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Confusing in the Conception "Reality": Is It Sensible or Insensible in Science Education?

--- *Scientific reality which makes scientific explanation significant* ---

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Summary: This paper presents science educators' strategy for teaching pupils to consider scientific reality in various cultural settings for science education. This strategy works on the basis of a distinction between "what exists" and "what ought to exist", namely appearance and reality. As a rule, "what exists" is explained in terms of "what ought to exist". Therefore, science teachers presuppose scientific explanation to be explained in terms of scientific reality. In the Western culture, scientific reality is definitely regarded as insensible. In the Japanese culture, however, "what ought to exist" consists of sensible things. Therefore, Japanese pupils are inclined to explain scientific phenomena they have just observed in terms of sensible things. Drawing their attention to this pupils' attitude, science educators can promote Japanese linguistic-cultural setting for science education. This strategy is applicable to other non-Western nations with proper linguistic-cultural interpretation.

Introduction

Science as a school subject shares an outstanding feature with mathematics: science is believed to have the same content in essence throughout the world. Therefore, a facet of this feature makes it possible to evaluate educational achievement in science and mathematics in different cultural units. Actually, The International Association for the Evaluation Achievement, IEA, has conducted International Mathematics and Science Study since First International Mathematics Study was undertaken in 1964. As is commonly known, IEA undertook the most recent study of Third International Mathematics and Science Study, TIMSS, in 1994. Definitely, no one can conceive such international studies on other school subjects, i.e., language, history, geography, etc. In other subjects, international evaluation of educational achievement must be impossible because educational intention and teaching materials in the subject must be incommensurate cross-culturally.

On the contrary, apart from mathematics education, science educators seem to claim that science education is commensurate cross-culturally. Their claim is obviously based on the universality of Western Modern science, referred as W-science hereafter. However, as I disclosed in Kawasaki (1996) from the viewpoint of structural linguistics, W-science is essentially coloured by the Western culture in which people identify themselves as linear successors to the legacy of Greco-Roman civilization. Therefore, W-science is incommensurate with other cultures. Actually, Burnet, who is known by Burnet Oxford Classical Texts, asserted in the author's preface to *Early Greek Philosophy*:

> My aim has been to show that a new thing came into the world with the early Ionian teachers -- the thing we call science -- and that they first pointed the way which Europe has followed ever since, so that, as I have said elsewhere, it is an adequate description of science to say that it is "thinking about the world in the Greek way." That is why science has never existed except among peoples who have come under the influence of Greece. (Burnet, 1975, p. v)

Therefore, in non-Western countries[1)] pupils as well as educators are confronted with cultural incommensurability in enculturation which science education takes part in. Science educators and researchers on science education are inclined to overlook this problem of enculturation unwittingly or deliberately by believing the universality of W-science.

However, science education is not necessarily established on the basis of the universality of W-science. As Kawasaki (1996) argues, science as a school subject is based on an institutionalized view of W-science. This means that a specific society exerts a cultural influence on science education in the process of institutionalization. Consequently, the society may lead science education to be particular to the culture by which the society is united. However, since the content of science appears to be practically identical throughout the world, science educators are apt to have an idea that science education is common with that conducted in all other cultural units: science teachers teach pupils the same things, and pupils accept and understand them in the same manner. This is the reason that international studies like TIMSS appear to be possible.

Nevertheless, I revealed Japanese pupils' understanding to be contingent on the Japanese language (Kawasaki, 1996): Japanese pupils receive a Japanese equivalent of "nature", i.e., "shizen", as supernatural according to meanings this equivalent conveys in the Japanese language. It is by no means probable that the term "nature" refers to something supernatural in the English language. Japanese pupils' understanding of this stems from a translation of "nature" into "shizen", which sometimes expresses a supreme being of a Japanese religious system (Kawasaki, 1990).

