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Note to U.S. Readers: This packet is a condensed version of the information given to observers of the research lessons on "The Secret of Trapezes (The Movement of Pendulums)"

In prior lessons, students thought about what changes the time it takes for a trapeze to make one back-and-forth swing. In these lessons, the class investigated three factors:

A. The weight of clay on the trapeze
B. The angle of release
C. The length of the wire

In actuality, only **C.** (the length of the wire) affects the cycle time. Some students have a hard time figuring this out because of measurement error and failure to control variables.

Lesson Plan and Teaching Record (condensed)

I. Overall Approach in Science

1. School's research theme: "To develop scientific perspectives and ideas by conversing with nature."
2. General organization of science lessons

II. Overall Organization of Unit

1. **Title of unit:** "The Secret of Trapezes"(The Movement of Pendulums)
2. **Objective:** *(written by Mr. Otaki)*

By investigating the factors that affect the cycle of trapezes, to learn how to control variables, and to consider measurement error; to develop a scientific perspective that the length of wire affects the cycle.

(Note from the translators: The study of pendulums is usually incorporated in the unit on the movement of things (*monono ugoki*) in the Japanese science curriculum. The objective in the *Course of Study for Elementary Schools* (1989), specifically related to the study of pendulums is: "To learn that the cycle of a weight hanging on a thread is affected by the length of the thread." (Note: the term "pendulum" is not used in the *Course of Study*.)

3. **Relating to students**

1). **Teaching materials**: Trapeze models with a paper clip doll and a magnet (See Illustration A)

2). **Motivating students**: Describes, for example, how Mr. Otaki began relating to students in the beginning of the school year and how he set up social goals for the students.

4. **Background information on three targeted students** (Attachment B)

5. **Unit plan (9 periods total):** Description of planned teacher instruction and anticipated students' responses
(Attachment C)

6. **Record of student investigation prior to the research lessons:** Teacher-student exchange record with detailed information on the behavior and statements of the three targeted students.

7. **Record of student reflection and comments** (dated June 19, after the fourth period): Described in a square per student representing their seat arrangement.

III. Lesson Plan for Day 1 of Research Lesson

1. Title of unit: "The Secret of Trapeze (The Movement of Pendulums)"
2. Date: July 2 (Tuesday), 1996.
3. Summary of prior lessons and hopes for today's lesson
4. Student investigation expected in today's lesson
5. Record of students' ideas prior to today's experiment, describing how they want to conduct today's experiment (Attachment D)

IV. Lesson Plan for Day 2 of Research Lesson

1. Title of unit: "The Secret of Trapeze (The Movement of Pendulums)"
2. Date: July 3 (Wednesday), 1996.
3. Hopes for today's lesson
4. Student investigation expected in today's lesson
5. Record of students' findings from Day 1 of Research Lesson (Attachment E)

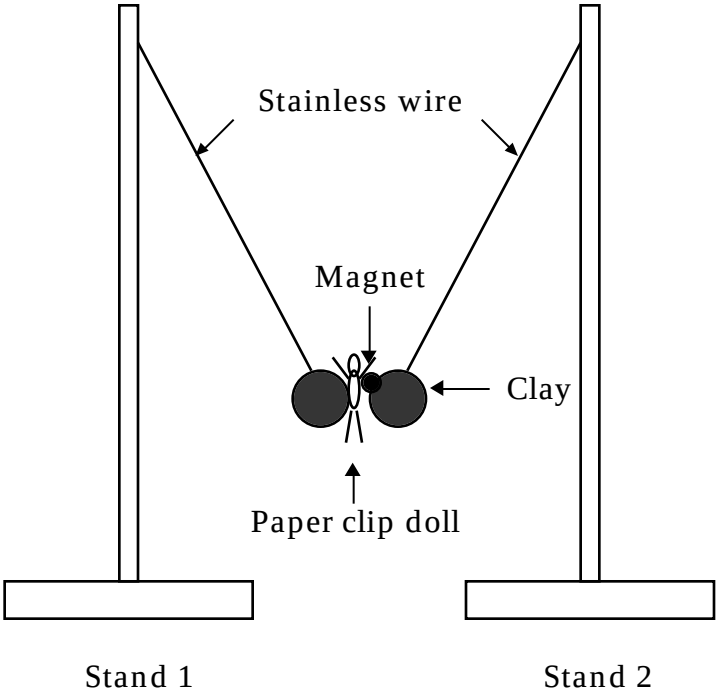
V. Record of Teacher-Student Exchange in Day 1 of Research Lesson and Comments from the Two Observers (recorded by two different teachers who observed the lesson; one teacher dictated the first half of teacher-student exchange while the other teacher dictated the second half of the lesson.)

