

<b>Improving Learning, Fostering the Will to Learn</b>	
	European Association for Research on Learning and Instruction

## Capturing the Structure of Japanese Mathematics Lessons as Embedded in the Teaching Unit

Yoshinori Shimizu  
Tokyo Gakugei University  
shimizu@u-gakugei.ac.jp

Paper presented as part of the symposium “Perspectives on International Comparisons of Lesson Structure in Mathematics Classrooms in Germany, Japan, the USA, and Australia” at the 10<sup>th</sup> Biennial Conference of the European Association for Research on Learning and Instruction, Padova, Italy - August 26 – 30, 2003.

Other papers in the same symposium are:

Clarke, D. “The Problematics of International Lesson Structure Comparisons”

Mesiti, C. & Clarke, D. “Lesson Patterns in Superficially Similar Cultures: The USA and Australia.”

Jablonka, E. “The Structure of Mathematics Lessons in German Classrooms: Variations on a Theme”

*\*The research reported in this paper was supported by the research grant (grant ID: 13680195) by the Japan Society of Promotion of Science.*

## Capturing the Structure of Japanese Mathematics Lessons as Embedded in the Teaching Unit

Yoshinori Shimizu  
Tokyo Gakugei University  
shimizu@u-gakugei.ac.jp

### Abstract

*This paper examines the structure of Japanese mathematics lessons by analyzing the videotaped sequence of ten consecutive lessons in eighth grade from the Japanese data in the Learners' Perspective Study. Particular attention is given to the lesson pattern of a series of single lessons as embedded in the teaching unit of the topic to be taught. The Japanese lesson pattern, which is identified by the analysis of a set of single lessons in the TIMSS Videotape Classroom Study, is reconsidered by contrasting with the pattern and topics appeared in each lesson within the instructional sequence. The perceptions of lesson events held by the teacher and students are also examined. The analysis reveals that multiple lessons are interrelated and that the pattern of each single lesson looks differently when we locate it in the entire teaching unit. The analysis reported in this paper suggests that mathematics teaching and learning in Japan cannot be adequately represented by the analysis of a set of distinct lessons. Also, the analysis shows that the students perceive the significant events in the lesson in a different way from the way the teacher perceives them. The result suggests that the units of data collection and data analysis for the study of lessons are crucial for the international comparisons. The need is emphasized to attend the meanings constructed by the learners as the participants in classroom events.*

### Introduction

In the TIMSS Videotape Classroom Study, certain recurring features that typified many of the lessons within a country, Germany, Japan, or the United States, and distinguished the lessons among three countries were identified as “lesson patterns”(Stigler & Hiebert, 1999). The following sequence of five activities has been described as the Japanese pattern: reviewing the previous lesson; presenting the problems for the day; students working individually or in groups; discussing solution methods; and, highlighting and summarizing the main point (Table 1).

Table 1

The Japanese Lesson Pattern (Stigler & Hiebert, 1999, pp.79-80)

Reviewing the previous lesson
Presenting the problems for the day
Students working individually or in groups
Discussing solution methods
Highlighting and summarizing the main point

The study has shown that, to a significant extent, Japanese lessons can be characterized as “structured problem solving” in the sense that the teacher typically

intends to have the students work on problem and discuss solution methods, and then to highlight and summarize the main points in each lesson.

Needless to say, however, the lesson pattern can be varied within the instructional sequence for teaching a topic, depending on the teacher's intentions. The earlier analysis of lesson pattern of the videotaped sequences of ten consecutive mathematics lessons in Japanese classroom in the Learners' Perspective Study (LPS) data suggests that there are variations of the pattern and that a more complex view on the structure of mathematics lessons is needed than the lesson pattern described by Stigler and Hiebert's (1999) analysis of single lessons (Shimizu, 2002b).

It is interesting to know that Stigler and Hiebert noted as follows, referring to one Japanese lesson in their data which does not seem to fit for the variations of "structured problem solving."

This lesson shows that "structured problem solving" does not capture the full range of Japanese instruction. Indeed, it seems that the teaching method in this lesson is more like the methods typically used in Germany than the method typically used in Japan. If nothing else, the lesson reminds us that not all teachers within the same country use the same methods. (Stigler & Hiebert, 1999, p51.)