As a rule, translation involves such problems that cause conceptual confusion to a certain extent. Therefore, an issue that needs to be discussed in science education and science education research is how to recognize and overcome this conceptual confusion, because it is impossible to conduct science education without translation from an SAE language (see Note 1) in non-Western countries. In order to resolve this problem of translation, I proposed, with the aid of structural linguistics, that science educators should identify science education with foreign language education (Kawasaki 1996). If this is accomplished, science educators in non-Western countries must be led to a denial of a nomenclature view of language. Since a nomenclature means a name list, every translation is uncritically accepted in this view of language. Even though the translation of "nature" into "shizen" is established in science education in Japan, science educators would always be aware that this translation entails linguistic or cultural incommensurability between the English and Japanese languages. However, science educators normally regard the Japanese term "shizen" as a precise equivalent of "nature" in Japan taking the nomenclature view of language.

In order to investigate linguistic or cultural incommensurability one by one, Kawasaki

(1996) revealed linguistic incommensurability between “nature” and “shizen”; succeedingly, Kawasaki (1999) exposed the same type of incommensurability between “to observe” and “kansatsu”, the Japanese word considered to be an equivalent of “to observe”. Although science educators consider that “to observe” and “kansatsu” are equivalent in Japan, a possible English equivalent of “kansatsu” is “to contemplate” (Kawasaki, 1999). Since these two English verbs, “to observe” and “to contemplate”, should be distinguished from each other, science educators as well as Japanese pupils are led to have a misunderstanding about an attitude toward natural phenomena to observe. Through the Japanese word “kansatsu”, they are inclined not to observe natural phenomena but to contemplate them. As a consequence of difference between “to observe” and “to contemplate”, additional incommensurability lies between “experiment” and “jikken”, the Japanese equivalent of “experiment” (Kawasaki, 1999). At the same time, Kawasaki (1999) proposed a general method for dealing with such incommensurability with the aid of the method for axiomatization in geometry (Blanche 1973).

The present paper will discuss the same type of incommensurability hidden behind the Japanese word “jitsuzai”, which science educators believe to be an equivalent of “reality” in Japan, and will present an axiomatic system to draw science educators’ attention to this incommensurability. Their awareness of it must be the first step to deal successfully with it. This strategy is applicable to other non-Western countries where science education would be impossible without translation.

As A social Phenomenon

Structural linguistics draws a clear distinction between a linguistic system and its actual manifestations:

> ……, we have reached the crucial opposition between *langue* and *parole*. *La langue* is the system of a language, the language as a system of forms, whereas *parole* is actual speech, the speech acts which are made possible by the language. (Culler, 1988, p.29)

“Speech acts” in the foregoing can be paraphrased as “linguistic acts” in the present context. People in a society as a cultural unit share a language, which sets a system of norms to individuals. Therefore, from the viewpoint of individuals’ linguistic acts, linguistic

communication becomes credible only when they follow the same system of norms. However, it is also true that the system of norms is changeable through collective effects produced by individuals' linguistic acts. Consequently, feeling a kind of tension, an individual undertakes his or her linguistic acts although he or she is normally unaware of this kind of tension. Normally, structural linguists investigate linguistic phenomena from these two facets and are interested in mutual influences between both facets.

On the contrary, from the viewpoint of education, educators should focus mainly on the system of norms because education is a process where pupils achieve competence in a culture by which they live: enculturation. This process consists of teaching norms, and educators are never aggressive in pupils' changing the norms. Hence, although structuralist approach is normally to investigate the mutual influences, it is proper that educators' concern is biased in favour of considering "*la langue*" to use Saussurian term. Thus, the present paper illuminates only one of the facets: a cultural system of forms or norms.

Surprisingly, in non-Western countries, science education appears to be an important exception to enculturation, the essential nature of education. The reason is that almost all non-Western countries have socially implanted W-science from the West and that they expect science educators to teach pupils W-science in order to have their countries industrialized. There, pupils cannot relate W-science to their cultural tradition, because W-science is not just a body of knowledge, but a system of knowledge formulated in harmony with the Western cultures. As a consequence of this, no mater how universal W-science appears to be, it is never culturally neutralized (e.g., Kawasaki 1996). When science educators intend to implant W-science for industrialization, this social expectation inevitably creates educational conflict between enculturation as such and cultural implantation for industrialization.

