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Exploring a New Code for Smart Classroom Analysis

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Abstract. With the rapid development of artificial intelligence, big data, cloud computing and other technologies, educational environments must inevitably evolve. The smart classroom will become commonplace. Comprehensively and deeply analyzing the behaviors of teachers and students in the classroom will promote the reflection and evaluation of teachers and students. However, smart classroom teaching is a dynamic process; existing classroom observation systems such as Flanders Interactive Analysis System (FIAS) and Information Technology-based Interactive Analysis System (ITIAS) cannot adequately aid in the analysis of a smart classroom. This study proposes a Smart Classroom-based Interactive Analysis System (SCIAS) which will provide a framework for educators to analyze and study smart classrooms.

Keywords. Classroom observation, Smart classroom, Interactive analysis.

1. Classroom observation

"Observation" is the most basic and common method of scientific research. It was first introduced into the field of education in 1950 when Bales, an American social psychologist, put forward the theory of "Interactive Process Analysis". He observed the interpersonal interaction process of group discussions in classroom context by using 12 codes of behavior interaction [1]. Thereafter quantitative research entered the classroom.

In the early stage of classroom observation, researchers firstly focused on the interaction between teachers and students. In 1960, Flanders, an American scholar, proposed FIAS (Flanders Interaction Analysis System), a classification system for classroom analysis which has been widely recognized and adopted by later researchers [2]. FIAS divides behaviors of teachers and students into three categories: teacher's language, student's language, and silence or confusion (total 10 possible situations in classroom), and it allows researchers to analyse the data through a matrix [3]. Since then, other influential classroom observation systems were gradually proposed and studied by Bellack in 1966 [4], Mehan in 1979 [5], Keizou in 1983 [6], Cazden in 1986 [7], Tadao in 1997 [8]. These classroom analysis systems provide a scientific analysis method for the description and analysis of interactions by classifying and quantifying

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teaching behavior in class. However, the classroom in this period was mainly composed of the interaction between teachers and students. The application of technology was not considered in depth in classroom observation since the technology was neither rich nor widely used at that time.

Only later did researchers begin to pay more attention to technical factors in the classroom. At the beginning of 21st century, with the rapid development of Internet and computer technology, educational resources—especially technical-support media—began to be created and used in class. Since this period, classroom teaching has undergone many changes due to rich teaching medias Professor Gu proposed ITIAS (Information Technology-based Interaction Analysis System) on the basis of FIAS [9], which firstly added specific contents to reflect students' behavior and human-media interaction. The improved coding system distinguished three subordinate behaviors, namely "teacher manipulation technology", "student manipulation technology" and "technology acting on students" at the level of technology interaction. But at this time, the description of technology use was not detailed, and specific applications for the classification of technology was not discussed. In 2010, considering the different media (traditional media and multi-media) applied in classroom, researcher Zhang added the teaching media dimension to the classical classroom observation system FIAS based on the typical method of teaching media classification developed by Laurillard (2002) [10]. He further expended the classroom observation system into two dimensions: classroom behavior and teaching media. Later, researcher Yang introduced TPACK theory as a new dimension into classroom observation, then proposed ETIAS (Educational Information Technology-based Interaction Analysis System) [11]. ETIAS expanded the classroom observation system into three dimensions: teaching behavior, teaching media and TPACK to analyze the behavior and the interaction with media of teachers and students in classroom, and also to analyze the knowledge structure that the teacher showed at classroom.

However, it has been 15 years since the dimension of technology was firstly introduced into classroom observation. In recent years, the rise and application of artificial intelligence, big data, learning analysis and other technologies have set off a revolution in Chinese primary and secondary schools. The Smart classroom has arisen at this moment. Our research team believes that smart classroom is an environment based on intelligent media and supplemented by traditional media, which can providing learners with personalized learning for learners, and providing teachers with a new, macro-controlled learning for teachers [12]. But the classroom observation systems previously constructed by Zhang and Yang are limited by technological development. The division of media dimensions is not applicable to the current smart classrooms based on intelligent media and resources. Educational informationization 2.0, a policy distributed by Ministry of Education in China, emphasizes the development of smart education based on various types of intelligent devices and networks, and promotes the transformation of education supported by new technologies.

