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The Study of Teachers' Questions Based on Videos of the Algebra Classroom

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Teacher's questions are the most important activities in classroom teaching, though the recording and quantitative analysis of videos of teaching algebra in the Middle School, this study explored the main content and length of time of teachers' questions, and also the link between the question and its response. The results after the analysis as follows: (1) There are many teachers' questions in the mathematics classroom, and the proportion of the type of questions is different; (2) The average time for students to answer questions is relatively short, but the proportion of the mechanical responses is high; (3) There is no direct relation between the "complex question" and "high cognitive response"; (4) Intelligent use of the frequency and intensity of the questions will help us to increase the effectiveness of classroom teaching.

Key words: mathematical question, video lesson, teaching algebra.

Introduction

Teachers' questions are one of the most important activities in the mathematics classroom, which help us achieve a variety of teaching and learning purposes. In fact, most of the activities and teaching evaluations are question-centered in the mathematics classroom (Bell, 1987). Practice has proven that a good question is the strongest point of effective teaching which can stimulate the students' motivation, focus their attention, help students learn and think better, and can also help the teacher know about a student's learning better (Dillon, J. T. 1988). The most important thing is that a good question can stimulate students' higher cognitive level thinking and develop students' awareness of the problem. Therefore, it's necessary for us to research about the question and its validity.

This study tried to find out the type and frequency of teacher's questions

and the students' answers in the algebra classroom, and explore the relationship between teacher's question and the quality of teaching through the analysis of 4 videos in a mathematics classroom.

Method

The TIMSS Video Study and Video Case Study are used for reference in this study. Questions by teacher under on-site observations and video recordings of the teaching in 4 classrooms were coded and classified, thus drawing some conclusions and inspiration.

Procedure

Participants

We chose two secondary schools in Hangzhou: Hangzhou Sandun Middle School and Hangzhou Binxing School, The schools were selected as the site for this research based on the act that we had a long-term cooperative relationship with them and the teachers were interested in participating. We began class observation, evaluation and shooting classroom video for 1 year. There are 4 teachers in this study, two of them come from Hangzhou Sandun Middle School, whom we coded as teacher A and teacher B. The content of their teaching is "The fundamental nature of Inequality"(the second half of the 8th grade). The other teachers come from Hangzhou Binxing School and we coded them as teacher C and teacher D. The content of their teaching is "The multiplication and division of the Fractions" (the first half of the 7th grade).

These 4 teachers have 2 or 3 years' experience in teaching. They have new concepts in teaching, working hard to assure their students' achievement in the general level at the school. These teachers actively participate in year-long lectures and class evaluation. Consequently, both the teachers and the students having adapted to having video cameras in the classroom, so that we can show normal classroom teaching as much as possible.

In the "digital age", algebra has become a door leading to higher education and more opportunities. The secondary school algebra courses bear the transformation from the constant to the variable, the change from arithmetic to algebra. Algebra teaching is both a focus and a difficulty. For this reason, as we considered a heterogeneous research perspective with one context, we chose two algebra classes: "The fundamental nature of Inequality"

and "The multiplication and division of Fractions" as seen in these 4 teachers' teaching videos. Before these two lessons are presented, the students have learned the relevant knowledge: "The basic nature of the arithmetic inequality" and "The multiplication and division of Fractions"

Analysis

We used two cameras to shoot video of the teacher and the students respectively in the process of classroom teaching, and then repeatedly viewed the video. During this process, we had three viewings: Firstly, transcribing the entire teaching process with a text, which included the teacher and the students' words and a supplementary description of the classroom. Secondly, recording the beginning and ending time, including its period of length, teachers' teaching and students' response. Thirdly, adding some details to the teaching, such as the teachers' line of walking line, facial expression, voice tone, and so on. The brief introduction to the process of arrangement is just as follows:

Firstly, (This part from "The multiplication and division of Fractions", phase three: Practice)

T18: Calculate this group of problems （00：09：45-00：09：54）

Q22: If anyone has the answer, please, hands up. （00：10:22-00：10:23）

Q23: S4, Do you have any explanations? （00：10：42-00：10：43）

S4: 3（00：10：44）

Q24: Is it right? （00：10：44）

S: Yes!（00：10：45）

T19: Good! Please sit down! Actually, we calculated this subject. In the verified process, how about the 1, 2, 4? OK! Because of the time, we won't verify this today, however, you need calculate it when you are verifying, but you can't just have a look. OK! Next one. This is a thinking question, you should calculate it seriously. （00：10：46-00：11：11）Next, we transferred the recording to a table.

