Invited Lecture

Characteristics of Teacher-Student Interaction in Mathematics Classroom of Chinese Senior High Schools in the Information Technology Environment

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ABSTRACT Based on the Flanders Interaction Analysis System (FIAS) and the Information Technology-Based Interactive Analysis Coding System (ITIAS), nine high school math lessons from the National and Local Public Service Platform for Educational Resources were selected as the research objects and were analyzed to investigate the characteristics of teacher-student interaction in Mathematics Classroom of Chinese Senior High Schools in the Information Technology Environment.

Keywords: Teacher-Student Interaction; Mathematics Classroom; Information Technology Environment

1. Research Background

At present, China's senior high school mathematics curriculum reform advocates that teachers should build a good teacher-student cooperative relationship, engage students into classroom teacher-student interaction activities, stimulate students' interest in learning, so as to realize students' independent learning and improve the classroom teaching effect.

Some people think that the "quality lesson" should be the model of teaching. But are these quality lessons really positive in terms of teacher-student interaction? There is a paucity of evidence to support this. To investigate the teacher-student interaction in "quality lesson", this study chooses the lessons from the campaign launched by the Ministry of Education to promote teacher professor development — "Every teacher should have one high-level lesson; In the practice of each lesson, a famous teacher emerges" (referred to as "one good lesson from one teacher, one good teacher from one lesson").

2. Literature Review

2.1. Previous studies of "Quality Lessons"

Generally speaking, high quality teaching means outstanding level of teaching. For high-quality classroom, it means to provide high-quality classroom teaching, achieve

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the purpose of cultivating outstanding talents, and meet the educational needs of parents and the society.

However, the classification standards of classroom teaching quality have always been different. Quality classroom is a concept of development, which is restricted by political, economic and cultural factors in different time and environment, and is the result of comparing with certain objects.

German scholar Meyer (2006) put forward ten characteristics of quality classroom teaching: (1) clear classroom teaching structure; (2) a high proportion of effective teaching time; (3) A classroom atmosphere conducive to learning; (4) Clear teaching content; (5) Creating meaningful teacher-student exchanges; (6) Diversified teaching methods; (7) To promote the individual development of students; (8) cleverly set exercises; (9) Having clear learning expectations; (10) A complete classroom teaching environment.

Chinese scholar Lan Ye (2014) believes that a good class should have the following points: (1) valuable (meaningful); (2) efficient; (3) generative; (4) normality; (5) rooms to be improved.

Through review of mathematical quality lessons at home and abroad studies, a certain commonality has been found between Chinese and western lesson for high-quality research. For instance, the mathematics classroom of high quality should have good classroom atmosphere; the students can actively participate in teaching; the teacher as a facilitator of classroom teaching can guide the student to study independently.

However, there are many differences. The research on the quality of mathematics class in China is mainly speculative, which is often the summary of the experience of the quality class. Foreign research is mainly empirical, through the development of some scales to observe and evaluate the classroom.

2.2. Studies on classroom interaction between teachers and students

The study of teacher-student interaction originated in the 1970s, when the American educator Brickley first introduced the theory of interaction into the field of education. Subsequently, researchers constantly shifted the focus of interaction research to teacher-student interaction.

The research on teacher-student interaction mainly focuses on: (1) the essential characteristics of teacher-student interaction; (2) the mode of teacher-student interaction；(3) the influencing factors of teacher-student interaction; (4) observation tools for teacher-student interaction.

2.3. Relevant research on teacher-student interaction observation tools

Flanders Interaction Analysis System (FIAS) is a kind of classroom Interaction Analysis System proposed by American scholar N. A. Flanders in the 1960s. This system innovatively uses quantitative analysis to observe classroom behavior and plays a very important role in classroom observation research.

In order to study the quality of Classroom interaction among students in different learning periods, a team led by Piata from the University of Virginia in the United States developed Classroom Assessment Scoring System (CLASS). However, the system requires professional observers to observe and evaluate, and the operating conditions are relatively strict.

The TIMSS Video Study is part of The Trend of International Mathematics and Science Study (TIMSS). This project carried out a large-scale video research, and developed a coding framework for mathematics classroom video, which mainly analyzed six dimensions including the content, mode, organization form, language, teaching fragments and overall quality of mathematics classroom teaching.