Whether in traditional or smart classrooms, teaching is always the key link of school education [13]. However, the quality of teaching varies greatly among teachers in different places. Therefore, objectively and accurately evaluating the quality of teaching has become a difficult problem in the field of education. It is especially important to construct a classroom observation system for smart classrooms.

This study constructs a Smart Classroom-based Interactive Analysis System (SCIAS) by combing the previous literature and with the characteristics of intelligent media. SCIAS re-constructed the classification of media in the classroom of primary

and secondary schools, and re-interpreted the meaning of behavior to provide valuable reference for researchers and teachers in research and practice processes. Research goals can be divided into the following points:

1) Collect and collate information about development of interactive analysis system at home and abroad.

2) Reconstruct smart classroom analysis code, including three dimensions:

A) Behavior code design

B) Media code design

C) TPACK code design

3) Try to use the proposed coding system SCIAS to analyze a teaching video recorded in a smart classroom.

4) Verify the usefulness of the coding system SCIAS and its value to teachers and researchers.

2. Design for SCIAS

A smart classroom environment has a unique structure and unique characteristics. Previous coding systems which were designed for traditional or early multimedia classrooms are no longer suitable for today's smart classroom environment. Therefore, this study mainly considers the characteristics of smart classrooms. Referring to the previous coding systems FIAS, ITIAS and ETIAS, a new coding system called SCIAS was prepared for the analysis of smart classroom environments. It draws from the three dimensions of teaching behavior, media and TPACK.

2.1 Teaching Behavior Dimension

Teaching behavior is the sum of all kinds of explicit and implicit behavior modes centering on teaching objectives and tasks. Teachers manifest teaching behaviors in the three-step process of teaching design, teaching implementation and teaching evaluation. This process requires teaching concepts, teaching skills, practical experience and individual psychological characteristics [14]. The selecting of teaching behaviors and their effectiveness directly determine the success or failure of instructing effect, and are the main direct factors affecting the quality of teaching [15]. In the implementation of the new curriculum, teaching behavior research has become one of the effective ways of classroom teaching research, which has received widespread attention [16].

Table 1. Behavior Dimension in SCIAS

Dimension	Code	Content Forms	Interpretation	Type
	B1	accept positive feelings	Often having nothing to do with the teaching content it is usually the teacher's behavior when greeting the class, doing an icebreaker, and/or getting things started. For example, a teacher sings a song for the students before class, a gift from teacher to students, a teacher's humorous words, etc.	Teacher control
	B2	praise or encourage	Teachers have a positive attitude towards students behavior. For example, the teacher could tell everyone to applaud, or say, something like, “Very good!”or“I like the way you did X!”or “Think about it and tell me later.”	
	B3	accept or	Generally speaking, after a student answers a question, teachers	

