

13. Developmental Research on New Teaching Materials Focused
on Discrete Mathematics in Upper Secondary Schools

Leader: NAGASAKI Eizo, Curriculum Director, Curriculum
Research Center

(1) Purpose and Aim of Study

This study's aim is to develop and evaluate new teaching materials for use in upper secondary school mathematics classes on topics in discrete mathematics such as combinatorics and graph theory, and fractals and related mathematical fields (hereinafter referred to as "topics in discrete mathematics"). Over the three-year term of the project, we will: (1) select and analyze topics in discrete mathematics that can be studied at upper secondary school level; (2) examine the educational curricula and textbooks used in this field in countries other than Japan; (3) build on the findings of (1) and (2) to develop content on topics such as numerical processing and produce teaching materials on topics in discrete mathematics for use in Japan; (4) test these teaching materials in the classroom and assess the degree to which they are actually understood by students and capable of arousing the interest and attention of students; and (5) propose the establishment of new content areas addressing these topics within Japan's upper secondary school Courses of Study.

(2) Outline of Research Results

Over the three years from fiscal 2004 to 2006, the research team undertook a wide-ranging investigation on the introduction of discrete mathematics content in upper secondary schools, and confirmed the feasibility of such an introduction. The principal outcomes of the study are as follows.

- Solicited opinions from mathematicians engaged in cutting-edge research on discrete mathematics in Japan, and identified the significance of including discrete mathematics in the upper secondary school mathematics curriculum, social applications for discrete mathematics, and relationships between mathematics and computers.

- Analyzed research papers and textbooks on discrete mathematics used in upper secondary schools in the U.S. and the UK; found that U.S. textbooks place discrete mathematics alongside continuous mathematics in the mainstream of the upper secondary mathematics curriculum and employ problem-solving approaches, and that UK textbooks treat discrete mathematics as “decision-making mathematics” for non-mathematics/science students and use exercises and drills.
- Conducted a survey of opinions on the possible introduction of topics in discrete mathematics to upper secondary schools, and found that Japanese scholars of mathematics present arguments both for and against this introduction, but that mathematics educators view the introduction positively.
- Implemented classes using discrete mathematics in upper secondary schools and examined the instructional materials, teaching methods, and assessment methods used therein; found that it would be feasible to introduce content such as the pigeonhole principle and discrete graphs.
- Identified the purposes of education in discrete mathematics within the upper secondary school mathematics curriculum. There are character formation purposes such as cultivating skills of logical thinking and expression, utilitarian purposes such as developing of mathematical modeling skills and mathematical approaches to solving real-life problems, and cultural purposes such as exploring the historical development of discrete mathematics as part of mathematical culture.
- Made proposals concerning both compulsory and elective upper secondary school subjects dealing with discrete mathematical content. Cited areas such as “mathematical thinking in social life” for compulsory subjects, and areas such as “sets and logic,” “discrete graphs and their use,” and “matrices and their uses” for elective subjects. “Mathematical thinking in social life” in compulsory subjects includes discrete graphs and the pigeonhole principle; in elective subjects, “sets and logic” includes the pigeonhole principle and binary processing, and “discrete graphs and their use” includes discrete graphs, their algorithms, and applications.