In order to resolve this educational conflict in science education, I proposed that science education should be identified with foreign language as stated above. From the viewpoint of non-Western countries, foreign language education constitutes the same exception as science education, and differs from enculturation in the original sense. Foreign language educators attempt to teach a foreign language different from the language which pupils ought to acquire. However, in foreign language education, pupils are prevented from conceptual confusion by the following two reasons: 1) science educators are always sensitive to linguistic incommensurability between languages concerned; 2) therefore, pupils are led to take linguistic incommensurability into consideration. In other words, one of the fundamental

objectives of foreign language education is to have pupils be aware of linguistic incommensurability.

In the same way, being sensitive to linguistic or cultural incommensurability between the W-scientific worldview and a traditional worldview concerned, science educators could prevent pupils from conceptual confusion in science as a school subject. However, few science educators must be fond of identifying science education with foreign language education. Science educators are inclined to emphasize to pupils familiar nature of content of science rather than its cultural incommensurability with non-Western cultures by which pupils live. If science educators just emphasize the familiar nature in science classroom, their pupils can neither succeed in realizing linguistic or cultural incommensurability nor be prevented from conceptual confusion in science. Then, it is necessary to formulate a way to reveal this incommensurability as to key terms in science as a school subject.

Axiom in Cross-Cultural Perspective

Such incommensurability as science educators should take into account is caused by difference in word cloud which a word or a thing recollects in mind. This psychological phenomenon is inherent in individual languages. Imagine a string of beads that is used for counting prayers in religious activity. Then, what is this? On one hand, Roman Catholic persons must answer that this is a rosary. Plainly, the word “rosary” forms a cloud of words: “Lord’s Prayer”, “Ave Maria”, “church”, “Christian faith”, etc. They are properly called rosary-associated relations (Kawasaki, 1996). On the other hand, seeing the same string of beads, Japanese Buddhists’ answer is definitely “juzu”, which they use for counting the number of invocations. For instance, an invocation is “namu-amidabutsu” meaning that I believe devoutly in Amitabha in the Pure Land. The Japanese word “juzu” forms another cloud of Japanese words: “Buddhist monk”, “Buddhist temple”, “Buddhist saint”, etc. The word cloud is “juzu”-associated relations. Furthermore, Muslim persons must say “tasbih”. And there may be a case that some impious persons remember it as a necklace.

This does not mean that the essence of religious characteristics is imbedded into the string of beads as such. What they understand depends on what they already know. Each individual person’s viewpoint determines what it is. In other words, a viewpoint creates an object of consideration. This is understood within anti-essentialism or anti-realism. Depending on a viewpoint, the string of beads appears to be a rosary, “juzu” or necklace. No one can perceive

the string of beads as a rosary, “juzu” and necklace at the same time. When perception is changed, Gestalt shift must take place (Kawasaki 1996). Before being cast a specific viewpoint, the string of beads is culturally neutral, but is not an object of human perception at all. A specific viewpoint determines what the string of beads is: a rosary, “juzu”, “tasbhi” or necklace.

> Man cannot come into direct contact with the elements composing his world as such. These elements constitute a world meaningless in itself, one which might aptly be described as disorderly and chaotic. One must conclude that the role of language is to bring order to this world and fashion in it meaningful and controllable objects, properties, and actions. (Suzuki, 1993, p. 40)

Linguistic or cultural incommensurability reflects difference in orders languages have established, and appears to be difference in associated relations. Therefore, anti-essentialism or ant-realism makes no sense when only one linguistic representation is present through out the world. This is the reason why science education in the non-West demands anti-essentialism or anti-realism.