The earlier analysis of this study suggests that even the same teacher teaches mathematics in different ways in the instructional sequence, while "not all teachers within the same country use the same methods." This result can naturally be interpreted when we notice that Japanese teachers usually plan a sequence of several lessons as part of the teaching unit. In other words, each lesson in a unit has a different purpose in order for attaining the goals of the entire unit. The lesson at the introductory phase of the entire unit, for example, may look like "structured problem-solving", whereas the lesson at the final phase of the unit may have an emphasis on practicing what the students have learned.

The earlier analysis of consecutive lessons suggests the need to explore the "lesson structure in the sequence of lessons" in more details, as compared with the lesson pattern identified by the analysis of a set of single lessons in the TIMSS Videotape Classroom Study (Shimizu, 2002a). The current paper reports a follow-up analysis of the Japanese data from the LPS with a focus on the context in which each single lesson is embedded as a part of instructional sequence. The data from Japanese school one is re-examined by referring to the unit plan written by the teacher and by analyzing the post-lesson video-stimulated interviews with the teacher and the students.

### **Lessons as embedded in the teaching unit**

As was mentioned above, the analysis of LPS data reveals that there are several variations of the lesson pattern depending on the place in the entire teaching unit. Japanese teachers usually plan a lesson as part of the sequence of several lessons within teaching unit.

Even when they just use the textbook to follow the page by page and unaware of the instructional sequence for teaching a topic, they after all follow the sequence of lessons in the teaching unit by the following reason. Mathematics textbooks in Japan, which are commercially available from private companies, usually have several chapters. Each chapter, which constitutes a teaching unit, is edited in the way that the

teachers use one or two pages in each class period, and spend roughly ten to twenty class periods through out it. Also, each chapter is divided into several sections which constitute sub-units within the entire unit.

Thus, a single lesson is generally embedded in the sub-unit within the entire teaching unit (Fig.1).

Teaching Unit	Sub-unit 1	Lesson 1-1 Lesson 1-2 Lesson 1-3 Lesson 1-4
	Sub-unit 2	Lesson 2-1 Lesson 2-2 Lesson 2-3
	-----	-----
	-----	-----
	Sub-unit $n$	Lesson $n-1$ Lesson $n-2$ Lesson $n-3$

Fig.1: An example of hierarchy among a unit, sub-units, and lessons

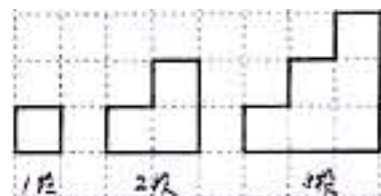
It should be noted that both the entire unit and sub-units constitute a coherent whole in terms of mathematical content or a series of problems posed in the sequence of lessons. This means that we cannot ignore the place of each lesson in the unit as well as the relationship between lessons when we explore the structure of lessons.

### The data analyzed

The main mathematical content taught in the videotaped classroom was “linear function”. The teacher intended to achieve the goals of the entire unit by having the students learn the change in the diagrams, graph, and formula, think about the domain of change, determine an independent variable against an dependent variable, learn the concept of the rate of change, and so on. The videotaped lessons included four major topics.

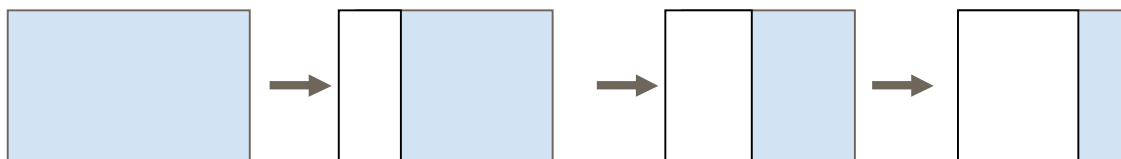
The teacher began by presented the “step problem”, the topic that continued for three class periods. She started the lesson with the following problem situation. The students explored the questions posed by the teacher as shown below.

Draw the figure of the fourth and fifth steps.  
 What is changing as the step becomes larger?  
 Explore the relationship between the numbers of steps and the perimeters.  
 Explore the relationship between the numbers of steps and the numbers of right angles.



Then, in the fourth lesson, the teacher posed the following “origami (paper holding) problem” in the classroom. The class spent four class periods for solving and discussing the problem.

Here is a yellow paper with length of 12 cm and width of 15 cm. What happens when we fold the paper like the following? Explore the relationship between changing two values.



In the eighth and ninth lessons, the teacher asked the students to draw the graph of linear functions of various slopes and y-intercepts.