Mathematical Quality of Instruction (MQI) is a widely used Mathematical classroom assessment tool. The MQI tool was developed by academic Heidhill and his colleagues. The evaluation system of MQI reflects the interactive relationship among teachers, students and content in the process of mathematics teaching, and evaluates the quality of classroom teaching from five important dimensions. The MQI tool does not evaluate the actual classroom teaching process but evaluates the recorded classroom teaching videos. The idea is to divide each video into roughly the same length segments of 5 or 7.5 minutes. Based on the encoding of these segments, the coder gives each segment a score on five dimensions, and then calculates the score for a lesson.

Because the Flanders interactive analysis system was produced in the last century, the analysis of the current classroom information digitization is not comprehensive enough, Chinese scholars have carried out corresponding research and improvement on the Flanders interactive analysis system.

Gu and Wang (2014) put forward the Information Technology Based Interaction Analysis System (ITIAS) supported by Information Technology.

Fang et al. (2012) proposed Improved Flanders Interaction Analysis System (IFIAS).

Through the analysis of existing teacher-student interaction research tools, it is found that all kinds of classroom evaluation tools have different foci and advantages and disadvantages in the study of teacher-student interaction in the classroom. In general, most of the tools pay more attention to the evaluation of classroom teaching effectiveness. Although they are applicable to a wide range, there are few evaluation tools with mathematical subject attributes.

3. Methodology

3.1. Research questions

This study aims to answer the following questions:

1) What is the status quo of the teacher-student interaction in the “quality lesson”?
2) What are the main characteristics of high school mathematics class in the aspect of teacher-student interaction?

3.2. Selection of research samples

According to the habits of Chinese teachers, this research divides the main mathematics classes of high school mathematics into: lesson of math concepts, lessons of math principle and lessons of math exercises.

It is determined that the representatives of the mathematical concept class are "3.1.2 Meaning of Probability", the representatives of the mathematical principle class are "4 Projection Theorem of Right Triangles", and the representatives of the mathematical exercises class are "3.3 Coordinate and Distance Formula of the Intersections of Straight Lines".

Tab. 1. Research samples

Teacher code	Teaching type	Topic	level	gender
G1	Main goal of learning mathematical concepts	Meaning of probability	A	female
G2	Main goal of learning mathematical concepts	Meaning of probability	B	female
G3	Main goal of learning mathematical concepts	Meaning of probability	C	male
Y1	Main goal of learning mathematical propositions	Projection theorem of right triangles	A	female
Y2	Main goal of learning mathematical propositions	Projection theorem of right triangles	B	male
Y3	Main goal of learning mathematical propositions	Projection theorem of right triangles	C	male
X1	Main goal of solving the math-topic	About the "line intersection coordinates and distance formula" exercise	A	male
X2	Main goal of solving the math-topic	About the "line intersection coordinates and distance formula" exercise	B	female
X3	Main goal of solving the math-topic	About the "line intersection coordinates and distance formula" exercise	C	male

3.3. Research methods

The following three methods were used in the study:

(1) Lesson study/Video study;
(2) Classroom Observation;
(3) Quantitative analysis.

Nine lessons from the above three topic were chosen as the objects of Video study.

3.4. Analysis framework

Based on the existing research, this study proposes an improved mathematics Classroom Interaction Analysis System (MCIAS), and mainly makes the following adjustments to the FIAS System:

(1) due to the information technology is widely used in classroom teaching, interaction between teachers and students gradually from words to information technology as the medium of multi-dimensional interaction, so words are no longer the sole cause of the interaction, and the use of information technology and classroom

activities, such as the classroom blackboard writing without verbal interaction influence the interaction between teachers and students.

China's mathematics curriculum standards emphasize that teachers should implement open teaching in the teaching process, create a teaching situation conducive to the development of students, stimulate the learning autonomy of students, and promote the all-round development of students. The raising of open questions is beneficial to the creation of teaching situation, so teachers' questioning is divided into two categories: "raising open questions" and "raising closed questions".

Students are the main body of learning, and stimulating students' initiative in learning is the key to achieve good teacher-student interaction. Students' active talking is divided into "active response" and "active questioning". Since student discussion has become an important part of classroom speech interaction, the category of "discussion with peers" is added under the dimension of "student language".