Obviously, it is incorrect to translate the English word “rosary” into the Japanese word “juzu” because no rosary plays the same religious role as “juzu”. If religious value is removed from a rosary, it cannot be a rosary any longer. Likewise, a “juzu” cannot be a “juzu”; a “tasbih” cannot be a “tasbih”. There remains something that is a string of beads, and the thing is neither meaningful nor controllable. Then, this stops being an object of human perception. Attaching religious values, giving its name and perceiving it as a “rosary” or a “juzu” are different aspects of the same psychological phenomenon: recognition. I discussed this in detail by adducing an example of forming constellations in the sky (Kawasaki, 1996). This is an immediate consequence of anti-essentialism or anti-realism.

The essence of this inseparability between value and name is the same as de Saussure expressed in a metaphor of a sheet of paper.

> Language can also be compared with a sheet of paper; thought is the front and the sound the back; one cannot cut the front without cutting the back at the same time; likewise in language, one can neither divide sound from thought nor thought from

sound. (de Saussure, 1966, p.113)

Hence, it is fictional to remove religious value from “rosary”, “tasbih” or “juzu” and it is impossible for pious persons to regard it as just a string of beads. In the strict sense of anti-essentialism, the expression “a string of beads” is inadequate in the sentence above. This sentence conveys a wrong impression of separability between value and name, because the thing becomes perceivable as “a string of beads” being given the name “a string of beads” at the same time. Therefore, the translation of “rosary” into “zuju” fails to convey any idea relating to Christian faith: rosary-associated relations. It is juzu-associated relations that the translation conveys to Japanese people. Consequently, Japanese people are led to a misunderstanding in this translation: Roman Catholic is practically identical to Japanese Buddhism.

Only when the translation takes account of respective religious values at the same time, the translation becomes justifiable. However, this makes the translation impossible because translation generally means to replace a foreign word by a single word. Consequently, in order to avoid misunderstandings like the above, it is essential to describe linguistic and cultural incommensurability between two words concerned. This is not translation but explanation of linguistic and cultural incommensurability. Axiom in the present context is a method to accept translation, replacement of a foreign word by a single word, and at the same time to remind science educators of incommensurability aroused in science education in non-Western countries (Kawasaki, 1999).

The axiomatic method essentially involves a fictional procedure. In this procedure, for example, religious value is removed from both “rosary,” “tasbih” and “juzu”; consequently, something imperceptible is left. Being reminded that something imperceptible is left, people can be aware of the incommensurability between “rosary,” “tasbih” and “juzu”. Similarly, science educators recollect the incommensurability between “nature” and “shizen” by using an axiom as to this word replacement; in this procedure, both nature-associated relations and shizen-associated relations are removed from the respective terms. Hence, I expect an axiom or a system of axioms for science educators to recall the fictional stage of cognition. As a consequence of their awareness of the fictional stage of cognition, science educators must pay their attention to linguistic incommensurability in science education.

In the sense of modern axiomatic theory, every axiom consists of indefinable terms, which

are connected only by logical relations between them; an axiom subordinates indefinable terms to relations (Blanche, 1973, p.167). For example, the hyperbolic axiom, i.e., an axiom of non-Euclidean geometry, is: There exist lines which have neither a point nor a perpendicular in common (Wolff & Bauer, 1983, p.167). On the contrary, the axiom of Euclidean geometry is: Two lines always have either a point or a perpendicular in common (Wolff & Bauer, 1983, p. 166). Obviously, these two axioms are contradictory to each other, and the characteristics of "point" and "line" in the respective geometries are not the same. Therefore, the term "line" should be considered indefinable from the viewpoint of "the set of all metric planes" (Wolff & Bauer, 1983, p.172). The extension of this indefinable term "line" includes all types of geometric "line". Therefore, according to a logical theory that extension of a term increases with a decrease in intension of the same term, intension of this term becomes close to infinitesimal.

1) Rosary-Axiom

I have paraphrased this feature of indefinable term: an indefinable term has infinitesimal intension then unlimited extension (Kawasaki 1999). Each indefinable term has no meaning, and is an object of neither human perception nor consideration. Furthermore, I would like to call relationships between indefinable terms "axiom" for the sake of its fictional feature in linguistics. Because of this fictional characteristic "axiom" must remind science educators that terms connected through translation is culturally incommensurable with each other.