Behavior		use student's opinion	accept te opinion. Examples include, “Yes, that’s right!” or“Yes, I think you mean. . .”The teacher might also record the answer on the blackboard.	
	B4	ask questions	The important behavior of testing students' learning effect in class. The teacher said, "Excuse me...? What plants are used in Mendel's hybridization test? etc.	
	B5	give explanation	Teachers’ important behaviors imparting knowledge to students, and teachers explain subject content knowledge. For example, what is a flat throwing exercise.	
	B6	give instruction or orders	Teachers give guidance and instructions to students. For example, teachers tell students to sit, stand up, go to the front of the class to give a speech, talk about something, etc. Teachers might also tell students that an experiment is over, or give students guidance on how to answer a question or how to solve problems during group discussions.	
	B7	criticize or maintain authority	Management behavior in the classroom that is not related to teaching content. Examples include pointing out bad behavior, telling students to be quiet, and telling students to focus on the lesson.	
	B8	practice with media or teaching aids	Emphasize that there is no teacher's words, but there are teaching behaviors, such as teachers playing Mendel's related experimental videos, demonstrating the use of guns to drop objects and connecting physical instruments, etc.	
	B9	interaction, promotion, or emphasis	It is generally the behavior of teachers and students simultaneously speaking and demonstrating. For example, when the students answer questions, the teacher writes the answers on the blackboard, or students answer at the same time teachers emphasize, and so on.	Both control
	B10	Passive to speak up	The student did not raise his hand, and the teacher instructed a student to answer questions. This behavior often occurs after the teacher asks questions (B4).	Student control
	B11	active to speak up	Students take the initiative to raise their hands to answer questions, propose questions, etc.	
	B12	speech or demonstration	Students give speeches or demonstrations in front of the classroom. This might include demonstrating experimental operations on the podium, drawing ecosystem diagrams on the blackboard, etc.	
	B13	collaboration	Students work in groups or teams. This could include students discussing problems in groups, conducting physical and chemical experiments in groups, etc.	
	B14	use educational resources independently	Emphasis on students' independent application of educational resources, such as student reading materials, searching online, doing calculations, playing simulation video games, etc.	
	B15	create works	Examples include students programming on a computer, writing in a notebook, or drawing on a piece of paper.	
	B16	silence or confusion	This does not refer to desirable silence. It refers to Silence here means neither words nor teaching behavior. Confusion refers to the behavior of students who are chaotic enough to fail to carry out the normal teaching process. For example, after the teacher asks questions, the students think about the problem for an	Uncontrolled

			abnormally long time; or the teacher has to take time to troubleshoot the classroom media system; or the teacher has to interrupt students silently working, which causes difficulty refocusing. The students are distracted by each topic and do not listen to the confusion of the teacher's classroom teaching.	

In this dimension, on the basis of the coding system of Flanders and Gu, the study refers to the classification code of classroom behaviors proposed by Zhang in 2010 [17], in which classroom behaviors of teachers and students are divided into 16 types, as shown in table 1. The behaviors are further divided into teacher control behaviors (B1 to B8), student control behaviors (B10 to B15), both control behaviors (B9) and uncontrolled behavior (B16). This code separates the teacher behaviors from the students' behaviors because researchers have different reasons for studying both behaviors, and it also specifically classifies the interaction between teachers and students in a more refined way.

2.2 Teaching Media Dimension

Teaching media is the carrier for teachers to transfer knowledge in class. Knowledge is intangible and abstract, thus teachers need to transfer knowledge visually to students through the carrier. This dimension is the key part of the design. Considering the coexistence of multiple media in today's smart classroom, the media dimension is divided into 12 types, as shown in table 2.

2.3 TPACK Dimension

It is not technology, but a teachers' use of technology that triggers educational reform. Such use not only involves the skilled operation of emerging technologies, but should also be informed by teachers' complex understanding of the comprehensive application of technology, knowledge and teaching methods. TPACK is not only a kind of new subject teaching knowledge that integrates technology, but also a new operational mode that can integrate information technology into the teaching process of various subjects. In the TPACK dimension, coding system are still divided into core elements (CK, PK, TK) and the composite element (PCK, TCK, TPK, TPACK) dimensions, which are shown in table 3.

Teaching media can be divided into four categories: traditional media and intelligent media. According to the actual situation of the class, two composing situations can be formed. Firstly, Composing Media (CM) will be composing into multiple media. For example, if a student is using an iPad to complete practice problems on a website, the media composing into a category consisting of II, IP and ID, namely CM. Another situation is that there is no media use in class, and teachers or students can only use language to communicate. This is classified as Verbal. In the classification of teaching media, the use of media in the smart classroom environment will gradually become the mainstream of teachers' use, while traditional media will not withdraw from the smart classroom due to its convenience, ease of use and other characteristics.