The original coding system was very rough in dealing with "silence", and many important classroom information was ignored, which could not reflect the characteristics of mathematics. In this study, the nonverbal behavior of both teacher and student are included in the teacher-student interaction, and the original "invalid speech" is detailed, and the codes "13 for silent thinking", "14 for students' practice", "15 for students' use of technology", "16 for teachers' demonstration", "17 for teachers' use of technology" and "18 for ineffective silence or confusion" are added. More detail please refer to Tab. 2 (on the next page).

3.5. Research process

3.5.1. Coding

Follow the Flanders Analysis method, according to the time sampling method, every 3 seconds is a sample of the classroom teaching. Record the encoding in a table chronologically. A record point in the table represents an action recorded every 3 seconds, each row represents 20 actions recorded in 1 minute, and the column represents the number of minutes of the lesson. There are about 700 to 1000 codes in one lesson.

3.5.2. Construct Analysis Matrix

After encoding the interaction between teachers and students in mathematics class, the observation record table is organized into a data matrix of order 18×18. Among them, the number of rows and columns of the matrix represent the 18 kinds of teacher-student behaviors stipulated by the coding system (Tab. 2).

The specific methods are as follows:

Each time, two adjacent data are taken from the encoded data sequence as an "order pair". The former data represents the number of rows of the matrix, and the latter data represents the number of columns of the matrix, which are accumulated in the corresponding matrix cells.

Assumes that the encoding of speech act between teachers and students, in turn, record of 4, 8, 9, 7, 10, 13, 17, 16, 5, 6, coding and link into a “sequence”, get nine corresponding “sequence”, (4, 8), (8, 9), (9, 7), (7, 10), (10, 13), 13 (2) and (17, 16), (16, 5), (5,6).

Where, (4, 8) means counting once in the cells of the fourth row and eighth column of the matrix, and (8, 9) means counting once in the cells of the eighth row and ninth column of the matrix.

The analysis matrix can be obtained by filling all the data into the cells of the matrix in turn.

Tab. 2. Coding system

Category	Coding	Item	Description
Teacher Talk	1	Teacher’s manner of acceptance emotion	Teachers do not accept, clarify, or express students’ feelings in a threatening manner.
	2	Teacher encouragement and approval	Approve or encourage student behaviour
	3	Accepting students’ ideas	Accepting students ideas; clarifying or developing their opinions or ideas.
	4	Raising open questions	Asking questions based on teachers’ opinions or ideas and expecting students’ answers
	5	Raising close questions	
	6	Teaching	The teacher provides facts or opinions on the content or steps of the procedure, expresses his or her own opinion, or quotes from authoritative scholars.
	7	instruction	Give instructions or orders that the student can comply with with a view to the student being able to carry out.
	8	Criticizing or defending teacher's authority	Change the behavior of students with harsh language and make it into acceptable behavior; scold and blame the students.
Student Talk	9	Passive response	(Response to code 4) Students respond to teacher questions. The teacher assigns the students to answer the questions, or triggers them to speak. Students are restricted in freely expressing their ideas.
	10	Active response	Students take the initiative to express their emotions and attitudes towards teacher behavior; students can express their opinions or ideas freely.
	11	Ask questions actively	Ask questions voluntarily and express your opinions freely.
	12	Discuss with peers	Students will discuss and exchange views with their peers.
	13	Static and silent learning	According to the teacher’s questions or instructions, students think independently, read silently, take notes, watch the teacher play videos, courseware, demonstration experiments, etc.
Student Behavior	14	Students practice	Students perform written exercises on the blackboard; students participate in games and demonstrate experiments; students participate in experimental operations independently or in groups.
	15	Students use technology	Students participate in teaching activities through information technology. Such as personal tablet, graphics calculator, answering machine and other equipment to learn
	16	Teacher demonstration	Teachers write on the blackboard, use traditional teaching AIDS or physical teaching AIDS for teaching, and operate equipment for experiments.
Teacher Behavior	17	Teachers use technology	Teachers use computers, tablet computers, slides, projectors, geometric drawing boards and other information technologies to conduct teaching activities.
	18	Invalid silence or confusion	The classroom is in a state of helpless teaching silence or chaos

3.5.3. Ratio Analysis

Matrix analysis can be used to explain the deeper meaning of the interaction between teachers and students in the classroom. These indicators are called variables. The variable here is mainly the ratio value of the interaction between teachers and students calculated through the analysis matrix.