Table1

Teaching Process

Teaching Links	contents	Start time(s)	End time(s)	Duration(s)	Remarks
Introduce	T	09：53	10：14	21	Introduce
	T	10：14	10：16	2	Operate PowerPoint
	Q1	10：16	10：18	2	Yes/No Questions
	S	10：18	10：20	2	Yes/No Response
	T	10：20	10：22	2	Transitional Language
	T	10：22	10：26	4	Operate PowerPoint
	Q2	10：26	10：31	5	Introduce
	S	10：31	10：33	2	Response
	T	10：33	10：34	1	Positive evaluation
	T	10：34	10：37	3	Operate PowerPoint

Coding and Analyzing

After the recording and statistics, we did some quantitative analysis on the statistics.

Coding the type of teacher's question. We compared every lesson and every teacher, including the number of types of teacher's questions.

The type of question. Teachers can question at various levels within the cognitive domain, such as knowledge, comprehension, application, analysis, synthesis, and evaluation (Bloom, 1956). According to Bloom's taxonomy and combined with the question's role and purpose, teacher's questions were coded as management, memorization, repetition, suggestion, suggestion, comprehension and evaluation.

① management: This question is just to make teaching orderly but it has nothing to do with knowledge.

Teacher: Can you see clearly?

Students: Yes!

② memorization: This question is about the basic facts, basic materials, such as concepts, formulas, theorems, properties, steps, procedures, and so on. Some academics have also called this type of question a factual question.

Teacher: OK, Let us see the next. Can you just remember what we should pay attention to in the fraction multiplication and division operations?

Students: The product of multiplied numerator as the new numerator, and the product of multiplied denominator as the new numerator.

③ repetition: Repeat the students' answer as the question. It shows the teacher suspects

the answer as incorrect or stressed the answer.

Teacher: An egg is probably equal to how much Newton?

Student: 2 Newton.

Teacher: 2 Newton?

Student: Two eggs are probably equal to 1 Newton.

④ suggestion: The teacher uses the related knowledge to stimulate students to think correctly because of the form of question.

Student: The possibility of occurrence is different.

Teacher: What is related to this difference?

⑤ comprehension: This question has a higher requirement for students. The students need to think, summarize and conclude the learned knowledge.

Teacher: If we still use the number axis to represent the number, I put "a>b" in the axes, now I plus "c" on both sides. So what does the "a+c" mean?

⑥ evaluation: This question requires the students to make a judgment based on some standard.

Teacher: Now who is willing to play games with me? OK! You choose first. If I throw two fair dice, Is the sum of two points odd or even? Which one has a better chance to win?

Student: Odd… Even…

The method of question. We coded the method of the questioning.

N: There is no student answer to the teacher's question;

Sn: The teacher calls on one student to answer the question;

GNSn: The teacher calls one line of students to answer the question one by one.

RS: The student answers the question randomly.

PS: Part of the students answer the question.

S: All of the students answer the question.

T&S: The teacher and the students answer the question together.

The type of response. According to the complexity of the student's response, students' responses were coded as no answer, mechanical, memorized, comprehensive, creative.

The definition of Response

A response was coded as no answer if the student did not answer the teacher's question; as mechanical if the student's answer was one the teacher or other students had given; as memorized if the student could answer the question through the memorization of knowledge; as comprehensive if the student answered the question by thinking and understanding; as creative if the student could use the existing knowledge to create new ideas.