For instance, including indefinable terms [ROSARY] and [PRAYER], an axiom of "rosary" can be formulated:

A [ROSARY] is used for counting [PRAYERS]. (A1)

In (A1) the indefinable terms are expressed in capital letters and put in square brackets. The indefinable term [ROSARY] can refer to all of "rosary," "tasbih" and "juzu", because it has unlimited extension. In the same manner, a set of denotation of [PRAYERS] includes both "Lord's Prayer," "Prayers dedicates by Muslim people" and the Buddhist's prayer "namu-amidabutsu" in addition to all other sets of words for all kinds of religious service in the world. Accordingly, the axioms (A2) below are exactly the same as (A1).

A [TASBIH] is used for counting [PRAYERS],
and
A [JUZU] is used for counting [PRAYERS]. (A2)

There is no way linguistic-cultural incommensurability between them.

It becomes possible to overcome linguistic-cultural incommensurability in return for establishing such a fictional stage of cognition. Although an axiom or a set of axioms is fictional in human cognition, it can serve as a common dimension of cross-cultural comparison. This is essential to equitable studies on cultures. This stance on axioms is identical to structuralist's stance on mathematical forms. Typically, structuralism formulates mathematical forms in order to carry out equitable investigation of social or anthropological structures. The forms serve as a common dimension of comparison. Levi-Strauss "was able to give mathematical form to his anthropological discoveries" (Piaget, 1973,p.110).

> And it [mathematical form] turned out that not only kinship systems, but all the "practices" and cognitive products of the societies under study --- the passage form one system of classification to another, or from one myth to another --- lend themselves to this sort of structural analysis. (Piaget, 1973, p.110)

Axioms, in the context of this paper, function in the same way as mathematical forms in structuralism.

2) Axioms in Science Education Research

The following is a system of axioms I formulated in Kawasaki (1999) in order to recognize and resolve the problem of linguistic incommensurability aroused in science education in Japan.

[SCIENCE] is a system of knowledge about [NATURE]. (A3)
In the sphere of [EXPERIMENT], [NATURE] is [OBSERVED]. (A4)

If science educators constantly take these axioms into consideration, linguistic and cultural incommensurability must be greatly reduced between the West and the non-West. The reason

is that these axioms are definitely fictional. Then, in particular in the non-West, these axioms must stimulate science educators to take consideration of the incommensurability they have to be confronted with. Their awareness of it necessarily leads them to overcome it (Kawasaki, 1996).

As to (A3), the indefinable term [SCIENCE] is connected to the other [NATURE] by a part of the sentence "is a system of knowledge about," and this part establishes relationship between the two indefinable terms. Since the intension of the term [SCIENCE] is infinitesimal, [SCIENCE] stands for an unlimited set of etho-sciences in addition to W-science. Therefore, this term [SCIENCE] is an ultimate superordinate to all ethno-sciences as well as W-science. Consequently, the expression [SCIENCE] makes it possible to accomplish equitable consideration of both W-science and a knowledge system based on traditional worldview. Science educators can liberate themselves from any cultural bias in their consideration of science education since the above system of axioms is a culturally unbiased description of a system of knowledge concerning the world.

It should be emphasized again that what the axiom (A3) describes is fictional. When the Western cultural value is attached to [NATURE], [NATURE] becomes "nature" in ordinary use in the English language. Then, [SCIENCE] becomes "W-science." Similarly, when the Japanese cultural value is attached to [NATURE], it becomes "shizen" in the Japanese language. As a consequence of articulation of [NATURE] in the Japanese language, [SCIENCE] represents a science as a knowledge system based on the Japanese traditional worldview (see Kawasaki, 1999, for detail account). Likewise, this procedure of articulation is naturally applicable to science education in other non-Western countries. Through this artificial and unnatural procedure, science educators can realize the incommensurability in science as a school subject.