For example, the proportion of teachers' discourse, the proportion of students' discourse, the proportion of teachers' operation, the proportion of students' operation, the proportion of silence, the proportion of teachers' questioning and the proportion of teachers' response.

Tab. 3. Ratio analysis

Variant	Formula	Description
Teacher talk ratio	$\left[\frac{\sum_{i=1}^{8} R(i)}{\text{Total}}\right] \times 100$	The ratio of teacher talk time in all the teaching time. The higher ratio indicates that the teacher talks more (Norm = 68)
Student talk ratio	$\left[\frac{\sum_{i=9}^{12} R(i)}{\text{Total}}\right] \times 100$	The ratio of student talk time in all the teaching time. The higher ratio indicates that the student talks more (Norm = 20)
Teacher operation ratio	$\left[\frac{\sum_{i=16}^{17} R(i)}{\text{Total}}\right] \times 100$	The ratio of teacher demonstration time or using information technology time in all the Teaching time. The higher ratio indicates that the teacher operates more.
Student operation ratio	$\left[\frac{\sum_{i=14}^{15} R(i)}{\text{Total}}\right] \times 100$	The ratio of student practice time or using information technology time in all the teaching time. The higher ratio indicates that the student operates more.
Silence ratio	$\left[\frac{\sum_{i=13}^{18} R(i)}{\text{Total}}\right] \times 100$	The proportion of the non-verbal teacher-student interaction time in the total teaching time. The higher the proportion, the less students have verbal interaction behavior and the more non-verbal interaction behavior.
Teacher response ratio	$\left[\frac{\sum_{i=1}^{3} R(i)}{\sum_{i=7}^{8} R(i) + \sum_{i=1}^{3} R(i)}\right] \times 100$	The ratio of discourse time that teachers respond to students' views and emotions in the discourse time that teachers are not directly related to teaching (except the teachers' questions and talking). The higher the ratio, the more teacher responds to the students. (Norm = 42)
Teacher question ratio	$\left[\frac{\sum_{i=4}^{5} R(i)}{\sum_{i=7}^{8} R(i)}\right] \times 100$	The ratio of the time when teachers ask questions in the time directly related to teaching (the time when they ask questions to teaching). The higher the rate, the better the teacher is at teaching through asking questions. (Norm = 26)

3.5.4. Validity of coding

In order to verify the scientific nature of the teacher-student interaction analysis system in mathematics classroom, the researcher invited three partners to code the classroom video of G1 teacher in the case study according to the coding framework and coding rules, and analyze the consistency with the researcher's own coding.

The analysis results showed that under the premise of 99% confidence, the Pearson correlation coefficient of the researcher and the three fellow observers was all greater than 0.993**, and the observed data were all highly correlated. Thus, the coding system has the characteristics of less subjectivity and strong objectivity.

The other six examples fall into two categories: lesson of math principle and lesson of math exercises.

4. Results and Discussion

In this section, the results of lesson of math concept (Teacher G1, G2 and G3) are presented though three types of lesson are studied due to the limitation of the layout (Fig. 1—Fig. 3).

4.1. The status quo of teacher-student interaction

The analysis of lesson of math concepts is arranged by their classroom language structure, question-and-answer of teachers and students, teachers' teaching style, teachers and students' emotion, teachers and students' behavior interaction.

Coding	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	20	6	3	7	8	0	0	1	0	0	0	1	0	2	4	0
4	0	0	4	10	1	1	0	0	10	6	0	0	6	1	0	0	2	0
5	0	0	0	2	10	1	1	0	15	0	0	0	3	0	0	0	0	0
6	0	0	0	5	8	129	4	0	0	0	0	0	1	0	0	5	18	0
7	0	0	1	6	1	1	21	0	3	3	0	0	1	10	2	6	4	0
8	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
9	1	0	18	4	1	2	2	0	3	0	0	0	0	0	2	0	0	0
10	0	0	5	1	0	3	3	0	0	2	0	0	0	0	0	0	0	0
11	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	1	0	0	0	0	0	0	11	0	0	0	0	0	0
13	0	0	2	1	2	7	3	0	2	0	0	0	47	0	1	0	0	0
14	0	0	2	0	0	0	7	1	0	0	0	1	0	33	4	0	0	0
15	0	0	0	1	1	0	2	0	0	0	0	0	0	3	29	0	2	1
16	1	0	0	2	0	7	4	0	0	1	0	0	0	0	0	55	1	0
17	0	0	0	3	3	11	2	0	0	1	0	0	7	0	1	3	57	2
18	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	7
Total	2	0	52	41	32	170	59	1	33	15	1	12	65	48	39	71	90	10

