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' view of science by means of a questionnaire survey. The results reveal that Japanese prospective science teachers' view of science conforms to the Japanese worldview, which has never laid a primary emphasis either on immutability or on universality. Accordingly, 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. This means that, regarding experimental data from a different view, the Japanese prospective science teachers will replace the scientific worldview by the Japanese worldview in science lessons. This introduces conceptual confusion aroused by language-culture incommensurability with the scientific thought, but many science educators do not realize this incommensurability so far. Only when they consider science and science education in its language-culture context, it becomes possible for them to realize. (The following two factors are essential:) It is essential to understand science in its language-culture context and to consider science education in pupils' language-culture context in order to prevent

them from the conceptual confusion in science education.

Seng's Comment:

Your research data only lead us to conclude that whether we learn about science in Japan or in the West, it is important to understand the language-culture setting in our own society and if the language-culture setting is different from that of the global language-culture setting (W-science), then steps must be taken to enable learners in the indigenous language-culture setting (JLSE) to understand the language-culture setting of W-Science. Conversely, people in the W-Science SAE setting should also be alerted to alternative language-culture settings in other societies.

有効数字の問題

INTRODUCTION

Recently, one of the present authors has 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 provides an intrinsic setting for science education, the setting inevitably brings about L-C effects on science education, namely its rationale, contents and style of teaching. These effects result in a linguistic mode of science education.

European languages are the languages that equipped cultivators of W-science for the W-scientific thought (see Kawasaki 1996; 2002 in detail). If a way of thought intrinsic in the L-C is incommensurate with the way of thought in Western Modern science, hereafter abbreviated to W-science, that linguistic mode of science education will be incommensurate with European language modes of science education. In W-scientific thought experimental data are related to a W-scientific law. In this way of thought, experimental data describe what happens in the sensory or phenomenal world, and the W-scientific law establishes some relationship assumed to be found in the world of Idea, to use the Platonic term, on the basis of the data. These W-scientific laws are expressed in terms of abstract nouns (e.g., force, acceleration, ect.) that have a generality beyond particular data. In other words, the experimental data are converted into abstract nouns for describing what happens in the world of Idea in the W-scientific thought. The W-scientific concepts, represented by these abstract nouns have, at particular stage in the development of W-science, a specific definition and a general applicability. They can thus be described as immutable and universal. These abstract nouns are essential for W-scientific thought and in W-scientific thought introduce a dichotomy between the phenomenal world and the world of Idea (Kawasaki 2002).

As pointed out in Kawasaki (2002), the Japanese language does not have any fully established method of turning ordinary nouns and adjectives into corresponding abstract nouns in its tradition. Therefore, the Japanese language cannot provide a suitable L-C setting for science education where W-science is taught (Kawasaki 2002). This implies: Some languages are commensurate with the W-scientific thought, and others are not. This is the reason why science educators need epistemological reflection on their L-C setting through the notion "linguistic mode of science education," especially in L-C settings incommensurate with the W-scientific thought. Hence, a possible standard for judging whether a language is commensurate with W-science is how abstract nouns are dealt with in the language concerned.

Since the Japanese language is incommensurate with the W-scientific thought, it is improbable that abstract nouns play their genuine W-scientific roles in pupils learning W-science in the Japanese language mode of science education, the JLSE (Kawasaki 2002). Unquestionably an acute situation occurs in pupils' finding a W-scientific law when the heuristic method is applied in the JLSE. There, the JLSE pupils are forced to find the W-scientific law without abstract nouns. According to the linguistic nature of the Japanese language, the pupils are inclined to focus only on what happens in the phenomenal world in the JLSE. In other words, the pupils have a tendency not to confirm their conclusion in asserting ideals or universals according to the W-scientific way of thinking but to give a full description of diversity of a phenomenon they really face (Nakayama and Iwakiri 1999; Kawasaki 2002). The JLSE pupils' outlook on experimental data shows that they cannot cope with abstract concepts in their experiments; the outlook is far from being W-scientific.　（この部分は後へ）

The present paper investigates how Japanese prospective science teachers understand the relationship between the phenomenal world and the W-scientific world of Idea. This investigation suggests Japanese prospective teachers' understanding of W-science, that is, what it is like. Assuming an actual phase of heuristic methods of learning in science lessons, the teachers were asked in the Japanese language the reason why they could derive a theoretical result from experimental data. If discrepancies are revealed between the genuine W-scientific thought and their understanding of it, the discrepancies may be one of the Japanese L-C effects on W-scientific thought. These discrepancies could arise from language differences the JLSE has implicitly set. Furthermore, the results obtained from the present survey will be contributory to reforming science-teacher-education programmes in Japan, and could also be contributory in other countries, where science education is carried out in languages incommensurate with the language of W-scientific thought.