VI. Record of Teacher-Student Exchange in Day 2 of Research Lesson and Comments by the Two Observers (recorded by two different teachers who observed the lesson; one teacher dictated the first half of teacher-student exchange while the other teacher dictated the second half of the lesson.)

VII. Record of Teacher Exchange with Three Targeted Students and Comments by the Recorders

VIII. Record of Student Investigation in Ninth and Tenth Lessons: Teacher-student exchange record with detailed information on the behaviors and statements of the three targeted students.

Illustration of Two Desk-top Trapeze Models with a Paper Clip Doll and a Magnet



Attachment B
Background Information on Three Students
(Verbatim translation from the materials given to observers)

The following three students were closely observed and analyzed by the host teacher and collaborators in the science department.

1. Student 1 (Kouji)

He likes reading "educational cartoons (gakushuu manga)." Using information he gets from these cartoons, he usually expresses his ideas willingly in class. He systematically engages in independent study at home, and voluntarily turns in five different study notebooks every day. He completed a commercial quiz booklet that he purchased, which covered the first volume of the science textbook in just a month and a half. At that pace, he will already have covered the study of pendulums, which is in the second volume of textbook, by that time I begin the lessons. Even if we use desktop trapeze models instead of pendulums, he will immediately realize, "Aha, this is the study of pendulums!" He will be the one who says to the class, "It is the length of the wire that changes the cycle of trapezes." However, to be able to state that in class, he will need to experiment, devising his own procedures. Besides, he needs to find out from the experiments that the weight and the angle of release are irrelevant. In the end, his knowledge alone will not convince his friends. Thus, he will struggle to learn how experiments should be designed and how the results should be interpreted. Through such activities, I hope that he will learn to value facts, analyze the findings carefully, and develop his ideas and a scientific way of thinking.

2. Student 2 (Sadako)

She often expresses her preferences, such as what she likes or dislikes or what she thinks right or wrong, very strongly. As a result, she sometimes gets in arguments with her friends. However, in the very next lesson period she can accept what is good about the friend whom she disliked earlier. Given these qualities, she will be able to express her opinions or challenge others' ideas in this unit. Regardless of who is her partner in the experiments, she will express her ideas honestly and participate in the experiments actively. . . Besides, since she tends to value facts, I assume that she will pay attention to the subtle differences in the movements of clay in the experiments. I wish for her to control conditions as precisely as possible, become aware of measurement error, and develop her scientific perspectives and ideas. In addition, I expect her to be at the center of class discussions. I want to closely observe how her opinions affect others and how carefully she considers others' opinions and reconstruct her ideas.

3. Student 3 (Takumi)

He likes animals and plants and often writes about natural phenomena as main themes in his journal. . . He also likes science lessons and expresses his opinions more often in science lessons than in other lessons. He often writes about the science lessons in his journal as well. In lessons, he conducts observations or experiments patiently and writes the facts or his thinking in his notebook. He also prefers writing his questions or opinions in a notebook over expressing them in class discussions. Thus, I can expect him to make a unique contribution to the class in this unit. By repeating experiments in pairs and being supported by his partner, he will gain confidence and feel more comfortable speaking out. I also would like to introduce his ideas to the class by referring to what he wrote in his notebook or by intentionally calling his name in class discussions. By listening to his opinions, his friends will recognize his goodness. At the same time, his friends will express their agreements or disagreements with him. If I can help him stay in the center of the discussion, I can help him reflect upon his experimental procedures and realize the importance of controlling variables or conducting experiments with high precision. Through these activities, I wish him to develop his scientific way of thinking and his ideas in this unit. By expressing his ideas clearly, I hope that he can gain recognition from his friends and learn the importance and satisfaction of participation in discussions.