Fig. 1. Classroom interaction behavior analysis matrix of teacher G1

oding	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	2	0
2	1	0	0	0	0	3	0	0	2	0	0	0	0	0	0	0	3	0
3	0	8	24	9	4	4	0	0	6	1	0	0	1	0	0	0	2	1
4	0	0	1	50	0	5	5	0	11	7	0	2	2	1	0	0	0	2
5	1	0	0	0	33	1	5	0	12	0	0	0	4	1	0	0	0	0
6	0	0	0	9	8	157	2	0	0	0	0	0	0	0	0	3	11	0
7	1	0	0	2	2	1	5	0	15	2	0	3	0	1	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1	0	30	8	3	0	3	0	78	0	0	0	1	0	0	0	0	1
10	0	0	5	2	2	0	1	0	0	10	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	1	0	0	1	0	0	3	0	0	0	0	60	0	0	0	0	0	0
13	0	0	0	2	0	1	3	0	1	0	0	0	3	0	0	0	0	1
14	0	0	0	1	1	0	0	0	0	1	0	0	0	16	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	1	0	4	0	0	0	0	0	0	0	0	0	19	2	0
17	0	0	0	0	4	12	0	0	0	0	0	0	0	0	0	4	0	0
18	1	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	2
Total	6	9	60	86	57	190	32	0	125	20	0	65	11	19	0	26	20	8

Fig. 2. Classroom interaction behavior analysis matrix of teacher G2

Coding	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2	0	0	1	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0
3	0	1	44	5	18	10	3	0	1	0	0	0	1	0	0	1	1	3
4	0	0	2	14	0	0	3	0	29	0	0	0	2	0	0	0	0	1
5	0	0	2	3	14	0	2	0	56	0	0	0	0	0	0	0	2	0
6	0	0	0	8	11	98	3	0	0	0	0	0	0	0	0	0	2	1
7	0	0	1	1	1	3	17	0	8	1	0	1	3	6	0	0	1	1
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	3	37	13	25	6	8	0	16	1	0	0	1	0	0	1	1	3
10	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	1	0	0	0	0	0	0	8	0	0	0	0	0	0
13	0	0	0	0	2	1	3	0	2	0	0	0	92	0	0	1	0	0
14	0	0	0	1	2	0	3	0	0	0	0	0	0	97	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	24	1	1
17	0	0	0	3	3	1	0	0	0	0	0	0	0	0	0	0	35	1
18	0	0	1	1	2	3	1	0	2	1	0	0	1	0	0	0	0	10
Total	1	5	88	51	79	123	44	0	115	2	0	9	101	103	0	27	43	22

Fig. 3. Classroom interaction behavior analysis matrix of teacher G3

4.1.1. Analysis of classroom speech structure

Results show that G3 and G1 give students more time to think and promote their autonomous learning (Tab. 4).

Tab. 4. Language structure of lesson of math concept

Code	Teacher talk ratio （%）	Student talk ratio （%）	Silence ratio （%）	Ratio of teacher talk to student talk
G1	48.31	8.1	43.59	5.96
G2	59.95	28.61	11.44	2.10
G3	48.09	15.5	36.41	3.10
Norm	68	20	11/12	3.4

On the whole, the ratio between teachers' speech and students' speech fluctuates alternately, and the verbal interaction between teachers and students is more frequent (Fig. 4—Fig. 6). Students have more time to communicate with teachers and students, and students can express their views more freely.

