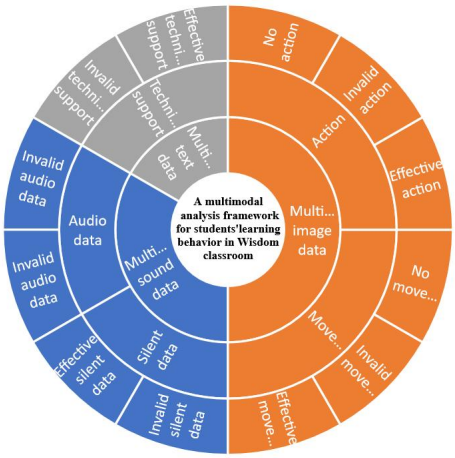

Fig. 1. S-I-T smart classroom student learningbehavior multimodal analysis frame-work

2.4. Multimodal data encoding system

2.4.1 data encoding

Firstly, the learning behavior analysis framework is refined and the corresponding learning behavior characteristics are listed. Secondly, coding and labeling are performed according to the enumerated learning behavior characteristics. Sound data includes ten learning behavior features, which are sequentially formed into S1-S10 ten codes according to the English initials of sound data. The encoding of image data and text data is consistent with that of sound data.

2.4.2 Qualitative representation of learning behavior

This study will qualitatively characterize multimodal data that reflects students' learning behavior. From the external manifestations and internal motivations of learning behavior, it is divided into participatory learning behavior, proactive learning behavior, and focused learning behavior. Among the three qualitative representations of learning behavior, active learning has participatory nature, which only reflects students' classroom participation behavior. Therefore, in this study, if a behavior has a proactive representation, it is classified as proactive in data statistics and no longer classified as participatory repetitive calculations. The final formation of a multimodal analysis coding system for student learning behavior in smart classrooms is shown in Table 1.

2.4.3 Multimodal data statistics

This study uses the sound, image, text data acquisition equipment and two observers ' real-time observation statistics in the smart classroom environment to encode and control the multimodal learning behavior. Independent coding was performed at an interval of 20 seconds, and ELAN6.1 software was used to code and mark the lessons. Finally, the statistical results were visualized. Two observers negotiated the specific rules and details of data collection according to the coding system of learning behavior. After reaching unity, data statistics were

carried out according to the coding system table, and the statistical coding data were sorted out and proofread to provide accurate multimodal data support for learning behavior research.

Table 1. Multimodal analysis coding system of students ' learning behavior in smart classroom

Research Object	Smart Classrom Environment	Multi-modal Data			Learning Behavior	Coding	Qualitative Representation
Pupil	Intelligent recording system, Pickup equipment, Microphone, Recording pen	Sound data	Audio data	Effective audio data	Active response	S1	Initiative
					Passive response	S2	Participation
					Active questioning	S3	Initiative
					Discussion communication	S4	Initiative
					Results sharing	S5	Initiative
					Evaluation feedback	S6	Initiative
				Invalid audio data	Invalid onfusion (words Problem shift, intentional confusion)	S7	Participation
			Silent data	Effective silent data	Thinking	S8	Initiative
					Listen	S9	Initiative
				Invalid silent data	Ineffective silence	S10	Participation
	Intelligent recording and broadcasting system, HD camera, Multi position recording, Teachers, The Observer	Image data	Movement	Effective movement	Seats	M1	Participation
					podium	M2	Participation
					Between groups	M3	Participation
					Within the group	M4	Participation
				Invalid movement	Corridor	M5	Participation
				No movement	No position movement	M6	Participation
			Action	Effective action	Staring interactive whiteboard	A1	Focusness
					Looking at teachers	A2	Focusness
					Looking at classmates	A3	Focusness
					Eye gaze learning tools	A4	Focusness
					Gaze at the book	A5	Focusness
					Interactive whiteboard	A6	Participation

					oriented		
					For teachers	A7	Participation
					For companions	A8	Participation
					Facing learning tools	A9	Participation
					Facing Books	A10	Participation
				Invalid action	Non-learning body movements	A11	Participation
				No action	Sleeping	A12	Participation
					Walking mind	A13	Participation
	Various learning platforms WeChat QQ Superstar Learning Chinese University MOOCs Baidu Cloud	Text data	Technical-support	Effective technical support	Technology platform(T-P) check-in	T1	Participation
					T-P response	T2	Participation
					T-P work practice	T3	Participation
					T-P independent learning	T4	Participation
					T-P exchange discussion	T5	Participation
					T-P results sharing	T6	Participation
					T-P evaluation feedback	T7	Participation
					T-P data collection	T8	Participation
				Invalid technical support	The Use of Technology for Irrelevant Learning	T9	Participation
					No technology use behavior	T10	Participation

