Science crisis in the making

By KAZUO NISHIMURA

Last November I delivered a lecture on complex-system economics at a world-famous institute in Santa Fe, New Mexico. I also attended a conference on science education in the same city, along with a physicist from Turkey who was visiting there at the time.

The conference, aimed at improving mathematics and physics education in the United States, was organized by David Pines, co-director of the Institute for Complex Adaptive Matters, and attended by university and high-school teachers, writers, directors of science movies, computer engineers and many others. The subject was how to prepare a teaching program on superconductivity for junior- and high-school students.

I spoke of my experience as the author of a math textbook, "Let's Study Math" (not approved by Japanese censors). The idea behind the book — providing children with a text for self-study — received a favorable response from the audience.

The Turkish physicist Ali Alpar, a professor at a newly established university in Istanbul, reported on education there. According to him, Sabanci University (named after a Turkish businessman) requires humanities students to study math and physics as well. In the case of sciences — physics, chemistry, biology and geology are organically combined. Generally, the first three subjects are taught in that order over a period of two years. Biology is taught last so that students can learn some of the latest developments in life science, as in genetic engineering and brain science.

All this illustrates that the university's founding committee conducted exhaustive discussions to create an educational institution in the true sense of the term. It is easy to imagine that students at Sabanci University are as excellent as those at prestigious universities of long standing.

By contrast, science education in Japan seems approaching a crisis. University students in the humanities have little knowledge of high-school-level sciences. Even some science students have no experience studying physics and biology in high school or lack an ability to make the grade. So universities are left to make up for these shortcomings.

One reason for all this lies in the the way that high-school science education is provided. According to a survey by Katsuhiro Arai, professor at Tohoku University, only 12 percent of students complete physics studies (category 2), less than the 16 percent of high-school graduates who enter universities' science departments. Those who similarly study math (category 3) represent about 20 percent, about the same percentage as those who enter natural-science departments.

> To raise Japan's technological level it is necessary not only to spend more time teaching science-related subjects, but also to increase the number of high-school students attending science classes

What this means is that many high-school students not good at math take up science and engineering courses at universities. With a large number of students failing to complete studies in physics (category 2) and math (category 3), those who do complete have a relatively low level of scholastic ability.

The waning interest in math and physics is not a new problem. The official response to this has been to alter the system so that students do not have to study difficult subjects.

To raise Japan's technological level it is necessary not only to spend more time teaching science-related subjects, but also to increase the number of high-school students attending science classes. By doing so, students interested in science should be motivated to enter science departments. For this to happen, systemic changes are needed so as to make high-school science lessons easier to learn.

At present, the science curriculum is divided into a variety of subjects, such as "basic sciences," "general sciences A," "general sciences B," "biology I" and "biology II." Since the divisions are largely artificial, study is made unnecessarily difficult.

Science studies in high school will become much easier if only four subjects — biology, chemistry, physics and geology — are taught. In fact, that was the case in the 1960s, when high-school students learned most of the basics about these subjects.

At Sabanci University, physics, chemistry and biology as well as geology are taught in an integrated manner, incorporating their basic elements. Biology has a fast-developing branch that requires knowledge of physics and chemistry. By the same token, knowledge of biology and geology is essential to an understanding of global environmental problems. Basic to this are chemistry and physics.

Physics should be studied first because it is a more basic and logical branch of science. That should make it easier to understand more applied subjects. That is also an efficient way to study a number of science subjects. At least high schools preparing for university entrance exams, if not all high schools, should provide such guidance.

In the past, as many as 80 percent of high-school students studied "physics I." Now, however, less than 30 percent complete the course. This is hardly the way to build a technology-oriented nation.

Kazuo Nishimura is a professor of economics and director at the Institute of Economic Research, Kyoto University. The original Japanese version of this article appeared in the Seiron column of the March 20 issue of Sankei Shimbun.

Survey: Humanities students poor at math

The Daily Yomiuri Jan. 17. 2000

Yomiuri Shimbun

About 25 percent of first year students enrolled in humanities courses at leading national and public universities are unable to solve basic mathematical problems involving the four rules of arithmetic and decimal fractions, according to the findings of a survey.

These findings demonstrate that poor mathematical ability among university students is not limited to the economics departments of private universities, which do not require candidates to take math for their entrance examinations. Rather, it is becoming common in all departments.