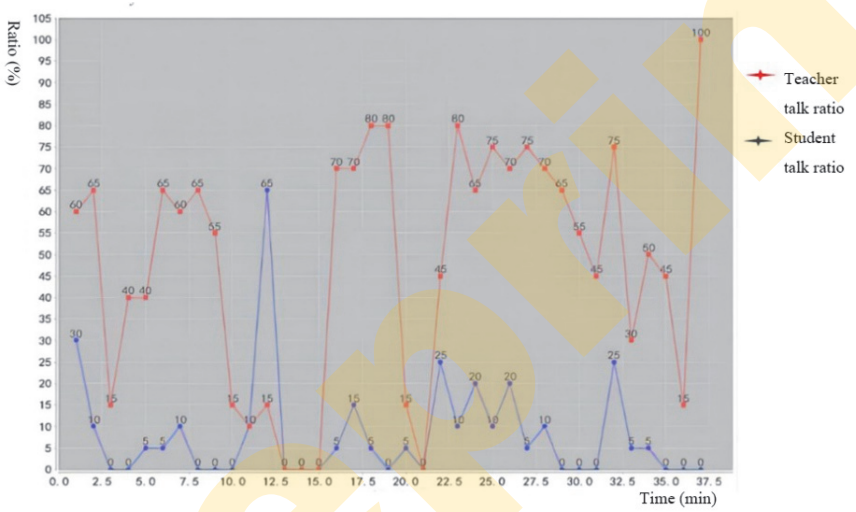

Fig. 4. Dynamic feature of ratio of teacher talk to student talk (for G1)

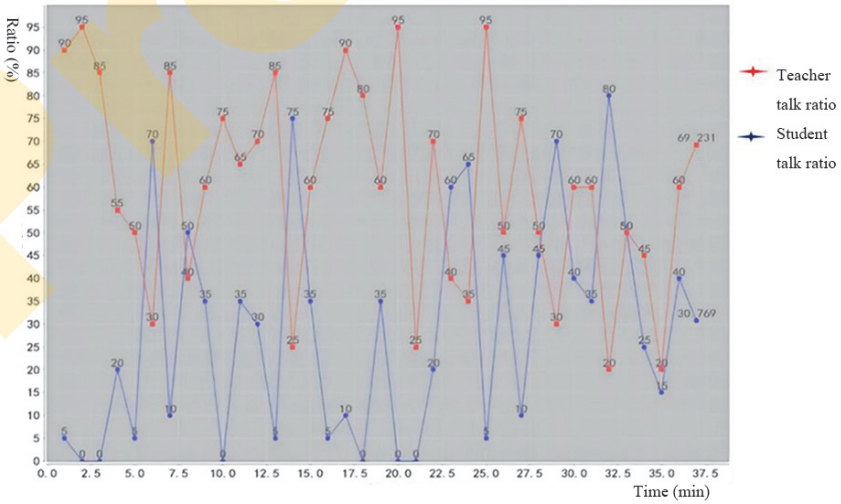

Fig. 5. Dynamic feature of ratio of teacher talk to student talk (for G2)

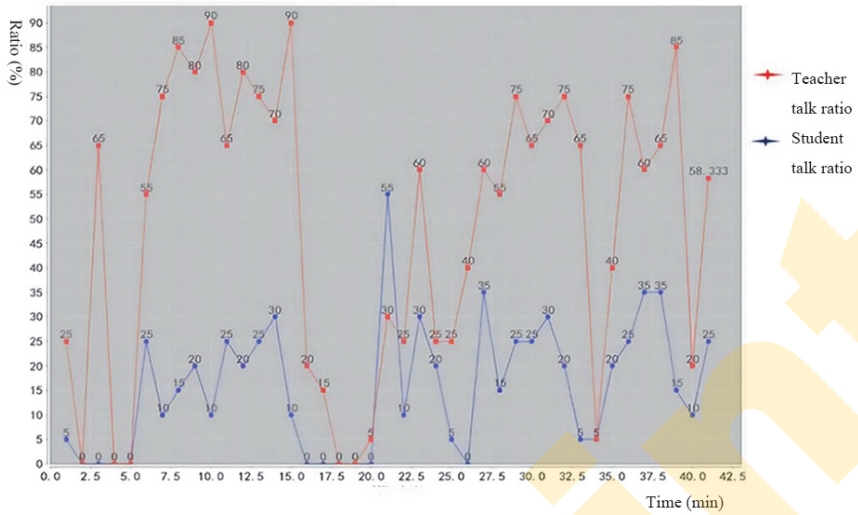

Fig. 6. Dynamic feature of ratio of teacher talk to student talk (for G3)

