Measurement Science for Liberal Education to rise up Scientific and Technical Sense of Society

K. Kariya, S. Takayama

Faculty of Science and Engineering Ritsumeikan University BKC, Shiga, JAPAN

1-1-1, Noji-Higashi, Kusatsu, Shiga, Post No.525-8577, Japan

Phone: +81-77-561-2662, Fax: +81-77-561-2663

E-mail: kariya@se.ritsumei.ac.jp, s-tkym@se.ritsumei.ac.jp

Abstract : *We had jointed with the conference "MEASUREMENT2001" and "MEASUREMENT 2003" and had presented two papers related with scientific education of people took in Measurement Scientific thought[1],[2]. During the IMEKO, we had presented another one paper the title is "Four Expressions of Fundamental Structure of Measurement Science" on IMEKO 10th TC-7 Symposium(Saint-Petersburg, RUSSIA, 2004)[3].*

In this conference "MEASUREMENT 2005" we report a concept of "MEASUREMENT SCIENCE FOR LIBERAL EDUCATION" by collecting the thought proposed in these three papers. Because in the age of science, technology and information oriented society, a science that all people able to learn at each education stage according to each level is wanted.

An act to measure is a fundamental action of a man so that when it is discussed systematically as the fundamental human activity and the carrier of roll on society, namely by scientific methodology, the science arise in hear becomes just appropriate science for Liberal Education to rise up the scientific and technological sense of people. Here this science takes a position of "MEASUREMENT SCIENCE FOR LIBERAL EDUCATION".

Keywords: l*iberal education, an action of a man, an act to measure, measurement science*

1. BACKGROUND of "Measurement Science for Liberal Education"

The society we live is consisted of man's background, and the society is going to develop with the growth of civilization, the development of economy and the upkeep of order by low. Here, there is "An action of a man" in basis and the action takes by a man starts as "An act to measure the things".

A man gets information by measuring the things and acquires knowledge by analyzing the information. Then people take the action individually by applying the knowledge. The process like these is discussed in "Measurement Engineering" or "Measurement Technique" as measurement methodology.

These are construction methods of measurement systems, measuring tools and devices use in the systems and measurement results based on measurement methods. In the first time, "Measurement Engineering (Measurement Technique)" had developed every engineering fields (for example: Electric measurement, Electronic measurement, Civil measurement, Mechanical measurement, Chemical measurement, Medical measurement, Optics measurement, ----- and so on). And then had developed every measurement objects (for example: Temperature measurement, Radiation measurement, Photo measurement, Radio measurement, Infrared measurement, Ultraviolet measurement, Force measurement, Hardness measurement, Length measurement, Area measurement, Volume measurement, ----- and so on). But now these each field's measurement is connected each other over the boundary and is concerning as a big and an important engineering.

Besides, the learning with measure is discussed as "Measurement Science". Here the birth-development process of society is discussed strongly through the view (theory) of measurement which is a fundamental action of a man. Of course the process to get information and to acquire knowledge is discussed, but here re-production of knowledge for the uplift of a man and the level up of society is main subject.

As above mentioned the learning with measure operates directly to an action of a man and to social action of people so that "Measurement Science" that an act to measure is discussed and organized suits very well to Liberal Education.

2. BASIC CONCEPTS of "Measurement Science for Liberal Education"

When consider a basis of "An action of a man" is "An act to measure" (Basis), the process of an action of a man is classified in four processes (1)(2)(3)(4), and these become "Four concepts of MEASUREMENT SCIENCE FOR LIBERAL EDUCATION". Fig.1 is the conceptual diagram.

(Basis) A basis of an action of a man is **"An act to measure".** .

(1) The first process is an act to measure by the need of an action of a man, that is, a process to detect the signal included information. This is **Fist concept of measurement "An act of sensing"**

(2) The second process is an operation to analyze the signal, that is, a process to get the analyzed signal to extract the knowledge. This is **Second concept of measurement**

"An act of analysis".