STUDY DESIGN AND RESULTS

I) 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. The number of male students was 38, and the number of female students was 46. All of them followed the same teacher-training course for becoming secondary science teacher. Questionnaire was presented to them containing a scenario in science teaching. 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 (the Figure in the Appendix). Then, the teacher directs the pupil to draw a graph on the basis of the results obtained. Finally, the science teacher drew a straight line that showed 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.

In the heuristic method, the pupil is expected to find a straight line through the origin, namely the Hooke's Law. The teacher's correction shows such a mathematical relationship: a direct proportion between length of stretching of the spring and weight. The teacher is now asked to choose the reason why the correction is justifiable, passing through three of five values only. It is the original line graph of the pupils that passes through all the plotted values.

<u>Figure 1 is here.</u>

If the teacher fails to offer an acceptable reason for the correction, the pupil cannot experience a feeling of achieving, which is a deciding factor for using the heuristic method of teaching.

Therefore, it is critical to form an idea of why the teacher justifies the correction. Showing four possible reasons, Question 1 asked the prospective teachers' opinion about each reason. These reasons were chosen to offer the following possibilities to the teachers.

Disagree ?

Reason1: The correction is transcendental: The reason focuses on a quality aspect of the correction.

Reason 2: The correction is theory-driven: The reason is based on inspiration received from Hooke's law.

Reason 3: The correction is data-driven: The reason is an explanation justifiable by accumulation of data.

The correction is convention-based: The reason 4 regards the correction as a convention adopted in the scientist community.

The reasons 1, 2, and 4 focus on something beyond experimental data and only the reason 3 emphasizes the experimental data.

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.

ii) 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 chose more than one reason. Reason 3 (data-driven) received the strongest support among the prospective teachers who chose one single reason. Those prospective teachers who chose two reasons all included Reason 3 (data-driven) in their choice, but 43 % also upheld Reason 2 (theory-driven). Fifteen percent of the prospective teachers chose three or four reasons, and all but two of these chose Reason 3 (data-driven).

<u>Table 1 is here.</u>

Table 2 shows the response to the 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 2 is here.

The present result exhibits a striking contrast with that obtained by Ryder & Leach (2000). Ryder & Leach reports that 40 % of their European science students chose a theory-driven interpretation of experimental data and 25 % of them chose a data-driven one. In contrast to the Japanese prospective teachers, the European science students incline to emphasize something beyond experimental data rather than experimental data themselves.

Table 3 indicates that none of the prospective teachers have studied about the reason for justifying corrections to data in their teacher-training course at the university. Therefore, it may be that Japanese science teachers have little understanding of the reasons that are justified in the philosophy of W-science.

Consequently, they naturally search the Japanese L-C tradition in order to find the most plausible explanation. Obviously, this leads them to make a misunderstanding of the W-scientific thought. （この部分は議論）

Table 3 is here.

As Tables 1 and 2 reveal, the number of prospective teachers who chose Reason 3 as the most plausible (see Table 2) is approximately obtained by adding the number of them who made a single choice of Reason 3 to the number of them who chose two Reasons, one of which was Reason 3 (see Table 1). Since the prospective teachers who made a single choice of Reason 3 must considered Reason 3 to be the most plausible, this roughly means Japanese prospective teachers who chose two Reasons considered Reason 3 to be the most plausible. It should be emphasized that these two Reasons, theory-driven and data-driven, are opposite to each other from the viewpoint of whether or not something beyond experimental data is focused on. From this point of view, more than 40 % of the Japanese prospective science teachers were in confusion. Then, when being asked which was more plausible, Reason 2 or 3, those prospective teachers made their choice following the Japanese L-C tradition, which has never upheld anything beyond the sensible (Kawasaki 2002). （理由を聞かないでなんで混乱と分かるのか）