4.1.2. Teacher asking and student answering

As can be seen from the Tab. 5, the questioning ratio of teachers G1, G2 and G3 is greater than 26%, indicating that the three teachers are good at using questions to conduct teaching in class, and teachers G1 and G2 are good at using open questions to cause students to think. Among them, the number of open questions of G2 teachers reached 86, accounting for 60.14% of the total question ratio, while G3 teachers had more closed questions, and the rate of open questions was 39.23%, but the question ratio of G3 teachers was the highest, indicating that G3 classroom is driven by problems and promote the interaction.

Tab. 5. Statistics of teacher questions

code	Teacher question frequency	Teacher question ratio%	Open question frequency	Close question frequency	Open question ratio%
G1	73	30.04	41	32	56.16
G2	143	42.94	86	57	60.14
G3	130	51.38	51	79	39.23
Norm	-	26	-	-	-

Tab. 6 shows that the student ratio of G1 teachers alone is close to 34%, while the spontaneous student ratio of G2 to G3 teachers is much lower than that of the norm, which is just in line with the G3 that drives classroom teaching through the closed problem and is proposed in the teaching process.

Tab. 6. Statistics of student response

code	Passive response frequency	Active response	Active asking questions	Spontaneous student ratio %
G1	33	14	1	31.25
G2	125	20	0	13.79
G3	115	2	0	1.71
Norm	-	-	-	34

4.1.3. Teacher teaching style

From the perspective of teaching effect, Flanders divides teachers' speech into positive reinforcement and negative reinforcement, and from the teaching methods, it can also be divided into direct influence and indirect influence, the ratio of indirect influence and direct influence, positive reinforcement and negative reinforcement can be used to analyze teachers' teaching style inclination. Tab. 7 illustrates the different teaching style of the three teachers.

Tab. 7. Comparison of teaching style

Description \ Teacher code	G1(%)	G2(%)	G3(%)
Percentage of numbers of indirect influence	17.27	29.84	27.55
Percentage of numbers of direct influence	31.04	30.25	20.54
Ratio of indirect influence to direct influence	0.577	0.987	1.34
Percentage of numbers of positive reinforcement	7.42	10.35	11.56
Percentage of numbers of negative reinforcement	8.1	4.36	5.41
Ratio of positive reinforcement to negative reinforcement	0.917	2.38	2.13

It can be seen from the above table that the indirect influence of teacher G1 is much less than the direct influence, and less than 1, indicating that teacher G1 prefers the teaching style and adopts less questions and opinions for students, and the positive and negative reinforcement ratio of teacher G1 is less than 1, indicating that there is less positive reinforcement, less encouragement and praise in class, and more teaching and instruction in teaching.

The ratio of indirect and direct effects of teacher G2 is close to 1, indicating that teacher G2 has complementary indirect and direct effects in the classroom; G2 has the highest ratio of positive and negative reinforcement, which G2 like to give positive feedback, and accepting students' feelings, encouragement and opinions in the classroom are higher than G1 and G3, and the evaluation language is rich.

The ratio of indirect and direct influence of teachers G3 is the highest, indicating that the indirect teaching style adopted by G3, and the ratio of positive and negative reinforcement is greater than 2, indicating that they like to accept and encourage students' emotions through positive reinforcement speech, which makes the classroom atmosphere more harmonious.

4.1.4. Teacher emotion

In classroom teaching, good classroom atmosphere can promote the emotional communication between teachers and students, so as to help to form a relaxed and harmonious psychological atmosphere, which is easier to stimulate students' learning motivation. According to the Flanders interactive analysis system, the classroom teaching atmosphere of the three teachers was analyzed by using both the positive integration lattice and the negative defect lattice in the analysis matrix.

Tab. 8. Statistics of teacher emotion

Description \ Teacher code	G1	G2	G3
Numbers of active integration of areas	20	33	46
Percentage of actively integrated regions in total	2.70%	4.50%	5.66&
Numbers of times in the defect area	3	3	8
Percentage of defect areas in total	0.4%	0.4%	0.98%

From the number of defect area, three teachers have up to 8 times, and the percentage of defect area is not more than 1%, this shows that the classroom rarely change students' behavior through instruction or critical words. According to the analysis of video, three teachers use more peaceful words to communicate with students, let students feel the relaxed classroom atmosphere, and promote their active interaction with teachers.