Unit Organization:
Description of planned teacher instruction

Note: The pendulum unit was planned to be nine lessons, with the seventh and eighth lessons to be research lessons with observers. The instructional plan for the nine lessons is written in italics inside the rectangles.

Lessons 1 & 2

Let's make trapezes.

Lessons 3 & 4

Can we move a paper clip doll [from one trapeze to the other by having them meet] within three swings when the trapezes are released from the same direction?

Lessons 5 & 6 (Experiment)

Let's verify in experiments if the predictions are true.

Lesson 7
(Research Lesson Day 1: Experiment)

What made the cycle of trapeze models shorter: the weight of clay, the length of wire, or the angle of release?

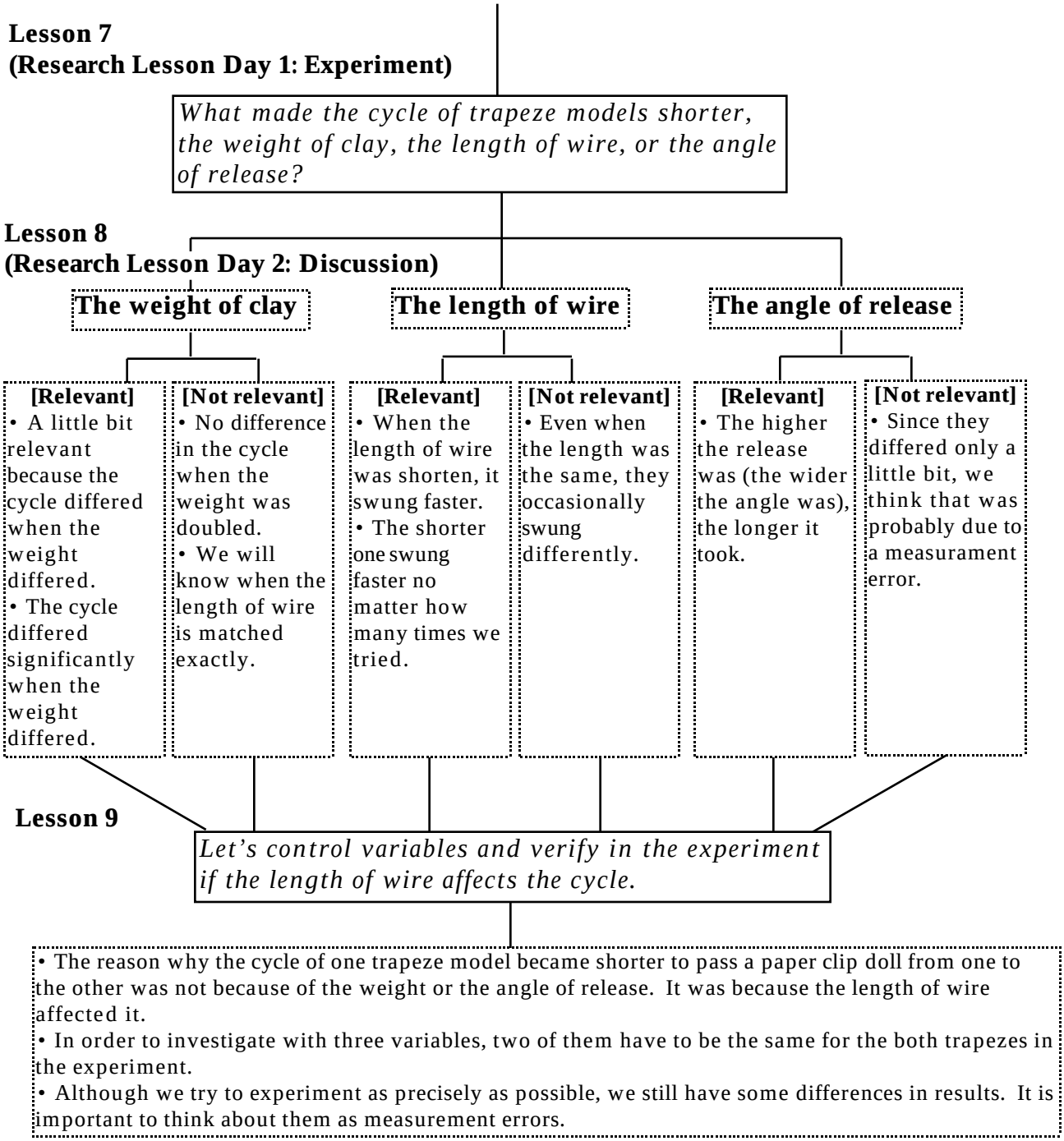
Lesson 8
(Research Lesson Day 2: Discussion)