DISCUSSION

Yolton (1973, p.94) argues that in every L-C people always become aware of a contrast between “what is the case” and “what appears to be so.” The relationship between “what is the case” and “what appears to be so” is subordinate to the language concerned, and it shows the variety in L-Cs. Likewise Kawasaki (1999; 2002) discussed this point on the basis of structural linguistics: a language creates its own system of objects. For instance, in the English language culture, the term “appearance” is assigned to “what is the case” and the term “reality” to “what appears to be so.” A similar linguistic phenomenon exits in other European languages which participated in developing W-science. These distinctive assignments are only natural in those languages. There, the term “appearance” refers to something mutable and particular whereas the term “reality” refers to something immutable and universal in the language culture.

In the context of the Western cultures, the concept “reality” has been valued above “appearance” throughout their history. This dichotomy is 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). There, the reason “why value was associated with the timeless and immutable has never been explained” (Boas 1973, 347).

> The association seems to be spontaneous and it is probable that value and duration form a couple which seems to many men to require no explanation. (Boas 1973, 347)

W-science has the same outlook on the priority of “reality” to “appearance.” In accord with the priority, the W-scientific thought bridges the gap between “appearance” made in the phenomenal world and "reality" being present in the world of Idea (Kawasaki 2002). Although W-scientific thought is a way to bridge the gap, the reason why and how it becomes possible to bridge it has been a fundamental and problematic issue in the main stream of philosophy of W-science (see Kawasaki 2002 in detail).

The problem to which the present study relates is known as the "curve fitting problem" (e.g., Ladyman 2000, 164-5), which is essentially the same issue raised in the main stream of philosophy of W-science. The questionnaire asks about the procedure for relating pupils' experimental data to a relationship supposed to be present in the world of Idea. Although the philosophy of W-science has considered this problem from various angles (e.g., see Ladyman 2000 ***), it is rather simple to trace the origin of it. The "curve fitting problem" would disappear without the dichotomy between the phenomenal world and the world of Idea. Thus, the "curve fitting problem" is innate to the dichotomy, thus, to the Western L-Cs.

In contrast to the Western L-Cs, the Japanese L-C tradition considers that "what appears to be so" should be associated with "what is the case" as discussed in detail in Kawasaki (2002). The Japanese L-C tradition has never established a dichotomy to include the world of Idea. 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 those Westerners who have acquired the Western culture, because, if they consider "the absolute world" to be identical with the world of Idea, there seems to be a Japanese distinction between the phenomenal world and the world of Idea. In the main stream of the Japanese philosophy and religious system, this is not what Nakamura means. "What appears to be so" is thought to be associated with "what is the case" as stated above, and Kawasaki (2002) provides examples of how Japanese people understand "what is the case."

In addition to these examples, we will adduce an aesthetic example which also supports Japanese people's outlook on "what is the case." Even in the present time more than one century after the opening of Japan to the world, a distinguished literary critic Kobayashi (1992, 15) wrote in his essay about "No," the Japanese musical dance-drama developed in the fourteenth century:

> There is not beauty with "flowers" but a beautiful "flower." …… Revise the workings

of your mind following your body motion. Your body motion is much subtler and finer than the changes in your idea in mind. [translated by the present authors]

This quotation is well-known today, and the term "flower" is used in the same figurative sense as used by Zeami who developed "No" in the early fifteenth century. This term stands for acting which gives artistic impressions in a "No" performance. In harmony with Kawasaki's (2002) claim that the Japanese L-C tradition discredits what is expressed in words, Kobayashi (1988, 223) clearly stated elsewhere: Seeing is no way uttering, and words are stumbling block to seeing. The literary critic denied the concept "beauty" abstracted from actual flowers. This concept can only be described in words. He accepted only "a beautiful flower" stimulating the sense of sight.