4.1.5. Behavior of teacher-student interaction

In the classroom interaction between teachers and students, in addition to the effective teacher-student language interaction, there is also a large number of teacher-student nonverbal behavior interaction, which contains the ineffective speech interaction in silence. If these teacher-student behavior interaction conducive to teaching is ignored, it is obviously unable to obtain the real situation in the classroom. These effective teacher-student interaction behaviors can be divided into teacher behavior and student behavior; now information technology has been widely used in classroom teaching, including teachers using multimedia, computer, interactive whiteboard and network technology, and students using touch-screen smart desks, electronic bags, tablet computers. Of course, the classroom also contains many non-information technology of traditional classroom behavior interactions, such as teachers use traditional teaching tools, teachers use blackboard writing, students use equipment for experiments and students conduct written exercises. By statistical analysis of teacher behavior and student behavior in the system, the result is shown in Tab. 9.

Among them, G1 teachers' operational teaching behavior accounted for 21.73% of the total time, For 12.15% of the time, These include using an interactive touch-screen whiteboard and classroom management software; Students' learning through operational behavior accounted for 6.48% of the total time, The use of information technology time accounted for 81.2% of the operation behavior, Students use tablet computers for classroom exercises, and conduct a large number of throwing experiments with coins in class, and use the classroom software to upload the experiment results, and cooperate with teachers for learning, realizing the classroom dual-screen interactive learning.

Tab. 9. Behaviors of teacher-student interaction

Description	G1 (%)	G2 (%)	G3 (%)
Percentage of silent thinking and learning	8.77	1.5	12.42
Percentage of student practice	6.48	2.59	12.67
Percentage of student using technology	5.26	0	0
Percentage of student operation	11.74	2.59	12.67
Percentage of teacher demonstration	9.58	3.54	3.32
Percentage of teacher using technology	12.15	2.72	5.29
Percentage of teacher operation	21.73	6.26	8.61
Percentage of invalid silence or chaos	1.35	1.09	2.71

4.2. Characteristics of teacher-student interaction

It is found that the selected high-quality lessons have excellent performance in teacher-student interaction on the whole, but they have their own characteristics in specific analysis dimensions, as follows:

a) Teachers' speech structure is good and speech act is moderate, and there is not too much control over the classroom. Teachers gives students more time for verbal interaction.
b) A large amount of time is left for non-verbal interaction in high-quality classrooms, and the types of teacher-student interactions in the classrooms are diverse.
c) The teacher-student conversation time and students' speaking time are long, and the teacher-student verbal interaction is frequent and lasting for a long time.
d) Teachers are good at interacting by asking questions and stimulating students' enthusiasm for learning by asking open questions, so students can express their opinions freely and have a better verbal interaction with teachers and peers.
e) Teachers are good at responding to students' words through the indirect influence of praise, encouragement and adoption, and are also good at interacting with students in the classroom through detailed and close questioning.
f) Teachers can organize the classroom in an orderly manner.
g) Teachers mostly use direct control methods such as lectures and instructions to mobilize students, but students are less proactive.
h) Teachers are good at adopting teaching techniques of positive reinforcement, giving positive feedback to students' opinions or emotions, and accepting, encouraging and praising students' opinions and emotions.
i) In terms of interaction, female teachers prefer to teach in the classroom through lectures, while male teachers are more inclined to interact by requiring students to conduct written exercises, classroom board performances, or participate in activities and experiments and so on.
j) Among the selected high-quality lessons, compared with provincial and municipal high-quality lesson teachers, national high-quality lesson teachers

are more adept at using the blank in the classroom to give students more time to think and express.

5. Conclusions

Though the high-quality lessons have excellent performance in teacher-student interaction, there are still some room to be improved. The teachers should update the educational concept, optimize the classroom speech structure; should pay attention to the classroom to ask questions, cultivate students' awareness of asking questions; create a good classroom atmosphere and increase the depth of interaction and attach importance to the use of information technology and promote the diversification of interactive forms.

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