(3) The third process is an act to extract the knowledge from the analyzed signal, that is, a process to get the knowledge to practice the need of action of a man. This is **Third concept of measurement "An act to get knowledge".**

(4) The fourth process is a social operation of a social action by utilization of the knowledge. This is **Fourth concept of measurement "An act for individual and social activity".**

These four processes and concepts are fundamental functions of a man on individual and social activity, and the functions contribute to the development of society by progress and expansion of the functions. Here the discussion of the functions of measurement as "SCIENCE" becomes very important, especially on the discussion of the process from second to fourth (regard the "Study" in Fig.1)

2.1 Basis of an action of a man ----- "An act of measure"

An act to measure starts by the need (desire) of action a man move on. The Basis of an action of a man, that is **"An act to measure",** is practiced for the purpose to get information. The information is classified in effective one and non-effective one. Now indicate an act to measure of a man as M and indicate the need of action of a man as N, then a relation N and M is given like next, and it is expanded to practical measurement..

$$N \Leftrightarrow M, \quad f: N \to M \quad (f; \text{mapping}) \quad (1)$$

Generally, the M is practiced as some acts to measure , and it is appropriate to classify in to four process. And the need of action becomes the condition for each process. The relation indicates like next.

$$(M \mid N) \to M_p \qquad (2)$$

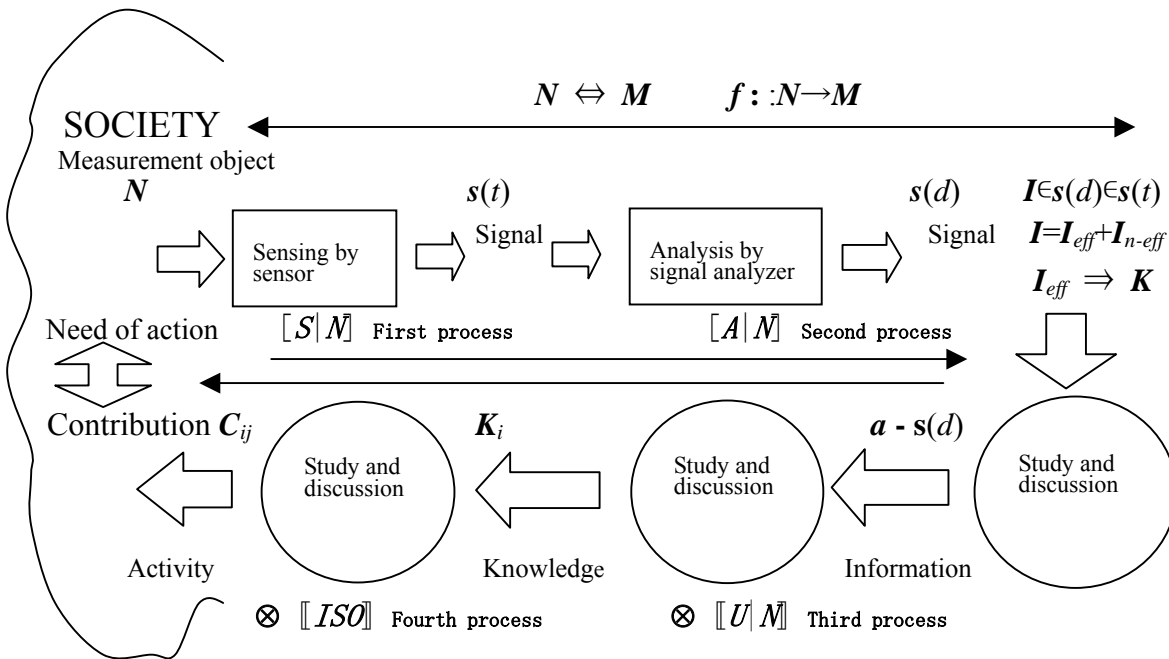Where, $p = 1,2,3,4$ are four process for the practice of M.