3 Conclusions

This study starts from the perspective of multimodal data analysis and constructs a multimodal analysis framework for S-I-T students' learning behavior based on multimodal data types, which qualitatively characterizes students' learning behavior. The S-I-T smart classroom student learning behavior multimodal analysis framework fully utilizes intelligent devices in the smart classroom environment to collect and generate sound, image, and text data. The S-M-A-T smart classroom student learning behavior multimodal analysis coding system is formed based on multimodal data types, which can effectively present changes in student learning behavior in the smart classroom from four dimensions: speech learning activities, positional movement, body movements, and technological use, and endow them with

qualitative representations, providing data collection and behavioral evaluation standards for multimodal student behavior research.

In a word, this study hopes to provide data sources and scientific basis for students to understand their own learning behavior and state, to carry out personalized teaching for teachers and to construct learning evaluation system for researchers through the analysis of multimodal data of students ' learning behavior. In the educational environment of the development and popularization of smart classrooms, trying to use data-based, scientific and intelligent learning behavior analysis methods is an effective way to promote the progress of smart classrooms and a strong guarantee for promoting teaching and learning.

References

[1] Liu,S,N,Y.Yang,Z,K.Li,Q.(2019) Computational pedagogy: Connotation and approach.J.Educational Research,. 41(03):152-159.

[2] Dai,Y,L.Yan,Z.Cheng,J,C.Duan,X,J.Wang,G,J.(2023) Analysis of multimodal data fusion from an information theory perspective.J. Information Sciences. Volume 623 , Issue . PP 164-183. 10.1016/J.INS.2022.12.014.

[3] Hu,Q,T.Wu,W,Y.Feng,G.Pan,T,F.Qiu,K,X.(2021) Research on interpretability analysis of multimodal learning behavior supported by deep learning.J. e-Education Research.42(11) :77-83. 10.13811/j.cnki.eer.2021.11.011.

[4] Wu,X,R.Liu,B.Q.Yuan,T,T.(2019)The new generation of smart classroom : concept, platform and architecture.J. China Educational Technology. (03):81-88. 10.27061/d.cnki.ghgdu.2018.000307.

[5] Shi,D,Q.(2021) Analysis and visualization system of classroom learning behavior data.D. Yunnan Normal University.08. 10.27459/d.cnki.gynfc.2021.001309.

[6] Mu,S.Cui,M.Huang,X,D.(2020) Multimodal Data Fusion in Learning Analytics: A Systematic Review.J. Sensors (Basel, Switzerland). Volume 20 , Issue 23 . 10.3390/S20236856.

[7] Noroozi,O.Alikhani,I.Järvelä,S.Kirschner,P,A.Juuso,I.Seppänen,T.(2019) Multimodal data to design visual learning analytics for understanding regulation of learning.J.Computers in Human Behavior. Volume 100 , Issue C.PP 298-304.10.1016/j.chb.2018.12.019.

[8] Giannakos,M.Sharma,K.(2020) Multimodal data capabilities for learning: What can multimodal data tell us about learning?.J.British Journal of Educational Technology.Volume51,Issue5.PP1450-1484. 10.1111/bjet.12993.

[9] Zhao,C.Shu,H.Gu,X,Q.(2021) Measurement and analysis of students' engagement in Classroom Learning Behavior based on Computer Vision.J.Modern Educational Technology.31(06):96-103. 10.3969/j.issn.1009-8097.2021.05.012.

[10] Zhang,L,L. Gu,X,Q.(2022) An analysis model and practical framework of classroom teaching behavior supported by multimodal data.J.Open Education Research.28(06):101-110. 10.13966/j.cnki.kfjyyj.2022.06.011.

[11] Mou,Z,J.(2020) Multimodal learning analysis : a new growth point of learning analysis research.J. e-Education Research.41(05):27-32+51.

[12] Sheng,X,Y.Wu,J,W.Zhang,Y,X.Li,Y.Ma,L,C.(2019) Research on MOOCAP learners ' online learning behavior and learning effect evaluation model.J.Chinese Journal of Distance Education .(07),38-46+93. doi:10.13541/j.cnki.chinade.20190508.002..