7 For the development of mathematics education—from the view-point of computer science

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Abstract

Mathematics has developed dramatically in today's world. However, the contents of mathematics education are almost the same as before. Our goal is to change this through the development of new content and approaches in mathematics education. We have studied how the inclusion of ideas such as algorithm, network, and operating system, as viewed from a computer science perspective, influences pupils' approaches to solving problems—in particular, their increased flexibility in the processes they employ in working on problems related to these computer science domains.

Keywords

Curriculum development, algorithms, cognition.

The present situation in Japan

Three key areas of concern have been identified in regard to mathematics education in Japan. These include:

- the paradox of the current situation in which Japanese pupils are quick and good at calculation, yet they dislike mathematics;
- the need for including new types of mathematics in the curriculum; and
- the need for new approaches which encourage the identification and investigation of new 'undeveloped' fields of study.

Dislike of mathematics Results of the recently conducted IEA study mathematics tests (TIMSS) show that Japanese pupils are better in mathematics than pupils in other countries. However, this same study also reveals that while they are good at calculation, they are somewhat poor at solving problems which require mathematical thinking. Although Japanese pupils have pretty good grades, many of them say that they 'hate mathematics' or 'find it difficult'.

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New mathematics The development and diffusion of computers has been accompanied by dramatic developments in mathematics (mathematical modelling, discrete mathematics, etc.). Hence, it now becomes more important than ever that young people be given the opportunity to study these new areas - and at the same time find enjoyment in such study.

Innovation Surviving in the rapidly changing world—pupils need to be empowered with an appreciation of approaches which enable them to open up undeveloped fields by themselves. They need to learn how to approach new areas through the identification of interesting questions, and further, learning to start by questioning whether or not an answer even exists.

The research experiments

In order to address the concerns indicated above it was necessary to take into account not merely the mathematical ideas and approaches, but the learners as well—in particular, aspects of cognitive development. Hence, the experimental work had as its focus aspects of pupils' behaviour related to ideas in computer science, i.e., information processing, including human information processing (problem-solving and modelling), which are closely related to mathematics. Three main themes were identified (Tokuda, 1990), namely those of algorithmics, network systems, and the concept of an operating system.

Algorithmics The study involved a consideration as how pupils changed in their thinking and approaches to problem-solving after becoming familiar with the idea of an algorithm in computer science, which is different from the usual interpretation in the school mathematics classroom. It was found that pupils who were generally prone to the idea, or stereotype, as to a 'single way to do something' came to be more flexible in their approach(es). An example of a primary pupil's exploration is shown in figure 1.

Networks Most pupils know of the word 'network'. However, they have little notion as to what kind of problems need to be solved in this domain of computer science, nor how one might approach the creation of better network systems. The experiment involved a consideration of the fact that interesting problems abound within their daily life. Models were made of newspaper delivery routes, routes for rubbish collection, and even relationships with friends. It was found that making models of networks of problems in their daily lives helped pupils to find the basic structures of these problems.

Operating system. In order to examine how primary age pupils address, or even avoid, problems which they face in their daily life we provided a context which involved solving a maze and observed their attempts in trying to avoid the deadlock. The results of this aspect of the research indicated that pupils who were good at arithmetic (calculations) tended to try to break the deadlock by trial-and-error rather than avoiding the deadlock through careful reasoning.

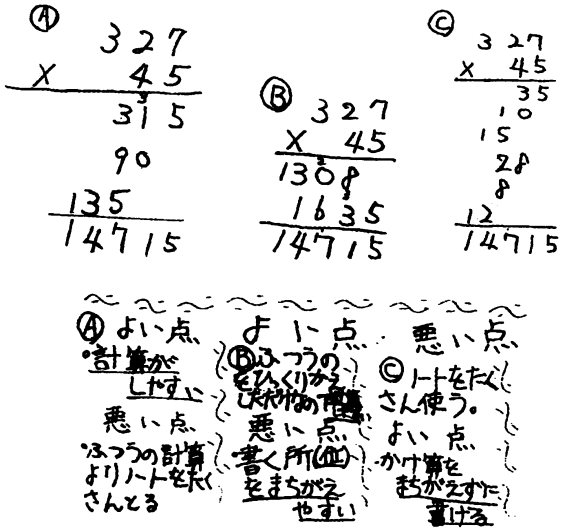

Figure 1 A primary pupil's algorithms for multiplication

Conclusion

The experiments provided support for the conclusion that we need to break from conventional content and methods in school mathematics—much of which has had its focus on improving calculation or manipulative skills. The approach taken in our work was to investigate pupils thinking and approaches in contexts taken from computer science—new or unprecedented situations for this audience, requiring logical thinking and reflecting the nature of today's mathematics. Our results have provided insights on pupils approaches and ways of reasoning in these new areas.

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Reference

Tokuda, T. (1990). *My First Adventures in Computer Science*. Tokyo, Japan: Iwanami Shoten.