The survey was conducted in April by Kazuo Nishimura, an economics of complexity professor at Kyoto University, and Prof. Nobuyuki Tose, who teaches mathematics at Keio University. It covered the humanities divisions of 11 national and public universities, most of which have their origins as Imperial universities.

About 1,300 first year university students were asked to solve 22 middle-to-high-school-level math problems. They were chosen from basic-level questions in the daiken test—a scholastic aptitude test that enables students that pass to sit university entrance examinations without graduating from high school.

To even out and randomize the test subjects, the survey was conducted during classes that are compulsory for all students.

At the top national university in eastern Japan, 73 percent of students solved Question 1 (see chart), a first-year-middle-school-level problem that involves all four fundamental rules of arithmetic and decimal fractions. However, the percentage of correct answers dropped to 33 percent among students who had not taken math in entrance exams.

Question 2, a second-year-middle-school problem that involved a linear equation, was answered correctly by 86 percent of students. Question 3, a third-year-middle-school-level problem that involves square roots, was solved by 83 percent.

However, the students fared considerably worse on high-school-level problems.

While, 87 percent of the students overall solved Question 4, which involved a quadratic inequality, the ratio dropped to 22 percent among students who had not taken math in the entrance exam.

Results at this university proved that there is a large gap in scores between students who did not take math in the entrance exam and the student body overall. The former group scored only 32 percent on average, while the average for students as a whole was 83 percent.

The same trend has been observed in other national and public universities.

At western Japan's premier university, 75 percent of students solved Question 1.

Average scores among the 11 schools ranged between 60 to 92 percent at that university.

Nishimura and Tose conducted a similar survey on economics students at private universities in 1998, and concluded that students who had not taken math in entrance exams were generally not strong in the subject.

"The survey results show that poor mathematical ability is also a problem at national and public universities. Some say that math is not necessary for students in humanities divisions, but I doubt how much logical thinking students can do if they do not a have basic grounding in arithmetic. I think that the three foundation subjects: math, Japanese and English, should be made compulsory components of entrance exams," Nishimura said.

[question]

(1) $\{1+(0.3-1.52)\} \div (-0.1)^2 =$ ☐

(2) $\begin{cases} \frac{x+y}{3} = \frac{3x+2y}{4} \\ 3(x-2y) = 3x-y+5 \end{cases}$ What are the values of x and y that satisfy both equations?

(3) $\sqrt{49} =$ ☐

(4) $2x^2-11x+15 > 0$ What is the range of the value x?

[answer]

(1) -22 (2) $\left(\frac{2}{5}, -1\right)$ (3) 7 (4) $x < \frac{5}{2}, x > 3$

Mathematics questions used in the survey

University students failing in basic mathematics

1 out of 5 pupils unable to solve simple problems

Yomiuri Shimbun

One out of five students at private universities cannot solve questions on mathematics at the primary school level despite being enrolled in courses that require some knowledge of the subject, a survey released Saturday revealed.

The survey results underscored a report issued last month by the University Council, an advisory body to the education minister, that called for entrance examinations to test potential university students on high school subjects relevant to their further education.

Sample questions

Q 1: $3\times(5+(4-1)\times2)-5\times(6-4+2)=$

Q 2: Determine the values of x and y in the following equations.
$3x+y=17$
$2x-5y=3$

Q 3: Determine the value for x in the following equation.
$x^2+2x-4=0$

The survey covered about 5,000 first- and second-year students, mostly at economics departments, of eight state-run universities and 11 private institutions. It was conducted in April by Kyoto University Prof. Kazuo Nishimura.

The students, who encounter math in lectures every day, were asked to solve 25 basic questions on areas of the subject that they had studied before high school.

Of students at one private university's economics department, 82 percent of the respondents were able to answer one primary school-level question correctly. The entrance exam for the department does not include a mathematics test.

The students at a second private university did only slightly better, registering a pass rate of 86 percent.

The figure fell for questions at the middle school level, with the two universities registering success rates of 56 percent and 77 percent, respectively.

When tested on quadratic equations taught in the third year of middle school, only 13 percent of students at the former university and 28 percent at the latter could give the correct answer.

"Students who want to study economics at the university level should at least be tested in mathematics in entrance exams," Nishimura said.

Yukihiko Namikawa, a Nagoya University professor and director of the Mathematical Society of Japan, said, "Students fail in basic math calculations because there is little in the way of review in further education."

—Answers on Page 4