The acting accomplished by a "No" performer naturally changes with the performers' growth in the same way that a beautiful flower blooms and falls. This is the reason why the acting is impressive and magnificent. It should be emphasized that the reason is based on the point that "a beautiful flower" falls rather than the point that it blooms. In the Japanese L-C tradition value was associated with the mutable as stated above; there, the association seems to be spontaneous. Moreover, Kobayashi definitely insisted the superiority of body motion over the workings of the mind. This means the Japanese people uphold change in "appearance" without the dichotomy. These two points, the denial of beauty in the abstract sense and upholding the change, have established the Japanese aesthetics, and decidedly indicate that the Japanese L-C tradition does not need the dichotomy between "what is the case" and "what appears to be so." (小林を消去の方向)

The JLSE is a mode of science education conducted in this Japanese L-C setting. Therefore, it is quite natural in this JLSE setting for pupils to search the phenomenal world for W-scientific "reality" in the science class room. The Japanese prospective teachers have also acquired the W-scientific knowledge from the JLSE, thus it is natural for them to consider the data-driven reason to be the most plausible in Question 2. The other reasons presuppose respective criteria beyond the phenomenal world, involving the dichotomy in W-scientific thought.

Nevertheless, regardless of linguistic mode of science education, the dichotomy should be confirmed as important for W-scientific thought. Neither pupils nor scientists should stick too closely to experimental data, which merely describe occurrences in the phenomenal world. Poincare (1952, p.141), for example, insisted in *Science and Hypothesis*: “Most important of all, the man of science must exhibit foresight.” More clearly, he pointed out:

> Experiment only gives us a certain number of isolated points. They must be connected by a continuous line, and this is a true generalisation. But more is done. The curve thus traced will pass between and near the points observed; it will not pass through the points themselves. Thus we are not restricted to generalising our experiment, we correct it. Poincare (1952, p.141)

In the heuristic method of teaching science, there is expectation that pupils can think as the same way as this. This is a big assumption and even bigger in the Japanese L-C tradition, because the JLSE pupils have no means of generalizing and correcting experimental data. Furthermore, the Japanese prospective teachers were unfamiliar with such a means for justifying corrections to experimental data.

TOWARD IMPROVEMENT IN TEACHER-TRAINING PROGRAMME

About two thirds of the Japanese science prospective teachers did not learn the reason for correcting data (see Table 3). This may produce the consequence that more than 40 % of them chose Reasons 2 (theory-driven) and 3 (data-driven) at the same time (see Table 2), although most of them consider Reason 3 to be the most plausible to use in the context of the scenario. It seems that the Japanese prospective teachers are inclined to put emphasis on occurrences in the phenomenal world. They fail, in this way to inform the JLSE pupils of a correct understanding of W-scientific thought.

Science educators reading this paper in their W-scientific settings may wonder why JLSE pupils achieve so highly in comparative study such as the Third International Mathematics and Science Study, TIMSS. The items in TIMSS can be treated instrumentally, regardless of the level of W-scientific thought to which they belong. Therefore, achievement in these tests can occur independent of the relationships of this dichotomy. The JLSE pupils’ high scoring is accomplished without W-scientific thought involving the dichotomy between “reality” and “appearance.” In like manner, Kawasaki (1996; 2002) drew a distinction between recognizing this aspect of W-science and its technological aspect that links directly to the global economy.

The present discussion is restricted to the recognizing differences in the L-C that can affect science education. In comparative studies of L-C differences L-C incommensurability is commonly investigated, but science education is rarely examined from this point. There are two possible reasons. First, in whatever language a linguistic mode of science education is conducted, the use of that language conceals the L-C incommensurability. For instance, the use of the Japanese language in the JLSE leads pupils to alter W-scientific concepts in accord with the Japanese innate concepts articulated in the Japanese language (Kawasaki 1996; 1999; 2002).

Second, because all linguistic modes of science education deal with W-scientific issues, science educators are internationally inclined to consider SAE*) linguistic modes of science education to set the basic guidelines for science education. In the JLSE science educators usually judge the JLSE from the SAE modes of science education and believe the JLSE should be reformed on the basis of them. From this perspective, the JLSE is not assured of equitable treatment in the sphere of science education research. Situation will be similar in other non-SAE linguistic modes of science education. Then, the present discussion becomes valid for them if appropriate L-C interpretation is made.