The teacher used the tenth lesson for giving her students the opportunities for practices of what they had learned from the beginning of the unit.

The teacher wrote a “unit plan” of linear function in advance of the start of lessons. The first three rows in Figure 2 shows the unit plan written by Mr. K and the fourth row includes the corresponding lessons in the LPS data.

Teaching Unit	Sub Units	Lessons in the sub units and topics to be taught	Data in LPS
“Linear Function” (16 class periods)	1. “Changing variable and linear function—Part One”	Lesson 1-1: Finding variables in the “step problem”	JP1-1
		Lesson 1-2: Exploring the relationship between the number of steps and length of perimeter	JP1-2 JP1-3
		Lesson 2-1: Finding variables in the “paper holding problem”	JP1-4
	2. “Changing variable and linear function—Part Two”	Lesson 2-2: Exploring the relationship between the number of steps and length of perimeter	JP1-5 JP1-6
		Lesson 2-3: Reflecting on the exploration	JP1-7
		Lesson 3-1: Drawing the graph of linear functions: slope and y-intercept	JP1-8
	3. “Change of Values of linear function and the Graph”	Lesson 3-2: Drawing the graph of $y=-2x+4$ ,	JP1-9
			JP1-10
	4. “Finding the expression of linear functions” (Three class periods)		---
	5. “Applying a linear function” (Three class periods)		---
6. “Simultaneous linear equations and linear functions” (Two class periods)		---	
7. “Use of functions in daily life” (One class period)		---	

Fig. 2: The Unit Plan of “Linear Function” and the Corresponding Lessons in the LPS data

In the analysis of Japanese data, following thirteen categories were used to identify the lesson pattern. These categories are not mutually exclusive and used to identify what had happened in each lesson by analyzing the transcriptions.

Table 2  
The Thirteen Categories for Analyzing Lesson Pattern

---

Reviewing the Previous Lesson (RP)
Checking Homework (CH)
Presenting the Topic (PT)
Formulating the Problem for the Day (FP)
Presenting the Problems for the Day (PP)
Working on Sub-problem (WS)
Working on the Problem Individually or in Groups (WP)
Presentation by Students (PS)
Discussing Solution Methods (DS)
Practicing (P)
Highlighting and Summarizing the Main Point (HS)
Assigning Homework (AH)
Announcement of the Next Topic (AN)

---

In the earlier analysis of the data from the Japanese school one reveals a difference of lesson structures between the one identified by the first TIMSS Videotape Classroom Study and the one found in our data. For instance, “assigning homework” and “checking homework”, which were regarded as typical activities in both the German and the US lessons, were often found in the LPS Japanese data with a slightly different style (Table 3).

As shown in Table 3, most lessons began by checking homework or reviewing previous lesson and this rarely appeared to happen at any other time in the lesson. Then, a problem was presented and followed by students’ work on it. In most case, discussion of solution methods presentation by students as well took place middle of the lesson. In some cases, the teacher highlighted and summarized the main points of the lessons. Finally she assigned homework or announced the next topic.

Table 3. Categories Found in the Lessons

Lesson	JP1-1	JP1-2	JP1-3	JP1-4	JP1-5	JP1-6	JP1-7	JP1-8	JP1-9	JP1-10
Categories	CH	CH	RP	PT	RP	CH	RP	RP	PT	P
	FP	RP	PP	FP	PS	RP	PP	PT	WP	WP
	PP	PS	WP	PP	WP	PP	PS	PP	PS	PS
	WP	WP	PS	WP	PS	WP	DS	PS	DS	DS
	PS	PS	DS	PS	DS	WS	HS	DS	HS	HS
	DS	DS	WP	AH	AH	DS		P	HS	P
	AN	AH	PS			HS		AH	DS	WP
	AH		HS			P				PS
			P			AH				AN
			AN							

JP1-10 looks differently from other lessons. After each lesson, the teacher was asked to fill out the teacher questionnaire in which she is supposed to answer a few questions about the lesson she just taught. One of the questions reads as follows; “For this class of students, was the content of today’s lesson review, new, or somewhere in between?” Five alternatives were provided, “all review”, “mostly review”, “Half

review/half new”, “mostly new”, and “all new”. Mr. K selected “half review/half new” for the first nine lessons out of ten, JP1-1 through JP1-9, and “mostly review” only for JP1-10. Thus, tenth lesson was just added for giving the students an opportunity for practicing.

