A Language-Culture Origin Understanding of Science in Japan: Japanese Prospective Science Teachers' View of Science

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Abstract

This paper illuminates Japanese prospective science teachers' outlook on the scientific way of thinking by means of a questionnaire survey. The results reveal that Japanese prospective science teachers conform to the Japanese traditional way of thinking, which has never laid a primary emphasis either on immutability or on universality. They are inclined not to abstract scientific reality that should be immutable and universal from experimental data but to content themselves with experimental data as such. As a result, regarding experimental data from a different view, Japanese prospective science teachers will replace the scientific worldview by the Japanese worldview in science lessons. This introduces conceptual confusion of the scientific worldview into pupil's mind, but many science teachers do not realize this incommensurability so far. Only when they consider science and science education in the language-culture context, it becomes possible for them to realize and overcome the confusion.

Key words: *Language-Culture Origin Understanding, Japanese View of Science*

1. INTRODUCTION

Recently, one of the present authors proposed a notion "linguistic mode of science education" (Kawasaki, 2002), which makes it possible for science educators to carry out epistemological reflection on their language-culture setting for science education. The modifier "language-culture" will be abbreviated to "L-C" in the following. Because a specific L-C community provides an intrinsic setting for science education, the setting inevitably brings about L-C effects on science education, namely its rationale, content and style of teaching. In addition to these L-C effects, the most significant for pupils' learning is a way of thinking fixed in the L-C community concerned. These effects result in difference among linguistic modes of science education.

The notion "linguistic mode of science education" coins "the European language modes of science education" on the basis of European languages, by which cultivators of Western Modern science have been equipped for the W-scientific way of thinking. Hereafter, "Western Modern science" will be abbreviated to "W-science." Since European languages can be lumped into one group called "Standard Average European, i.e., SAE" (Whorf, 1959, 138), various language modes of science education in the setting of the European languages are properly called the SAE language mode of science education. Because there lies difference among language modes of science education, some language modes of science education are commensurate with the SAE language mode of science education and others are not on a global scale. In other words, language modes of science education are incommensurate with the SAE language mode of science education if they are conducted in L-C communities where people do not share the W-scientific way of thinking in their L-C tradition. In these L-C communities like Japan, dissimilarity in way of thinking brought up a problem in right understanding of W-scientific concepts.

In the W-scientific way of thinking, data obtained from an experiment are related to a W-scientific law in some way. There, the W-scientific law is abstracted from the experimental data describing what has happened in the phenomenal world; according to the dichotomy between the phenomenal world and the world of Idea, to use the Platonic term, the W-scientific law establishes some relationship that exists only in the world of Idea (Kawasaki, 2002). As a result, W-scientific laws are expressed in terms of abstract nouns, namely, force, acceleration, point mass, rigid body, ideal gas, etc., which have generality beyond the data obtained from specific experiments. Every W-scientific concept and law can thus be described as immutable and universal. It is pointed out in Kawasaki (2002) that abstract nouns are essential for the W-scientific way of thinking, into which the dichotomy is inevitably introduced.

The present paper investigates Japanese prospective science teachers' understanding about the phenomenal world and the W-scientific world of Idea; scientists could never succeed in doing the W-scientific way of thinking without opposing the W-scientific world of Idea against the phenomenal world. Assuming an actual phase of heuristic methods of learning in science lesson, the teachers were asked in the Japanese language the reason why they could derive a theoretical conclusion from the experiment. Results from the present investigation will suggest Japanese prospective science teachers' understanding of W-science, that is, what it is like.

2. STUDY DESIGN AND RESULTS

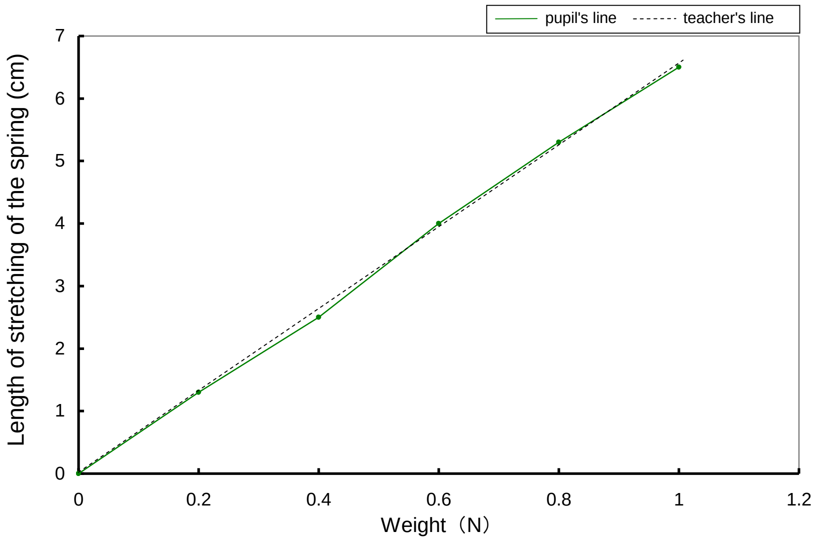
2.1. Design

This study targeted science students at a national university in Japan. It covered a total of 84 prospective undergraduate science teachers from departments of science and agriculture of Ehime University. Among the students 38 were males and 46 were females. All of them enrolled in the same teacher-training course for becoming secondary science teacher.