In the analysis of the response, sometimes "no answer" didn't just mean the student won't thinking, but might mean that the question was too difficult to be answered, or the students didn't have enough time to think about it. So we divided the responses into low cognitive and high cognitive, except for "no answer". Because the "mechanical" and "memorized" answers don't need the students to think in complexity, we classified that as low cognitive. In a similar way, the "comprehensive" and "creative" answers need the students to think about and convert received information, and then arrange the content of answer, we classified that as high cognitive. The answers which are defined as high cognitive will better reflect the student's change in thinking and more abundantly than the low cognitive.

We included every question and response into Tables 2 and 3.

Table 2

The analysis of teacher's question

Teaching Links	Question ①	②	③	④	⑤	⑥	Summary Number	Time(s)
Ⅰ	0	2	12	2	5	0	21	88.5
Ⅱ	0	0	0	1	0	0	1	1
Ⅲ	0	0	50	4	7	3	64	193
Ⅳ	1	0	3	1	1	0	6	12
Ⅴ	4	0	26	1	4	4	39	166
Ⅵ	1	0	19	5	4	0	29	124.5

Summary	6	2	110	14	21	7	160	585

Ⅰ: introduce ; Ⅱ: explain the new knowledge ; Ⅲ: explain the example ;

Ⅳ: practice; Ⅴ: explain the practice; Ⅵ: summarize

①: memorization ; ②: management; ③:repetition;

④: suggestion; ⑤: comprehension ; ⑥: evaluation

Table 3

The analysis of students' response

Teaching	Response					Summary	
Links	①	②	③	④	⑤	Number	Time(s)
Ⅰ	1	6	5	9	0	20	88.5
Ⅱ	1	0	0	0	0	0	1
Ⅲ	5	18	15	25	1	59	193
Ⅳ	2	4	0	0	0	4	12
Ⅴ	3	19	4	13	0	36	166
Ⅵ	6	6	3	13	1	23	124.5
Summary	18	53	27	60	2	142	585

Ⅰ: introduce ; Ⅱ: explain the new knowledge ; Ⅲ: explain the example ;

Ⅳ: practice; Ⅴ: explain the practice; Ⅵ: summary

①: no answer; ②: mechanical; ③: memorized; ④: comprehensive; ⑤: creative

Conclusion and implication

The Approach of Questioning

We can see from the 4 videos that every teacher uses questions in classroom teaching, but the number of every type of question is different. As seen in Table 4, teacher C has the most questions among the 4 teachers in the classroom, having 160 questions , and teacher D's questions are the least, having 54 questions. The average number of questions is 117.25, and it takes 28.19% of the time in the lesson. As seen in Fig. 1, the proportion of every

type of question is different, but we can still find that the “suggestion” and “comprehension” is most frequently used by every teacher. The “suggestion” shows that the teachers are good at raising the appropriate questions to stimulate students to further thinking, which based on the students’ answer. Certainly, when the teacher used the “suggestion” she will appropriately reduce the demand and add the conditions, as the “suggestion” is relative to the “comprehension”, to remind students to complete answers or help students think them over. The “repetition” is just a repetition of the students’ answer as the interrogative question, which can serve as an emphatic function and help the students to enhance the understanding of knowledge. Relatively few questions are of the “management”, ”memorization” and ”evaluation” type in the 4 teachers’ classrooms. On the one hand, it shows that the discipline in mathematics classroom is good, on the other hand, because the ”memorization” and ”evaluation” are at the lowest and highest levels of cognitive demands, we can see that the teachers are conservative in using the questioning strategies at different levels, and the atmosphere of the whole classroom is relatively stable. There is no student who demonstrate high divergent thinking or too low.