*The role of homework as a building block for the next lesson*

Stigler and Hiebert noted that “no home work is typical” (Stigler & Hiebert, 1999, p.30) for Japanese lesson, as contrasted with the other two countries. All the three classrooms in the Japanese data in the LPS, however, included both “assigning homework” and “checking homework”.

Table 4 shows the lessons that included “assigning homework”. In such cases, homework played the role of “connector” between two lessons (Sekiguchi, 2003). Homework tasks were treated as important building blocks for the next lesson. “Checking homework” at the beginning of the lessons was also used for building scaffolds to help the students.

Table 4. “Assigning Homework” Found in the Lessons

Lesson	JP1-1	JP1-2	JP1-3	JP1-4	JP1-5	JP1-6	JP1-7	JP1-8	JP1-9	JP1-10
Homework	*	*		*	*	*		*		

Table 5, on the other hand, shows the lessons that included “Highlighting and Summarizing the Main Point.” In the lessons JP1-3, JP1-6, JP1-7, and JP1-9, the teacher explicitly highlighted and summarized the

Table 5. Highlighting and Summarizing the Main Point

Lesson	JP1-1	JP1-2	JP1-3	JP1-4	JP1-5	JP1-6	JP1-7	JP1-8	JP1-9	JP1-10
Highlighting /Summarizing			*			*	*		*	*

When we focus on both “Assigning Homework” and “Highlighting and Summarizing the Main Point” simultaneously, we see multiple lessons as a coherent body. Namely, homework as a building block for the next lesson plays the role of connector between two lessons and the teacher highlighted and summarized the main point of the lesson at the level of sub-units. Thus, four different group of lessons at the level of sub-units appears (Table 6), as JP1-1~JP1-3, JP1-4~JP1-7, JP1-8~JP1-9, and JP1-10.

Table 6. Multiple Lessons Woven at the Level of Sub-units

JP1-1	JP1-2	JP1-3	JP1-4	JP1-5	JP1-6	JP1-7	JP1-8	JP1-9	JP1-10
AH	AH		AH	AH	AH		AH		
		HS			HS	HS		HS	HS

The correspondence of the table to the unit plan written by Ms. K is rather clear. Table 6 suggests that if we ignore the time elapsed by the activity in each category in Table 3, the pattern can be viewed in a broader way by using three general headings which are traditionally used in Japanese education community; introduction, development, and closing. Similarly, multiple lessons as a whole may have such a general structure like introduction, development, and closing.

### Perceptions of Significant Events between the Teacher and the Students

While Japanese teachers may devote considerable effort into the planning and structuring of their lessons, these structures may be perceived differently, or even may not be perceived, by the students. The methodology employed in the Learner's Perspective Study offered students the opportunity in post-lesson video-stimulated interviews to "parse" the lesson they had just experienced. That is, the students were requested to identify for the interviewer those elements in the lesson that they felt to be significant. Data collection involved videotaping classroom and individual interview data, using the video record as stimulus for their reconstruction of classroom event. The teacher and the students interviewed after lessons, were given control of the video replay and asked to identify and comment upon classroom events of personal importance.

Table 6 shows the numbers of elements in the lessons felt to be significant by the teacher and students. It is clearly possible that students identify as significant classroom events quite different from those identified by the teachers. As the table shows, the number of elements identified varies from one to twelve. Also, the numbers of elements of both between the teacher and the students and between two students in the same lesson are different.

Table 7  
Elements in the Lessons Felt to Be Significant: JP1-1~JP1-10

Lesson	Teacher	Student 1	Student 2
J1-1	—	Shi: 2	Tsu: 5
J1-2	—	Ma: 8	Mo: 6
J1-3	—	Shi: 5	Tsu: 2
J1-4	—	Ma: 7	Mo: 2
J1-5	9	Ni: 8	Ta: 7
J1-6	—	Un: 3	Ii: 4
J1-7	12	Ni: 8	Ta: 3
J1-8	—	Un: 1	Ii: 4
J1-9	—	Su: 8	No: 3
J1-10	—	O: 4	Iw: 4

In the post-lesson interview of the lesson J1-5, the teacher identified nine elements in the lesson to be significant, while each of two students interviewed identified eight and seven elements respectively. Although the number of elements identified as felt to be significant are similar between the teacher and two students, the point they identified were different. Only four elements were identical among three of them. As for the lesson J1-7, the teacher identified twelve elements in the lesson to be significant, while one of the two students identified only three elements and the other student did eight. In this case, the numbers of elements are different between them.