AXIOMATIZING "REALITY"

Whoever intends to coin an axiomatic expression of conceptions has to begin by formulating a relationship between the conceptions concerned, and then has to revise the relationship in order that the terms may not imply linguistic-cultural bias. In the case of the axiom of "rosary," "tasbih" or "juzu", for example, the indefinable terms do not imply any religions by definition; the other terms, namely "a", "is", "used", "for" and "counting", rarely imply any bias toward a specific religion. If there are terms recollecting a specific religion,

they must be considered indefinable as “nature” is treated as [NATURE].

Obviously, the term “reality” or “scientific reality” is another keyword, to which science educators should pay cross-cultural attention in addition to “science”, “nature”, “experiment” and “observation”. In science teaching, science teachers always encourage pupils to find out scientific realities by means of theoretical and experimental consideration, and demonstrate scientific explanations with postulating other scientific realities concerned. Therefore, the essence of scientific explanations is to relate realities to other realities, and the scientific explanations become scientific laws if the explanations are confirmed to a certain degree. Hence, W-scientific realities play a central role as the beginning of scientific explanations. In other words, some realities are always considered as “what ought to exist” without demonstrations. This is the reason why science teachers encourage pupils to find out scientific realities.

W-scientific explanations have a general form: an explanation of the world describes a specific phenomenon or thing in terms of a few postulates consisting of W-scientific realities. As to an axiomatic expression of “scientific realities”, a possible relationship fulfilling the unbiased condition is:

[SCIENTIFIC] explanation postulates [REALITIES], (A5)

where the term “scientific” is treated as indefinable in relation to (A3) which considers the term “science” to be indefinable. Thus, the three axioms, namely (A3), (A4) and (A5) the present paper newly adds to these two, form themselves into an axiomatic system. This system must support science educators in taking linguistic and cultural incommensurability into consideration.

ARTICULATION OF THE AXIOM

In the following, the present paper will give a cross-cultural description of [REALITY] by articulating the axiom of [REALITY] according to respective cultures concerned. Of course, one of these cultures must be the Western culture where W-science has been nurtured and developed.

1) [REALITY] Articulated in the West

In the tradition of Western intelligence, reality which every scientific explanation has postulated is absolutely insensible. In order to demonstrate this, it is enough to cite from *The Republic* (Plato, 1987). For instance, Socrates says:

> The stars that decorate the sky, though we rightly regard them as the finest and most perfect of visible things, are far inferior, just because they are visible, to the true realities; that is, to the true relative velocities, in pure numbers and perfect figures, of the orbits and what they carry in them, which are perceptible to reason and thought but not visible to the eye. (pp. 277-278)

Throughout the history of Western intelligence, reality is never thought to be sensible, and what science educators encourage pupils to find out is still insensible in the present time.

For instance, those science teachers who follow the heuristic method encourage pupils to discover Hooke's low by means of the following experiment. First, a spiral spring with a scale pan and pointer attached is held vertically by a clamp and stand. Second, standard masses are then added to the pan, say 10g at a time, and the corresponding extensions to the spring are calculated from the readings of the pointer on a scale of millimetres. As the consequence of the experiment, pupils may have a numerical table of the readings of extension and the numbers of standard masses. If pupils conduct this experiment for verifying Hook's law, this lesson may be completed by their plotting a graph of extension against force and obtaining a straight line through the origin on the graph.

However, in the case that science teachers follow the heuristic method, they have to encounter a problematic situation because of encouraging pupils to find out the straight line through the origin on the graph. Of course the essence of this situation is the same as W-scientific researchers always encounter, because science teachers expect pupils to behave as scientists. Then, science teaches must be aware that there is no reason to draw the straight line. Popper (1980) pointed out this essence:

> The advance of science is not due to the fact that more and more perceptual experiences accumulate in the course of time. Nor is it due to the fact that we are making ever better use of our senses. Out of uninterpreted sense-experiences science cannot be distilled, no matter how industriously we gather and sort them. Bold ideas,

> unjustified anticipations, and speculative thought, are our only means for interpreting nature: our only organon, our only instrument, for grasping her. (p.280)

The straight line may be drawn on the basis of "bold ideas, unjustified anticipations, and speculative thought".