Table 4

The analysis of question and response

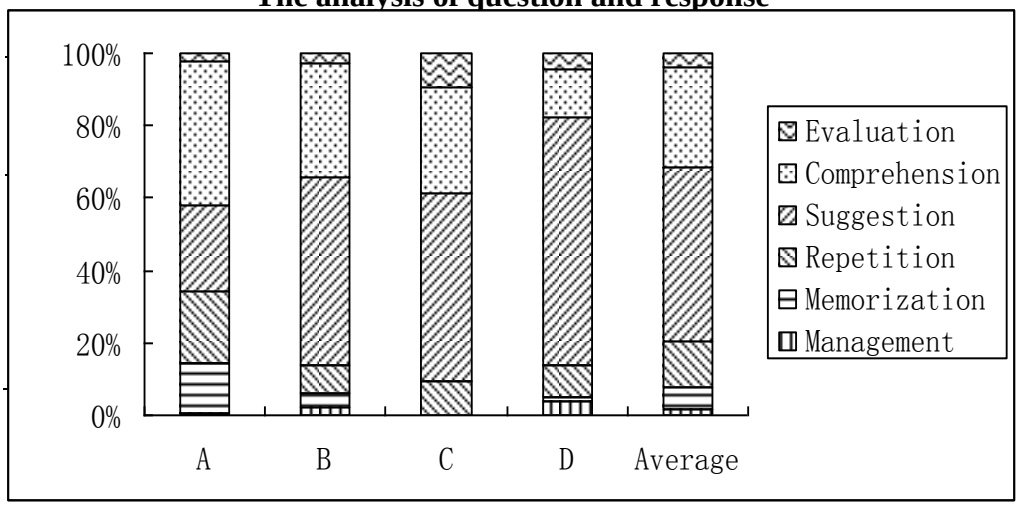

Figure 1. **The analysis of 4 teachers’ question.**
A: Teacher A B: Teacher B C: Teacher C D: Teacher D

The Student Response

As seen from Table 4, 28.19% of the whole lesson is occupied by the teacher's questions, and the time taken to ask question is longer than the time taken to respond to them.

Particularly, for teacher B and teacher C, the total questioning time is nearly twice as long as the students responses. This shows that the question is an important part of the teaching. The teacher controlled the entire process of the lesson with the question and the students are still in a relatively passive position.

On average, nearly 48.54 percent of responses are "comprehensive" and 23.31 percent of responses are "mechanical". These are the two types of responses which mostly evident. However, the "creative" response appears only 2.52 percent of the time. Figure 2 displays the students from teacher D's lesson are passive. They have more "mechanical" response than the others. Teacher B is better at encouraging students to in-depth thinking, and the occurrence of high level responses is high.

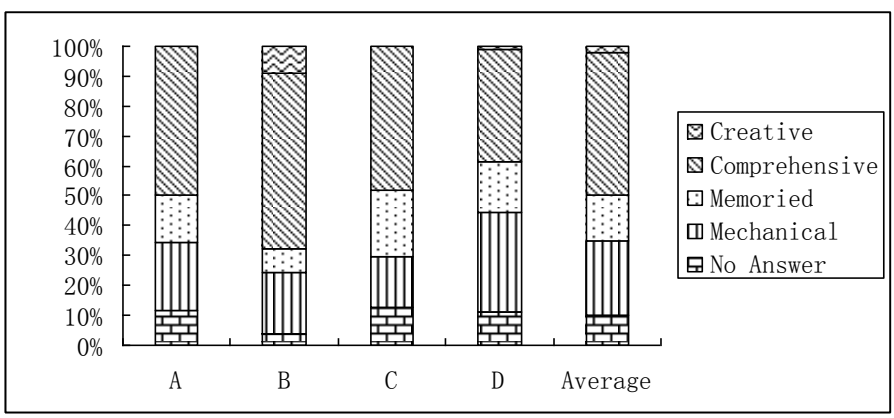

Figure 2. **The analysis of students' response in 4 teachers' lesson.**
A: Teacher A B: Teacher B C: Teacher C D: Teacher D

The Relationship between the "Complex Question" and "High Cognitive Response"

According to the different degree of the question, teacher questions are divided into the "simple question" and the "complex question". The "simple question" includes "management", "memorization", "repetition" and "suggestion". The "complex question" includes "comprehension" and "evaluation". As seen in Figure 3, the ratio of "complex question" to "simple question" is nearly 1 : 2. However, significant differences which can be found

in Figure 3. The teacher D's ratio of "complex question" to "simple question" is 1 : 3.93.