Table 2: Teaching Media Dimension in SCIAS

Dimension	Code	Content Forms	Interpretation	Type
Teaching Media	IL	Narrative media with ICT	Media presenting narrative content using modern educational techniques, such as PPT, Word, TV, projectors, etc.	ICT Media
	II	Interactive media with ICT	Media using modern educational technology to realize resource interaction functions, such as mobile phones, iPad network resources, special websites, online libraries, etc.	
	IC	Correspondence media with ICT	Media using modern educational technology to achieve communication functions, such as online discussion groups, chat rooms, forums, online meetings, etc.	
	IA	Symbolic intelligent media	Artificial intelligence using modern educational techniques to present and interact in symbolic form, such as expert systems, simulation labs, virtual travel, simulation programs, etc.	
	IX	Computing intelligent media	Artificial intelligence using modern educational technology to regard data, algorithms as the core and interactive, such as collaborative filtering, personalized recommendation, intelligent computing, intelligent analysis.	
	IP	Productive media with ICT	Media using modern educational technology to achieve productive functions, such as using computers, mobile phones, iPad software to answer questions, take photos, writing, program, etc., especially the use of various software behaviors	
	ID	Troubleshoot	Struggles with media and devices, such as solving audio problems, connecting lines, switching projection devices, electrical problems, programs crash, etc.	
	TI	Traditional interactive media	Traditional media with interactive functions, such as notebooks, blackboards, cards, physical and chemical lab instruments, etc.	Traditional media
	TL	Traditional narrative media	Traditional media presenting narrative content, such as textbooks, blackboards, cards, etc.	
	TP	Traditional productive media	Traditional media with productive functions, such as notebooks, pens, etc.	
	CM	Composing media	Using two or more teaching media at the same time, or the same knowledge to use different media for presentation, such as teachers using iPad annotations and slide shows to explain.	Two or more media
	Verbal	Only verbal, no other media	Only use language without using teaching media, such as instructing students to sit down and stand up; teachers only teach knowledge through words, without using any media, etc.	No media

Table3. TPACK Dimension in SCIAS

Dimension	Code	Content Forms	Interpretation	Type
TPACK	CK	Content knowledge	The content knowledge of the subject taught by teachers includes concepts, theories, methods, facts, etc. In classroom teaching, the content knowledge of the subject rarely exists alone and is generally integrated with pedagogical knowledge and integrated technology knowledge.	Core component
	PK	Pedagogical knowledge	The teacher's knowledge of teaching and learning processes, methods and practices has nothing to do with the specific subject content. For example, when the teacher says: please sit down, do a good job, start the discussion, finish the discussion, etc.	
	TK	Technological knowledge	Traditional technology and digital technology used in teaching do not involve teaching knowledge and knowledge of subject content, such as teachers' media debugging.	
	PCK	Pedagogical content knowledge	The teaching transformation of specific subject knowledge, such as the process of teachers' explanation and questioning, emphasizes no application of technology.	Compound element
	TCK	Technological content knowledge	The two-way interaction between technology and subject content does not involve pedagogical knowledge. For example, teachers connect physical instrument circuits, which is about the integration of subject content knowledge and technology, but is not teaching knowledge.	
	TPK	Technological pedagogical knowledge	It refers to how teaching changes due to the use of technology. For example, the teacher switches from PPT projection to physical projection. The process is that the teacher changes the use of teaching method through the application of technology.	
	TPACK	Technological pedagogical content knowledge	Emerging from the interaction of three elements, all using traditional and digital techniques in the classroom.	

