EVEN COLLEGE STUDENTS CANNOT CALCULATE FRACTIONS: MATHEMATICS GOALS AND STUDENTS' ACHIEVEMENT IN JAPAN

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Abstract: The goals and content of the current "Core and Option Module Curriculum" at the upper secondary schools in Japan are briefly reviewed to discuss mathematics goals for the different groups of students. Students' achievement in mathematics is discussed, referring to the results from large-scaled international comparisons of mathematics and smaller-scaled national achievement tests. It appears that the academic achievement of Japanese students is satisfactory with respect to knowledge of concepts and procedures at the lower secondary school level. At the upper secondary and tertiary level, however, there are signs that students' achievement has declined with the growth of enrollment ratio of students to those levels.

Japanese mathematics educators, like their counterparts in other countries, recognize mathematics as the basic discipline for science, technology, and other areas of human activities. At the time of transition to the new curricula based on the revised curriculum guidelines just released, however, it is not so clear that school mathematics meets the expectations of our society.

In this paper, the author discusses goals of mathematics education in Japan for various groups of students and reports on the evidence that students are achieving those goals with respect to three levels of achievement.

The goals and content of the current "Core and Option Module Curriculum" at the upper secondary schools in Japan are briefly reviewed to discuss mathematics goals for the different groups of students at this age. Then, students' achievement in mathematics is discussed at three levels, referring to the results from both large-scale international comparisons of mathematics and smaller-scale national achievement tests. Finally, some issues of mathematics education remaining to be explored will be discussed as a basis for setting research questions in this area.

Goals of Mathematics Education in Japanese High Schools

In the Japanese educational system, a national curriculum standard, the Course of Study, describes the goals of school education and basic guidelines for school curricula (Ministry of Education, Science, Sports, and Culture, 1989). The educational expectations are communicated through the Course of Study, as well as through other additional materials issued by the Japanese Ministry of Education.

A Core and Option Module Curriculum has been implemented in mathematics at the upper secondary school level in Japan since 1989. There are three major factors for using curricula of this type rather than the former uniform curricula.

First, about 96.8% of graduates of lower secondary students entered upper secondary school in 1998 (94.7% in 1989). This means that there were great differences among students in their aptitudes, interests, career plans, and so on. It is very difficult to cope with such diverse differences in the uniform curriculum.

Second, the growth of enrollment of students in upper secondary schools has led to polarization among students. Namely, we can typically find two major streams of students in the upper secondary schools. The proportion of the age group going on to universities and junior colleges was 42.5% in 1998. About 22.7 % (male 25.0 / female 20.5) of upper secondary school graduates went to the work force. About one fourth of the group were college-bound mathematics and science students; the remaining were college-bound liberal arts students.

Third, there are the requirements of the information age. The role of technology in mathematics education should be considered for setting mathematics goals with respect to the students of different groups.

The "philosophy" about the goals of mathematics education in Japanese high school underlying the current Course of Study is as follows. Cultivation of "mathematical intelligence" should be emphasized as the goal of mathematics education. "Cultivation of mathematical intelligence" includes fostering sound “mathematical literacy” for the majority of students, as well as the development of deep mathematical potential among the brighter students (Fujita, Miwa, & Becker, 1990).

In the revised Course of Study that will be implemented beginning in 2003, a new subject, “Basic Mathematics,” which incorporates mathematical history and statistical processing of daily events, will be introduced (Ministry of Education, Culture, Sports, Science, and Technology, 1998)). It will be an elective required subject; that is, students will be required to take one of two courses: “Mathematics I” or “Basic Mathematics.”

Students' Achievement in Mathematics

In this section, students' achievement in mathematics is discussed with respect to three levels of achievement: knowledge of concepts and procedures, understanding of the relationship of mathematical ideas in specific domains, and use of mathematics to mathematize unfamiliar problem situations.

Relatively little survey research has been done to find the levels of Japanese students' achievement in mathematics at the upper secondary school level. A few large-scale international comparisons of mathematics achievement like SIMS included Japanese students in the final year of upper secondary school. An overview of the results from both large-scaled international comparisons of mathematics and smaller-scale national achievement tests is given here with respect to the following three groups of students: (a) non-college-bound students, (b) college-bound liberal arts students, and (c) college-bound mathematics and sciences students.

A Quick Review of the SIMS, TIMSS, and TIMSS-R

One of the findings of the SIMS was the superior mathematical achievement of students from eastern countries like Japan compared with countries like the United States, Canada, and New Zealand.

Under the present curriculum, the academic achievement of Japanese students seems to be satisfactory with respect to knowledge of concepts and procedures at the lower secondary school level. On the other hand, Japanese students' negative attitude toward mathematics has been found through the SIMS and the TIMSS. Many students want to do well in mathematics and feel that their parents also hope they will, but in reality many of them are not very diligent about learning mathematics and do so passively. Further, not a few students do not realize the power of mathematics in applied work and see mathematics merely as exercise for solving given problems.

At the upper secondary and tertiary level, there are signs that students' achievement has declined in recent years, possibly with the growth of the enrollment ratio of students in higher education.

An eight-year longitudinal study on science and mathematics education was conducted by the National Institute for Educational Research (NIER, 1998). Using the data from three groups of students ($n > 2000$ for each group) in 11th grade, in 1989, 1992, and 1995, we can compare student achievement levels. Achievement has slightly declined from 1989 to 1995 on some items:

- *Item 55, 20% of 125, "Knowledge"*

Correct answer: 85.9% in 1989, 84.0% in 1992, 83.2% in 1995.

- *Item 17, Range of the square root of 75, "Understanding"*

Correct answer: 62.0% in 1989, 57.8% in 1992, 55.4% in 1995.

- *Item 66, linear function, "Use"*

Correct answer: 86.4% in 1989, 80.2% in 1992, 79.6% in 1995.

Another study done by a group of mathematicians shows that achievement of liberal arts students even in prestigious universities is relatively low (Tose & Nishimura, 1999). In particular, the achievement of college students who did not take a mathematics test as part of the entrance examination was inferior to those who did. It should be noted that students simply do not take further mathematics than required, if the entrance examination to the university to which they wish to go does not include mathematics.

Final Remarks

The current goals of mathematics education in Japan for various groups of students are described in the national curriculum guidelines. However, the evidence that students are achieving those goals with respect to three levels of achievement has not been explored systematically. We need to assess students' understanding of the relationship of mathematical ideas in specific domains and their use of mathematics to mathematize unfamiliar problem situations.

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