Furthermore, Poincare (1952, pp. 142-143) justifies this: "we are not restricted to our experiment, we correct it". This clearly implies that W-scientific researchers adopt a hidden standard for correcting experimental data. It is this hidden standard that derives W-scientific laws, and coins W-scientific realities insensible to human sense organs. Following heuristic method, science educators have to keep this insensibility in mind.

2) *[REALITY] Articulated in Japan*

On the contrary, "reality" in the Japanese sense is concrete and sensible. This must be implausible to English-speaking people, because this use of "reality" is contradictory to *langue* of the English language. On the contrary, explanations start something sensible according to the Japanese tradition. This stems from the traditional view of learning. Ogyu Sorai (1666 - 1728), a distinguished Japanized Confucianist, "did not like the sort of abstract speculation found in the Sung school; he made more of particular 'things, *wu*[2]' than of universal 'principles, *li*[2]'" (Nakamura, 1973, p.537).

> "learning" meant to amass a knowledge of particular facts, and culminated, for him, in the study of history --- a preference which is closely related to the ethical character of his "learning": "Since learning is to have wide information and to have experience with realities, it culminates in history". (Nakamura, 1973, p.537)

In the context above, "realities" are clearly understood to be sensible and concrete.

Another example indicating that Japanese "realities" are sensible is drawn from Motoori Norinaga (1730 - 1801), the great scholar of Japanese classics. He "exhorted all students just to be diligent in study, and did not develop any constructive thinking about the method of learning itself" (Nakamura, 1973, p.543). Nakamura (1973) concludes:

> At least, it is historically true that the neglect of logic is one of the salient features of

> traditional Japanese ways of thinking. Concrete intuitions are favored much more than abstract concepts devoid of any tangible connection with the humanly perceived world. (p. 543)

This means that Japanese ways of thinking are restricted only to the humanly perceived world. Hence, Japanese realities are sensible and concrete.

Nakamura also points out that this salient feature of the Japanese way of thinking is supported by the linguistic fact that "the Japanese language does not have any fully established method of composing abstract nouns" (Nakamura, 1973, p.533); on the contrary, some combinations between the definite article "the" and a noun or adjective make abstract nouns corresponding to the noun or adjective. Relating closely to the linguistic feature of the Japanese language, this salient feature must influence pupils' thinking in the science classroom in Japan. Science educators now encounter linguistic and cultural incommensurability as to the conception "reality". Even though science teachers encourage pupils to find out W-scientific realities, what pupils can find out may be sensible and concrete.

Additionally, I adduce another example from a sphere of comparative literature that Japanese people's thought may be restricted only to the phenomenal or sensible world. Japanese people have been fond of and polished up enumeration as a literary rhetoric method throughout the Japanese literary tradition (Pigeot, 1997, pp.62-66). Pigeot asserts that a pedagogical aim must be involved in making enumeration of things by giving examples from *otogi zoshi*, an anthology of Japanese tales edited more than four hundred years before.

> Perhaps the authors of the *otogi zoshi*, by including lists such as these, had a pedagogical aim, and sought to remind their readers (many of them woman) what the education of a person of condition meant. (Pigeot, 1991)

This pedagogical aim is identical to what the Japanese scholars upheld.

It is natural in Japan that pupils seek to make an enumeration of aspects of a natural phenomenon even in the science classroom. Nakayama and Iwakiri (1999) suggest that pupils try to give a full description of diversity of a W-scientific phenomenon they are really faced with, not to confirm their conclusion asserting ideals or universals according to the W-scientific way of thinking: establishing relationships between Ideas to use Platonic term.

Pupils who have acquired the Japanese language as the first language cannot deal with Ideas because “the Japanese language does not have any fully established method of composing abstract nouns” as stated above.