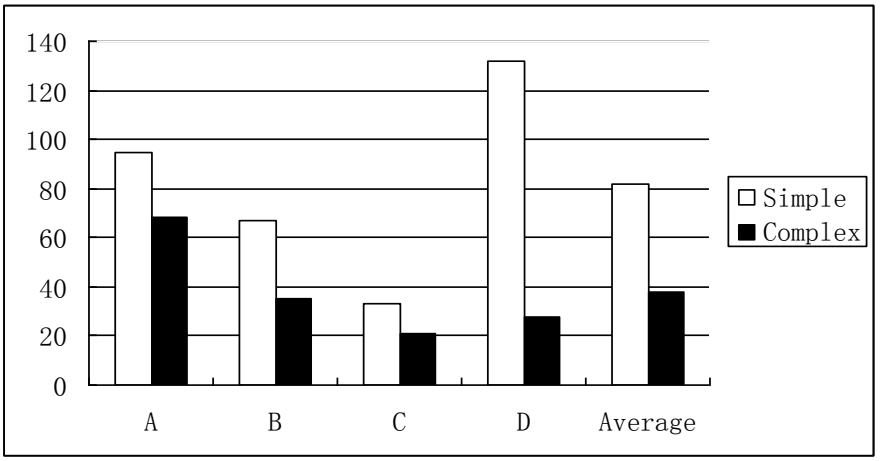

Figure 3. **The comparison of simple and complex questions in 4 teachers' lesson.**

A: Teacher A B: Teacher B C: Teacher C D: Teacher D

According to the different cognitive demands of the response, responses are divided into "low cognitive response" and "high cognitive response". The "low cognitive response" includes "no answer", "mechanical" and "memorized". The "high cognitive response" includes "comprehensive" and "creative".

We used the Pearson correlation test between the "complex question" and "high cognitive response" with the SPSS 13.0. The test results are shown in Figure 4:

Correlations

		Q	A
Q	Pearson Correlation	1	.728
	Sig. (2-tailed)		.272
	N	4	4
A	Pearson Correlation	.728	1
	Sig. (2-tailed)	.272	
	N	4	4

Figure 4. **The results of Pearson correlation test.**

Fig .4 displays that the value of Sig is greater than 0.05, which shows that there is no significant correlation between "complex question" and "high

cognitive response". In other words, increasing the difficulty of the questions is not the direct factor leading to the high cognitive response.

The Questioning Strategies

In general, the 4 lessons all demonstrated six teaching links: "introduce", "explain the new knowledge", "explain the example", "practice", "explain the practice" and "summarize", so we analyzed the questions in these different teaching links. In the different teaching links, we found that there is a significant difference in the number of kinds of questions. The "suggestion" and "comprehension" is mainly in the teaching link of "explain the example" and "explain the practice". In the link of "explain the new knowledge", there are only a few questions. That is to say, classroom teaching focused mainly on practice and explains the practice. The teachers achieve the teaching goal mainly through the practice.

Effectiveness of Questioning

We find that in mathematics classroom teaching, the teachers intelligently use of further questioning can enhance the students' mathematical concepts and theorem learning. Meanwhile, during the process of practice, the teacher can develop students' thinking through the high frequency and intensity of further questioning.

Further Discussion

(1) How do we define a good question in mathematics classroom teaching? Does the good question stimulate students' interest in learning mathematics and influence the achievement mathematics?

(2) How do we improve the teacher's capacity of asking questions in the mathematics classroom teaching?

(3) How many questions are appropriate? What is the relationship between the number of questions and the quality of classroom teaching?

(4) How can a teacher make the questions adapt to the level of students, raising the different level of question so as to target different students?

(5) Find the relationship between questions and the learning of mathematics.

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