Questionnaire that was developed originally for this study was presented to the Japanese prospective science teachers containing a scenario in science teaching about the Hooke's Law. In the scenario, a pupil plots his or her results with weights as abscissa against corresponding lengths of stretching of a spring balance, as ordinates, to which weights are connected. Then, the teacher directs the pupil to draw a graph on the basis of the results obtained. Finally, the science teacher draws a straight line that shows a directly proportional relationship. In Figure 1, the solid line indicates a line graph the pupil drew, and the broken line is the teacher's correction to the line graph.

The teacher's correction is a direct consequence of the heuristic method of teaching. As a rule, science teachers expect pupils to find a straight line through the origin, namely the Hooke's Law, and to have a feeling of achievement in the heuristic method. However, when pupils do not succeed in finding the Hooke's Law out, as the occasion demands, science teachers have to demonstrate the Hooke's Law even in the heuristic method of teaching. The pupil may have an impression that the teacher's correction shows the very mathematical relationship: a direct proportion between length of stretching of the spring and weight. It is critical to the heuristic method of teaching for the teacher to give a definite explanation of the reason why the correction is justifiable though it passes through only a few of values the pupil obtained. The pupil may emphasize that his or her line graph passes through all experimental data he or she has just obtained.

Showing four possible reasons to the correction, Question 1 asked the prospective teachers' opinion in a binary form: agree or disagree about each reason to explain the correction. Reasons 1, 2, and 4 focused on something beyond experimental data and only Reason 3 emphasizes the experimental data.



Figue 1. Pupil's Line and Teacher's Line in the Experiment of the Hooke's Law.

Reason1: The relation is the simplest that you know. (The correction is transcendental, because it is based on an assumed principle.)

Reason 2: The relation is the most effective expression of the theory concerned. (The correction is theory-driven, because it is based on inspiration received from the Hooke's Law.)

Reason 3: The relation is based on the largest number of experimental data. (The correction is data-driven, because it becomes justifiable by accumulation of data.)

Reason 4: The relation is based on the largest number of scientists who agree. (The correction is convention-based, because it regards W-scientific laws as convention adopted in the scientific community.)

Question 2 asked the subjects to select the most plausible reason among the four: transcendental, theory-driven, data-driven and convention-based. In addition to the selection, the students were invited to give an alternative reason if none of the four reasons accorded with their respective opinions. Finally, Question 3 asked whether they had learnt about the reason to justify the correction in their teacher-training course.

2.2. Results

Table 1 summarizes responses to Question 1. Because the prospective teachers were not asked to choose a single reason among the four, about seventy percent of them agreed more than one reason. Reason 3 (data-driven) received the strongest support among the prospective teachers who agreed one single reason. Among the prospective teachers who agreed two reasons, all of the subjects agreed Reason 3 (data-driven), and 43 % also upheld Reason 2 (theory-driven). Fifteen percent of the prospective teachers (13%+2%) agreed three or four reasons; all but two of them agreed Reason 3 (data-driven).

Table 2 shows the prospective science teachers' response to Question 2: Which reason is the most plausible? Their answer corresponds to that given to Question 1. The majority, over 70% of the prospective teachers, chose Reason 3 (data-driven) as the most plausible. This suggests that the Japanese prospective teachers are inclined to emphasize experimental data as such rather than something beyond them.

Table 1. Japanese Prospective Teachers' Responses to Four Types of Reason

Number of Agreements	Combination of Agreements on the Reason	Number of Students (%)
1	Reason 3 (data-driven)	18 (21)
	Reason 2 (theory-driven)	4 (5)
	Reason 1 (transcendental)	2 (2)
2	Reason 3 and 2	36 (43)
	Reason 3 and 1	10 (12)
	Reason 3 and 4 (convention-based)	1 (1)
3	Reason 1, 2, and 3	6 (7)
	Reason 2, 3, and 4	3 (4)
	Reason 1, 2, and 4	2 (2)
4	Reason 1, 2, 3, and 4	2 (2)

Table 2. The Most Plausible Reason for Japanese Prospective Teachers

Types of L-C Mode	Types of Standard	Types of Reason	Number of Students (%)
European L-C Mode	Transcendental	Reason 1	7 (8)
	Theory-driven	Reason 2	13 (16)
	Convention-based	Reason 4	1 (1)
	Total		21 (26)
Japanese L-C Mode	Data-driven	Reason 3	60 (71)
	Total		60 (71)
Others			3 (4)

The result in Japan looks a striking contrast with that obtained by Ryder & Leach (2000). From our point of view, Ryder & Leach (2000) seems to report that 40 % of their European science students chose a theory-driven interpretation of experimental data and that 25 % of them chose a data-driven one. In contrast to the Japanese prospective science teachers, the European science students incline to emphasize something beyond experimental data rather than experimental data as such. However, it should be also emphasized that these two Reasons, theory-driven and data-driven, are dissimilar to each other from the viewpoint of whether or not something beyond experimental data is focused on. It should be stressed that, though most of Japanese prospective teachers who chose two Reasons considered Reason 3 to be the most plausible, more than 40% of the Japanese prospective science teachers assigned two different reasons at the same time.