Obviously, science educators have to take this linguistic feature of the Japanese language into consideration; the axiom of reality makes it possible for them to realize the linguistic incommensurability with SAE languages. This must be the first step to overcome the linguistic incommensurability pupils as well as science teachers inevitably confront in the science classroom in Japan.

CONCLUDING REMARKS

Imagine a society where people postulate fairies to explain every natural phenomenon. For example, “Rainy” can let it rain, and “Windy” can let wind blow. The people can give the reason why it is raining now: “Rainy” is working diligently. When “Windy” thinks it is enough, “Windy” has “Rainy” stop working. Thus, the people explain why wind blows just before dry season begins. In this manner, the people can explain all natural phenomena the people have experienced. The people just add a fresh fairy to their knowledge system of fairies, confronting a new phenomenon that they have never experienced. According to (A5), their fairies are [REALITIES] articulated in that society as a cultural unit.

Thus, every explanation involves a system of premises, which are self-evident truth known immediately as such and taken for granted. Therefore, what is considered to be self-evident is critical to science education and science education research in respective cultural units. Since W-science is an outcome of Western cultures, the self-evident truth is acceptable only to Western cultures: Nature has mathematical form which is known only by human reason. No doubt is raised about existence of W-scientific realities in the context of both science education and science education research. This is the reason that science educators encourage pupils to explain phenomena in terms of a system of scientific realities. In order to avoid pupils’ conceptual confusion, science educators should raise a question whether the W-scientific reality is self-evident in the linguistic-cultural setting concerned: A fundamental issue that needs to be discussed is whether the self-evidentness of W-scientific realities is independent of linguistic-cultural setting for science education.

In the fairy postulating society, younger generation must receive an education in making a matching list of fairy names with natural phenomena; then, they may make use of the

matching list in order to decide when they should go on a hunt or seed their fields with a specific type of plant. Although the example above seems simplistic, the essence of the role of reality in education is fundamentally presented. Their knowledge about [NATURE] articulated in their society is systematized, foreshowing and useful to their life in the same way that the W-scientific knowledge is. Therefore, the education the younger generation receive in this cultural unit could properly be called “science education” if its conception is broadened and described in an axiomatic expression. Since this axiom organizes a common dimension for comparative study, such studies will clarify characteristic features of science education.

Now, an axiom of science education is obtained.

[SCIENCE EDUCATION] is a system of teaching [SCIENCE]. (A6)

This effort to formulate the axiom (A6) is not a result from just intellectual amusement, but a basis for conducting an epistemological reflection on science education in a linguistic and cultural unit. Linguistic and cultural incommensurability as to “science education” between the cultural unit and the West will be carved against the axiomatic system including the axiom (A6). It is impossible to carry out cross-cultural studies on science education research until this framework is formulated.

However, on one hand, cross-cultural research demands cultural relativism, which must appear to break down a motive of encouraging pupils to learn W-science in non-Western countries. On the other hand, without cultural relativism, science education inevitable leads pupils to replace their traditional worldview by the W-scientific worldview, and they must be led to cultural identity crisis. Science educators can resolve this dilemma by identifying science education with foreign language education (Kawasaki, 1996). In identifying, science educators can go further, and they encourage non-Western pupils to conduct an epistemological reflection on their culture by which they live. This must be accomplished in the same way that whoever learns a foreign language is led to be aware of his or her first language, and should be included into the rationale for science education in the non-Western countries.

Notes

1. Non-Western countries are countries where people use non-SAE language as the first language, i.e., mother tongue. “SAE” is an abbreviation to Standard Average European which Whorf defined as:
2. The terms “*wu*” and “*li*” the Chinese sounds of keywords of Neo-Confucianism; usually Japanese people do not pronounce as these. They are “*ki*” and “*ri*”, respectively. Although they retain their original Chinese conceptions naturally, there are some important cases their conceptions are radically Japanized. However, this is not a matter that needs to be discussed in this paper.

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