3. Application of SCIAS

In order to verify the validity of SCIAS, this chapter uses SCIAS coding to analyze a junior high school third grade geography examination paper evaluation course. According to the coding record, the lag sequence analysis method is used to analyze the data by GSEQ software. The experimental design is as follows:

1) Video is recorded in the school being studied
2) Two independent analysts use SCIAS tagged video to get data records (refer to table 4)
3) The curriculum model is analyzed based on data records
4) Researchers propose corresponding strategies for upgrading and improving teachers' behavior model, so as to further optimize teachers' reflection and teaching. The detailed analysis process is as follows:

Table 4. Coding table for lecture and evaluation of Geography Papers

Number	Start time	Duration	Behavior	TPACK	Instruction Media
1	00:00.0	00:05.4	6	TPACK	IL
2	00:05.4	00:04.2	14	TPACK	CM
3	00:09.6	00:06.4	9	PK	verbal
4	00:16.0	00:03.8	9	PK	verbal
5	00:19.8	00:18.9	6	TPACK	IL
6	00:38.7	00:14.6	13	TPACK	CM
7	00:53.3	03:16.2	13	TPACK	CM
8	04:09.5	00:02.7	6	PCK	verbal
9	04:12.2	00:07.9	5	TPACK	IL
...	...	...	...	...	...
374	43:18.8	02:06.9	14	TPACK	CM
375	45:25.7	00:09.7	6	TPACK	verbal
376	45:35.4	00:02.5	5	TPACK	ID
377	45:37.9	00:56.6	5	TPACK	IL
378	46:34.5	00:22.9	6	TPACK	IL
379	46:57.4	00:03.5	9	PK	verbal

3.1 Teaching Behavior Dimension

In this lecture on geography papers, teachers' and students' behaviors can be roughly divided into three types: acceptance-questioning mode, acceptance-explaining mode and students' independent use of resources. Among them, acceptance-questioning mode is one of the types of teacher control mode, which is based on questions. Here we only extract the acceptance-questioning-interaction mode in acceptance-questioning mode for specific analysis.

From the Fig 1. , we can see that after teachers ask questions, it may be because the questions are too simple, most students basically grasp the content and there is no need to ask a student to answer, or the questions are difficult, teachers try to guide students with their own words, which leads to both teachers and students voicing at the same time (B4 to B9). We also can see that there are two situations after teachers and students make sound at the same time, that is, interaction/promotion or emphasizing behavior. One is that teachers continue to ask questions to form a cycle (B9 to B4), the other is that teachers give explanations (B9 to B5). The contents of the explanations here are divided into two kinds: in the case of simple problems, teachers go over to the next knowledge point and continue to explain new content; if the problem is difficult, the teacher will explain the teaching content related to the problem.

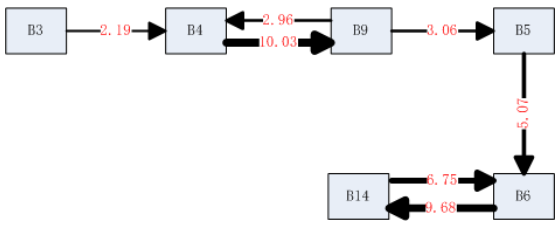

Fig 1. Pattern of Acceptance-Question-Passive Answer

3.2 Teaching Media Dimension

We also performed a lag sequence analysis on the use of classroom media. Based on the analysis results, we selected the smart media model for specific analysis, as shown in Figure 2:

The main corresponding teaching behavior using IX (IX to IX, Z=11.28) is explanation (B5). Reflecting the advantages of a smart classroom, teachers mainly use data for feedback and evaluation, analyzing the performance of class performance, and use interactive devices to explain exercises. Troubleshoot (IX to ID, Z = 6.81) will inevitably be involved in the process of using computational intelligence media by teachers, including both classroom media debugging by teachers and media debugging by students. The frequent debugging of students' media is followed by the use of composite media (ID to CM, Z=2.26). The composite media here using is corresponding to behaviors of student writing (B13) and students' self-use of educational resources (B14), that is, students use smart media to do exercises or some students make exercises because of different progress, and some students read book; and the teacher's behavior of explanation (B5), guidance, and instruction (B6), mainly embodied in teachers real-time check the progress of students' problem-solving, assign new tasks for students with fast progress, and comb the situation of students' problem-solving according to intelligent media feedback.