The response to Question 3 indicates that none of the prospective science teachers have studied about the reason for justifying corrections to data in their teacher-training course at the university. A probable consequence of their lack of learning is that Japanese science teachers have only a stereotyped idea about the W-scientific way of thinking and that they actually have little understanding of the reasons justified in the philosophy of W-science. Consequently, Japanese science teachers will fail to direct pupils' attention to the world of Idea where W-scientific laws are established.

3. DISCUSSION

The problem this study has addressed is known as the "curve fitting problem" (e.g., Ladyman, 2000, 164-5). The questionnaire asks about the reason to justify the procedure for relating experimental data to a W-scientific relationship. The experimental data have described what happened in the phenomenal world in terms of mathematics whereas the W-scientific relationship is supposed to be present in the world of Idea. Accordingly, the procedure implicitly assumes the dichotomy between the phenomenal world and the world of Idea. This assumption essentially characterizes the W-scientific way of thinking as well as Western ways of thinking.

In the main stream of the Western philosophy, this problem is associated with a relationship between the phenomenal world and the world of Idea as Kawasaki (2002) discussed. Yolton (1973, 94) discusses this issue in a broader perspective and begins "Appearance and Reality" in Dictionary of the History of Ideas with: "The general sense of the contrast between appearance and reality would be any difference between what is the case and what appears to be so." In the W-scientific way of thinking, the term "appearance" refers to something mutable and particular whereas the term "reality" refers to something immutable and universal. In context of the Western cultures, then W-science, "reality" has been valued above "appearance" throughout the history. The dichotomy between them is thus linked to the fact that value associated with the timeless and immutable is upheld in the main stream of the Western philosophy (Boas, 1973, 347).

Comparing the Western worldview, which has founded the W-scientific way of thinking, with the Japanese innate worldview, Kawasaki (2002) elucidated that the Japanese worldview in basically different from the W-scientific worldview. He argues that the Japanese worldview leads Japanese people to search the phenomenal world for what appears to be so. The present questionnaire survey elucidates the L-C incommensurability between the W-scientific way of thinking and the Japanese L-C way of thinking. As pointed above, the Japanese prospective teachers who agreed two Reasons considered Reason 3 (data-driven) to be the most plausible. Around 43% of them agree Reasons 2 and 3 at the same time, and attach little importance to Reason 2 (theory-driven). Their emphasis on Reason 3 elucidates their positive outlook on the phenomenal world by comparison with their inattention on Reason 2, because these Reasons 2 and 3 assume opposite stances, namely, Reason 2 (theory-driven) to focus on Ideas beyond appearance and Reason 3 (data-driven) to emphasize things within appearances. Those prospective teachers made their choice following the Japanese L-C tradition, which has never upheld anything beyond the sensible. International science classroom video study will support the results in this study showing that Japanese eighth-grade science lessons empathized much on "collecting and recording the data" but little on "generating the research question" and "organizing or manipulating data collected" (National Center for Educational Statistics, 2006).

In contrast to the Western worldview, the Japanese worldview does not rely on the world of Idea. It is not possible to describe the Japanese relationship between "appearance" and something transcendental in terms of the dichotomy between "appearance" and "reality" in the English language. In the Japanese L-C tradition "reality," i.e., something transcendental or absolute, allows for a mutable and particular character (Kawasaki, 2002). The Japanese L-C tradition considers that "what appears to be so" should be identical with "what is the case" as discussed in detail in Kawasaki (2002). In other words, the Japanese L-C tradition has never valued the timeless and immutable, and has led Japanese people to take it for granted that they can appreciate value associated with mutable and particular. For example, Nakamura (2000, 359) argues that "the Japanese esteem the sensible beauties of nature, in which they seek revelations of the absolute world." Nakamura's argument may perplex Westerners who have acquired the Western culture, because there seems to be the Japanese sameness encompassing the phenomenal world and the world of Idea, not a distinction between them.

4. TOWARD IMPROVEMENT IN TEACHER-TRAINING PROGRAMME

The results obtained from this survey can contribute to reforming science-teacher-education programmes in Japan, and in other countries, where science education is carried out in languages incommensurate with the language of W-scientific thought.
The present discussion is based on differences in cognition between L-C communities. They are caused by various language modes that are used in science education. Science education, however, is rarely examined from this point of view. The notion "linguistic mode of science education" was originally coined in order to encourage international science education to give equitable treatment to the Japanese language mode of science education. The notion makes it possible for science educators to become aware that there is a L-C incommensurability in the Japanese language mode of science education. Accordingly, they should be able to realize the necessity to distinguish the Japanese language mode of science education from its other language modes, especially the SAE modes of science education. Conversely, it recognizes that the Japanese language mode of science education will require additional teaching based on the Japanese L-C tradition, aesthetics and philosophy in order to clarify the differences between the Western way of thinking about the world and the Japanese way of thinking about natural phenomena (shizen, more correctly).

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