Table 8

Elements in the Lessons Felt to Be Significant: JP1-5

Categories	Teacher	Student 1	Student 2
RP	3:50		
PS			6:00
	9:29	9:23	
	14:00	14:25	14:22
WP		16:00	
	16:50		
			17:30
			24:44
		27:09	
	28:00		
PS/DS	29:30		
	32:26		
	33:30		
		34:30	
		37:45	37:26
			40:00
	42:50	42:55	43:02
AH		45:20	

Table 9

Elements in the Lessons Felt to Be Significant: JP1-7

Categories	Teacher	Student 1	Student 2
RP	2:00		
		2:38	3:00
PP	11:30		
	15:00		
WP		17:25	
	22:00		
		22:40	
			23:30
PS/DS	24:11		
		26:40	
	(**:**)		
	30:00		
		31:17	
		31:40	
	34:30		
		36:25	
	37:00		37:00
	40:00		
	40:20	40:24	
	42:00		
HS			

Analysis of student interview data suggests that Japanese students perceive lesson structure differently from their teacher. The elements in “Reviewing the Previous Lesson” in JP1-5 and JP1-7, for example, were perceived differently by the same students. In deed, the teacher identified the elements in “Reviewing the Previous Lesson” both for JP1-5 and JP1-7 as of significance, two students identified the elements only for JP1-7.

## **Discussion**

### *The issue of units of data collection and data analysis*

As was the case in the TIMSS Videotape Classroom Study, a research design of the international comparative study of mathematics lessons may use “lesson” as the unit of both data collection and data analysis. It is natural that we consider a lesson as a basic element of practice of teaching and learning. However, a single lesson as a administrative and organizational unit may not be a meaningful unit from the participants’ perspectives. For the teacher who plans and controls the teaching unit, in particular, a single lesson may not be enough for teaching particular topic from a mathematical point of view or in her educational intentions. The analysis of LPS data reveals that there are several variations of the pattern in relation to the place of each lesson in the entire teaching unit.

The process of mathematics teaching and learning in Japanese classroom cannot be adequately represented by a single lesson pattern by, at least, the following two reasons. First, lesson pattern differs considerably within the teaching unit or the sub-unit depending on the teacher’s intentions. Second, elements in the pattern themselves can have different function in the sequence of lessons. Needless to say, it is an important aspect of teacher’s work not only to implement a single lesson but also to weave multiple lessons that can stretch out over several days into a coherent body of unit. Then, if each lesson is analyzed as “stand alone”, it is not possible to capture the dynamics of teaching and learning process.

Then, how mathematics lessons might be compared internationally? An alternative approach to capture the lesson structure may be to identify the specific components from which each lesson is constructed and to examine the function of the components in the instructional sequence. The analysis reported in this paper suggests the value of a sequence of consecutive lessons as the preferable unit of data collection than the single lesson. An alternative choice for the international comparison of lesson can be comparing the lesson event as embedded in the teaching unit that takes participants perspective into considered. Lesson events may be compared by locating it at the level of sub-unit or the entire unit as well as within the single lesson.

### *The voice of the teacher and the students as participants in the lesson events*

As the analysis of the elements in the lessons felt to be significant by the teacher and the students reveals, the perceptions of lesson events held by the teacher and the students differ quite a lot. The result raises the issue of differences between teacher and student perceptions of lesson structure and of the need to attend the meaning constructed by the learners as the participants in classroom events. If we take an approach of comparing the specific components from which each lesson is constructed and to examine the function of the components in the instructional sequence to capture the lesson structure may be to identify we have to listen to the voice of the participants in the lesson events.

The comparison of perceived events to be felt significant by the teacher and the students clearly shows that there are similarities and difference between them. When we look into the interview data closely, the difference can be understood as discrepancies in perceptions of classroom events between the teacher and the students.

#### Final remarks

The Japanese lesson pattern has been identified by the analysis of a set of single lessons in the TIMSS Videotape Classroom Study. The pattern seems to be quite similar to those lesson structure which we typically find in the observed lesson “lesson study meeting” in Japanese mathematics education community and to the segments in the format for writing lesson plans which is usually used in pre-service teacher training course at universities. The analysis reported in this paper suggests, however, that mathematics teaching and learning in Japan cannot be adequately represented by a single lesson pattern and that the unit of data collection and the unit for the analysis are crucial for the lessons to be compared internationally.