Lesson 9

Let's control variables and verify in the experiment if the length of wire affects the cycle.

Unit Organization: Description of planned teacher instruction for Lessons 7, 8, and 9

Note: Below, teacher instruction that was planned for Lessons 7, 8, and 9 is written in Italic inside rectangular boxes. Anticipated students' responses were written in dotted boxes.



Sample of Teacher Recording Sheet
(Partial translation sheets recorded for 40 students)

Question: What needs to be changed in order to change the round-trip time of a trapeze: weight; angle; length?

Note: Below, the planned experimental procedures that students wrote in their notebooks prior to experimenting are identified with an asterisc "*." The comments and plans that the teacher added are identified by a bullet "•." The names of students are altered for confidentiality.

Student Pair 1	Student Pair 2
Satoshi *Weight: It can be examined by making one of the weights heavier than the other and release them with the same angle of release by measuring it with a protractor. *Angle: To measure the weights on a scale and change the angles. *Length: To change the length and keep the same weight and the angle, by measuring it with a protractor.	Masako *In order to examine the weight: To make the length of wire and the angle of release the same for two models. For example, to make one weight 20g and the other 40g. *In order to examine the angle: To examine with the angle of 90 degrees for one and 45 degrees for the other. •I would like to ask her how she thinks of measurament errors in her findings.
Masaki *Weight: To measure it in a scale. *Angle: To measure it with a protractor. *Length: To measure it with a ruler. •Probably, Kenyuu will teach him more concrete ways to proceed with the experiments. I hope that he will also realize that the two other variables need to be considered when one variable is examined.	Ayano *Weight: The smaller one with the larger one, the same one with the same one. To measure them in a scale. *Angle: To make one of them smaller and the other wider. *Length: To make one of them longer and the other shorter.

Attachment E

Sample of Students' Findings After Lesson 8, Day 2 of Research Lesson
(Partial translation of notes on 40 students)

Question: What needs to be changed in order to change the round-trip time of a trapeze: weight; angle; length?

Note: Students' writing about their findings are shown below. The teacher marked the findings with a "•" when students investigated the effect of one variable while controlling two other variables. Of 42 students, he counted 11 students who controlled the variables adequately. The names of students were altered for confidentiality.

Student Pair 1	Student Pair 2
Yutaka We tried with weight and length. Of 36 trials, we succeeded at 6 times. Only twice when they met at the third swing.	Yumiko Mine: 48 cm, 70 degrees, 115g. Emi's: 35 cm, 50 degrees, 60 g. When the length is the same, the clip doesn't get attracted (length). When the angle is the same, it doesn't touch (angle). The speed was different (weight). I think every one of them is necessary.
•Masako A: Mine was 150g and Asako's was 100g. 80 degrees and 36 cm for both; X B: Length 36 cm, mine was 60 degrees and 150g andAsako's was 40 degrees; ○ C: Mine was 30 cm and Asako's was 36 cm, 50 degrees with 100g and 150g. The weight is irrelevant. The one with a wider angle moved faster. The one with a longer wire moved faster.	Satoru Large one was 80 degrees, 47 cm. Small one was 60 degrees, 65 cm. Of 36 trials, 6 were O.K. The magnet moved downward. For some reason, the larger one moved higher and the smaller one moved lower.