Fig.1 Conceptual diagram of "MEASUREMENT SCIENCE FOR LIBERAL EDUCATION"

2.2 First concept of measurement -----"An act of sensing"

The practical an act to measure of a man M_p is, in the first process, practiced by sensor. The action is

generally called as "Sensing" and this is first concept of measurement, that is, **"An act of sensing".** And it is proper to classify into two categories, the feeling sensing and technical sensing. Anyway, the result of sensing becomes time series signal $s(t)$, and the

information comes out oriented in the signal. Since an act to measure of a man M is practiced in the first by getting the information I which takes practice the need of action of a man N, the M becomes to an action $I \cdot M_p$. At the first process M_p becomes an act of sensing M_s and the action $I \cdot M_s$ is practiced by sensor S conditioned by N. These relations are indicated like next.

$$M \Rightarrow I \cdot M_{p=1} \Rightarrow I \cdot M_s \qquad (3)$$

$$I \cdot [S \,|\, N] \quad \rightarrow s(t) \qquad (4)$$

Here, [ ] shows the instrument as technical factor.

2.3 . Second concept of measurement ----- "An act of analysis"

The second concept is a process to analyze the signal $s(t)$ and to get another domain signal $s(d)$. Because, more information is embedded in $s(d)$ related with the need of action. This is well known as "Signal analysis" or "Signal processing", that is, **"An act of analysis".** Then, here, it must be memorized that the time series signal $s(t)$ is a set and has a structure of a stochastic process as like next.

$$s(t) = \{ s(t, \omega) \,;\, -\infty < t < \infty,\ \omega \in \Omega \} \quad (5)$$

Here,: ω is stochastic parameter, and the measured signal (detected signal by sensor) is determined by $\omega = \omega_i$. Then practical output signal is given like next.

$$s_i(t) = \{ s(t, \omega = \omega_i;\ -\infty < t < \infty) \} \quad (6)$$

This signal is analyzed by the signal analyzer A related with N and the result becomes signal $s(d)$. This signal is almost case given on the domain d except time domain t. These relation is shown in same with the case of sensor..

$$M \Rightarrow I \cdot M_{p=2} \Rightarrow I \cdot M_a \qquad (7)$$

$$I \cdot [A|N] \Rightarrow s(t) \cdot [A|N] \rightarrow s(d) \qquad (8)$$

Here, M_a is an act of analyzing and the act practiced by signal analyzer A conditioned by N. Practical analyzers are Frequency analyzer, Frequency spectrum density analyzer, Probability density analyzer, and so on..

2.4 . Third concept of measurement- -----"An act to get knowledge"

Third concept is a process to get the knowledge. The information I is embedded in the signal $s(d)$ that the detected signal $s(t)$ by sensor was analyzed by signal analyzer. Then it becomes need to extract

the knowledge in the information. This is **"an act to get knowledge"** of measurement. The relation with information and signal is clear from the formula (4) and (8).

$$I \in s(d) \in s(t) \qquad (9)$$

Then the information is consisted of effective information and non-effective information, and it is not fixed with the effective and non-effective. As the effective information becomes knowledge K so that the relation is shown like next.

$$I = I_{eff} \rightleftarrows I_{n\text{-}eff} \qquad (10)$$

$$I_{eff} \Rightarrow K, \qquad K \in I \qquad (11)$$

When a man uses effectively the information, the information becomes knowledge. Then some operation becomes need to take out the knowledge K from the information. Fundamental operation is indicated as like same style with the first concept and the second concept.

$$M\,I \Rightarrow I \cdot M_{p=3} \Rightarrow I \cdot M_u \qquad (12)$$

$$I \cdot [\![U|N]\!] \Rightarrow K \qquad (13)$$

Here, M_u is an act of use of information, and the action $I\,M_u$ is discussed by U conditioned by N. And $[\![\ ]\!]$ shows the scientific factor not technical factor. If U is practiced by "information processor" or "information analyzer" at parallel with "sensor" and "signal analyzer" which are instruments as technical. factor, .the relation is given similarly with formula (4) and (8).