#### References

- Clarke, D.J. (2001a) *Study Design: Learner's Perspective Study*. University of Melbourne
- Clarke, D.J. (2001b) *Perspectives on Practice and Meaning in Mathematics and Science Classrooms*. Dordrecht: The Netherlands, Kluwer Academic Publishers.
- Sekiguchi, Y. (2003) Analysis of connections between lessons in mathematics classrooms in Japan: A case study of two classes. (in Japanese) In Y. Shimizu (ed.) *Cross-cultural Study on the Teaching and Learning Process in Mathematics Classrooms*. Tokyo Gakugei University.
- Shimizu, Y. (1999a) Aspects of mathematics teacher education in Japan: Focusing on teachers' roles. *Journal of Mathematics Teacher Education*, 2 (1):107-116.
- Shimizu, Y. (2002a) Discrepancies in Perceptions of Lesson Structure between the Teacher and the Students in the Mathematics Classroom. Paper presented at the interactive symposium, “International Perspectives on Mathematics Classrooms”, at the Annual Meeting of the American Educational Research Association, New Orleans, April 4, 2002
- Shimizu, Y. (2002b) An analysis of lesson pattern in the sequence of mathematics lessons and associated values held by the teacher and the students in Japan. *Paper presented at the ICMI Comparative Study, Mathematics education in different cultural traditions: A comparative study of East Asia and the West, Hong Kong, October 21-25, 2002*
- Stigler, J.W., Patrick Gonzales, Takako Kawanaka, Steffen Knoll, and Ana Serrano (1999) *The TIMSS Videotape Classroom Study: Methods and Findings from an Exploratory Research Project on Eighth-Grade Mathematics Instruction in Germany, Japan, and the United States*. Washington, DC: U.S. Government Printing Office.
- Stigler, J.W. & Hiebert, J. (1999) *The Teaching Gap*. New York: NY, Free Press.

## APPENDIX

**Elements in the lesson felt to be significant: Lesson 1-5**

	Teacher (9 elements)	Student 1(Nii)(8 elements)	Student 2(Taka) (7 elements)
	3.50 Reviewing the previous topic students on the same starting		
			6.00 Discussion on the problem
	9.29 Two students presenting their	9.23 Checking the table	
	14.00 Group work	14.25 Group work	14.22 Group work
	16.50 Taught at the students' desks	16.00 Discussion in pair and then the to their desks	17.30 Teacher came to their desks
	28.00 Student (Nobo) presenting	27.09 Student (Nobo) presenting	24.44 Student (Nobo) presenting
	29.30 Student (Nobo) presenting		
	32.26 Student (Ume) presenting		
	33.30 Student (Taka) presenting	34.30 Student (Taka) presenting	
		37.45 Herself presenting	37.26 Students (Niibo) presenting
			40.00 Student (Taka) explaining
	42.50 Student (Ume) explaining	42.55 Student (Ume) explaining	43.02 Two graphs compared (Student (Ume) explaining)
		45.20 Student (Nobo) explaining	

**Elements in the lesson felt to be significant: Lesson 1-7**

	Teacher (12 elements)	Student 1(Nii)(8 elements)	Student 2(Taka) (3 elements)
	2.00 Reviewing the previous topic	2.38 Reviewing the previous worksheet	3.00 Reviewing the previous worksheet
	11.30 New worksheet was distributed to students		
	15.00 Students working on the task		
		17.25 Teacher explaining by using a diagram	
	22.00 Student (Shima) presenting his idea		
	24.11 Group discussion	22.40 Group discussion	23.30 Group discussion
		26.40 Group discussion	
	( ) Asking students decision		
	30.00 Confirming the point	31.17 Student (Nobo) presenting and expressed her opinion	
		31.40 Student (Nobo) presenting and expressed her opinion	
	34.30 Drawing the graph		
	37.00 Teacher explaining by drawing the graph	36.25 Teacher explaining by drawing the graph	37.00 Teacher explaining by drawing the graph
	40.00 Being Stuck		
	40.00++ Student (Nobo) presenting his idea	40.24 Classmates looked understood and their ideas	
	42.00 Teaching at the students desks		