The notion "linguistic mode of science education" was originally coined in order to encourage science educators to give equitable treatment of the JLSE in the sphere of science education research. This notion makes it possible for science educators to become aware of the L-C incommensurability aroused in the JLSE. Consequently, they should be able to realize the necessity to distinguish the JLSE from other linguistic modes of science education, especially from the SAE modes of science education. It must be concluded that the JLSE will require additional teaching based on the Japanese philosophy and aesthetics in order to clarify difference in way of thinking between W-science as "thinking about the world in the Greek way" (Burnet 1975, v) and the Japanese way of thinking about natural phenomena. This additional teaching will need to be deliberately taught in science teacher-training courses in order that Japanese prospective teachers will have appropriate understanding of W-scientific thought.

謝辞（F

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Appendix

Gender： Male ・ Female

Age： __________ Years Old

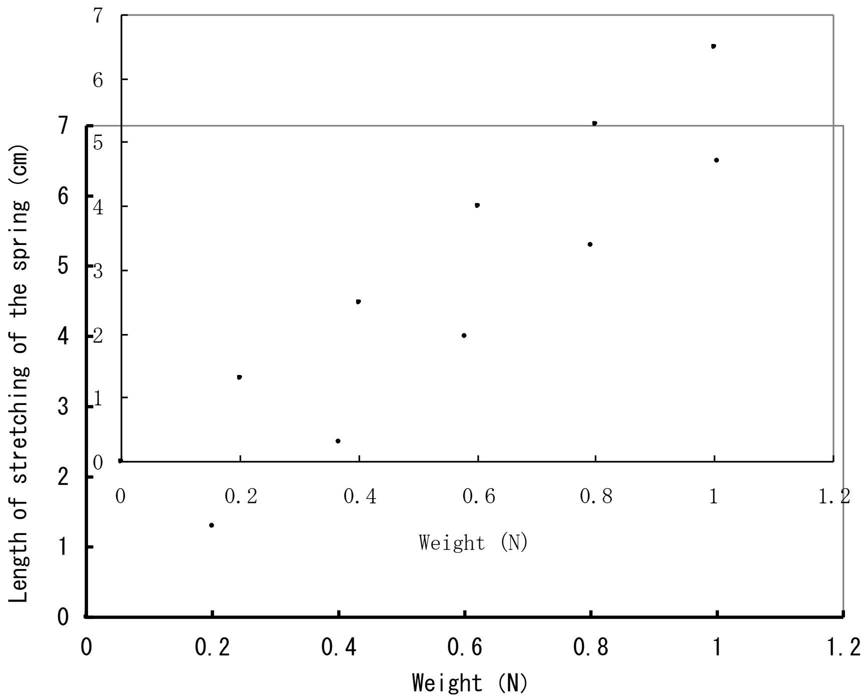
Teaching Experience：____________ Year

Major in Science：

Physics ・ Chemistry ・ Biology ・ Earth Science

This is a very important investigation to improve science education.

A pupil conducted an experiment about the relationship between weight and length of stretching of a spring balance in a secondary science lesson. The experimental data the pupil obtained were plotted on the figure below.



Question 1. The science teacher drew a straight line that showed a directly proportional relation. Below are four reasons for drawing a straight line between weight and the length of stretching. Put a check mark on each reason that positively describes your opinion. You can select "Agree" as often as you choose.

Reason 1 : The relation is the simplest that you know. Agree・

Explanation 2 : The relation is the most effective expression of the theory concerned. Agree・

Explanation 3 : The relation is based on the largest number of experimental data Agree・

Explanation 4 : The relation is based on the largest number of scientists who agree. Agree・

Question 2. Which reason is the most plausible to the students? If you have other more plausible

reasons than these four reasons, please write in your own reason.

The number of the most plausible reason : ____

Other Reason : ______________________________

____

Question 3. You might have principles to decide which reason is the most plausible. Did you study such principles in the teacher-training course or out of the teacher training course? Put a check mark about your answer.

1. *Yes, in the teacher training course at the university.*
2. *Yes, out of the teacher training course at the university.*
3. *No.*