$$s(d) \cdot [\![U|N]\!] \Rightarrow K \qquad (14)$$

But the U is more strong scientific factor which is discussed at the relate with the need of action of a man N and the signal $s(d)$. Then the relation gives by Cartesian product ($\otimes$) for a $s(d)$ like next.

$$s(d) \otimes [\![U|N]\!] \rightarrow K_1, K_2, K_3, \text{---}, K_i, \text{---}, \quad (15)$$

For example, when power spectrum and its density, cross spectrum, correlation function and etc. were asked from the frequency amplitude spectrum $s(d)$ that the detected signal $s(t)$ was analyzed by signal analyzer, at the relation with the need of action N, these become the knowledge K_1, K_2, K_3, --- support the need of action. And then, similarly, when characteristic function, amplitude probably density distribution transition process and etc. were asked from the amplitude probability density $s(d)$ that the detected signal $s(t)$ was analyzed by signal analyzer, at the relation with the need N, these become the

knowledge K_1, K_2, K_3, --- practice the need of action.

2.5 Forth concept of measurement -----"An act for individual and social activity"

What purpose a man wants to get the knowledge? The reason is that a man wants every time to be leveled up individual life and to be developed human society. The knowledge is used to the operation, that is, **"An act for individual and social activity"** of measurement. When now indicate the individual and   social operation as ISO and the contribution as C, the relation is shown by scientific factor as next.

$$K_i \otimes \ [\![ISO]\!] \ \Rightarrow \ C_{i\,1}, C_{i\,2}, C_{i\,3}, ---, C_{i\,j}, ---- \quad (16)$$

Where, i=1,2,3,---, j=1,2,3,---
$\otimes$ is Cartesian product.

Here, the $[\![ISO]\!]$ will becomes to a contribution factor or an accommodation factor, and the measurement methods should be studied. .Generally, the measurement is doing by discussion, and then the C must be studied in future adequately..

3. APPLICATION OF BASIC CONCEPTS
to each education stage according to each level (As Conclusion)

In "What an act to measure" based on "An action of a man", the "Basis" and "Four concepts" showed in **Section 2** exist, and here, it is known that the mapping of the need of an action of a man is an act to measure. In the discussion of **Section 2**, to express the simple structure of "MEASUREMENT SCIENCE FOR LIBERAL EDUCATION", "**Four Definition-Functions"** are introduced.

These functions become easy understandable to compare with each other like Table 1. Here, $[\ \ ]$ shows a definition- function which is possible to practice by   artificial and   technical   method, and

$[\![\ \ ]\!]$ shows a definition - function which becomes need of the study, the discussion, the decision, and so on by the thought of a man. Namely, $[\ \ ]$ is technical function but $[\![\ \ ]\!]$ is scientific function, and here an act to measure is discussed as SCIENCE not ENGINEERING.

At practical education, it is expected to study and discuss, and to show the relation with science and technique and development of society by using appropriate example according to education stage and level. Radiation measurement, Disturvance(Typhoon) measurement, Traffic measurement, -----, and so on are appropriate examples.

Table 1   Definition–functions concern a simple structure of "MEASUREMENT SCIENCE FOR LIBERAL EDUCATION"

Basis	An action	Definition function	Results	Methods
$f:N$ $\rightarrow M$	to get signal	$[S\|N]$	$s(t)$	technical
	to analyze signal	$[A\|N]$	$s(d)$	technical
	to get knowledge	$[\![U\|M]\!]$	K_1, K_2, K_3, – K_i, – –	scientific
	individual and social activity	$[\![ISO]\!]$	$C_{i\,1}$, $C_{i\,2}$, $C_{i\,3}$, – $C_{i\,j}$ – –	scientific

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