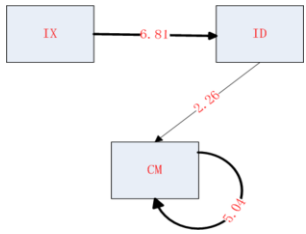

Fig 2. Intelligent Media Usage Model

3.3 TPACK Dimension

Analyzing the TPACK dimension, the TPACK structure of teachers in classroom teaching can be divided into the pedagogical structure model and the subject teaching method model of integrated technology, focusing on the pedagogical structure model of integrated technology, as shown in Figure 3:

This structure mainly involves the relationship between TPK and TPACK. TPK and TPACK mainly correspond to teachers' control behavior. TPK behavior mainly turns to TPACK behavior (TPK to TPACK, Z=2.61), and TPACK behavior also turns to itself (TPACK to TPACK, Z=4.48). Combined with a teaching video, we can see that TPK elements mainly refer to teachers giving instructions to students while using technology, such as teachers reading lists, or debugging the media and arranging some tasks at the same time; TPACK mainly refers to teachers asking questions to students while using technology, while students answer teachers' questions according to the content (or questions or knowledge points) presented by technology.

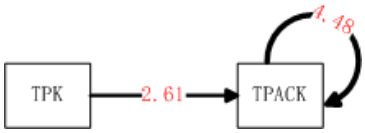

Fig 3. Structure of TPK

3.4 Improvement for teachers

Combined with the characteristics of the smart classroom, the SCIAS coding system has a complete coding system for behavior, media and TPACK. Through the analysis of the coding results, it can be seen that the teacher's behavior, media, and TPACK have further room for development and improvement.

In the aspect of teachers' behavior, when teachers get feedback from students and receive the signal that most students have mastered this knowledge point, then teachers give instructions to students and arrange for students to use teaching resources independently for autonomous learning. In the process of self-regulated learning, teachers should give further and continuous instructions, such as arranging new tasks for students who take the lead in self-regulated learning, so as to optimize the rhythm of the classroom.

In media applications, through coding research, media debugging is inseparable from classroom confusion. In this way, teachers can propose suggestions and strategies for improvement, such as: teachers have certain control over the classroom, or make adequate preparations or test equipment before class. Therefore, when the media equipment cannot be used in class, teachers can assign the task of using resources independently for students (B14) (such as asking students to do calculation questions, etc.), or give students guidance or instructions (B6) (such as letting students carry out Interpretation, guidance during the experiment, etc.), while debugging the media, making full use of the classroom time to avoid classroom confusion.

TPACK emphasizes the integration of technology application, pedagogical knowledge, and subject content knowledge. The model found in the study reflects the teacher's flexible use of technology to service the teaching of subject matter content, which shows that the teacher can not only select the appropriate technology according to the content, but also use technology to expand the source and type of richer learning content. Therefore, through the SCIAS code, we further evaluate the integration of teacher technology application with classroom and discipline.

It can be said that SCIAS coding is a very helpful coding system for teachers' development. Teachers can evaluate their own behavioral pattern and knowledge structure by using SCIAS, thus further promoting their professional development and constantly improving the teaching process.

4. Conclusion

The smart classroom has a solid place in the future of education, and the relevant analysis of smart classrooms must also become a focus of researchers. This research puts forward an interactive analysis system for smart classrooms, allowing the analysis of interactive teaching behavior in smart classrooms by focusing on three dimensions: behavior, media and TPACK. The SCIAS coding system can be applied to smart classrooms, and will result in an objective description of classroom teaching, which

will in turn help teachers to reflect on their own teaching process and practice. This will better promote the development of teacher education, and help students to reflect on their own learning process and activities. Altogether, SCIAS will improve the learning situation. However, there are still some limitations in this research. The design and formulation of the code has not been subject to expert external review. In addition, although the case provided by this study proves that the code is effective, the coded sample is too small, contingent, and not universal. In the next study, two tasks will be completed: one is to use the Delphi method to test the code, and the other is to use the SCIAS code to analyze more specific instructional videos.

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