How should the coming mathematics education get connected with the computer? - Starting by solving problems within our daily life-

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Abstract

The contents of school mathematics are now being prompted from various quarters for innovations. For example, we are facing the following realities. Japanese pupils dislike, and keep themselves apart from, mathematics, while on the contrary mathematics has come to be more widely put into practical use in society, and mathematics itself has drastically developed.

With these realities in mind, we wonder if it is necessary to look at how the computer should be concerned in mathematics education in reexamining its teaching contents without limiting ourselves under the category of the conventional contents of school mathematics. We propose this by demonstrating several experiments we have carried out, here.

The Purpose of Our Investigation

About ten years have passed since the use of computers came to be positively thought of in school education. The present situation is that with multimedia, the Internet and other technology joining the computer, school education is groping its way, pressed with its further attempts to set up the new education employing these computer domains. Under these circumstances, we wonder where the direction of the use of computers is going.

When the computer was brought into school first, mathematics started putting it to good use the most enthusiastically among other school subjects. Later, after the software on the market got moving, mathematics software outnumbered any other school subject's. The reality is at present, however, that despite its high software holdings, mathematics software cannot to be said to be put in positive use, compared with other subjects' software. We have heard teachers carrying actual teaching loads say that they hardly use mathematics software in class especially in elementary school.

Now is high time for us to consider how the computer should be concerned in mathematics education. What we have to take into consideration in this regard is the hard fact that we have got our way dragged by computer performance while leaving the contents of mathematics education almost the same as before based on the traditional teaching contents without questioning what new mathematics should be like. This situation can bring us home the failure of "modern mathematics movement" in Japan in the 1970's, which was due to the limited improvement of the old teaching materials under the pressures outside us in mathematics education. We must inspire ourselves and develop new contents and approaches in mathematics education through questioning what kind of mathematics education is needed in the rapidly moving world and how the computer is put into practical use to match our needs.

Pupils' dislike for mathematics has become a serious problem now at school. The IEA survey results, for instance, showed that the ratio of those answering in the affirmative to whether they like or dislike mathematics was the second lowest and that when they were asked if mathematics is important in daily life to anyone, the lowest ratio of them thought so. Isn't there quite a gap, however, between the current school mathematics pupils regard as "hateful" or "not practically used in life" and the mathematics living in society? Mathematics has come to be increasingly put into practical use widely in various fields in society. And behind this lie the development of the computer and mathematics developing together with it.

We can come up with computer science, discrete mathematics, mathematical science, applied mathematics and others, developing along with the computer, but it is part of the fact that these contents have not yet been picked up in school mathematics. Don't we need to think of what kind of teaching contents and methods are important as a basis for the new learning exactly living in society now when we consider the contents of the coming mathematics education?

How the computer should get involved in mathematics education put into the perspective mentioned above, the following things can be pointed out.

Using the computer as a tool for simulation and for making complex calculations in solving our daily problems. Thinking of the familiarized information processing by computer itself as a subject of study and learning mathematics hidden in information processing by computer.

Let us show our research experiments based on these ideas as follows.

The Research Experiments

(1) The problems of illegally parked bicycles -function of several variables- 1) In guidance Function education up to the senior high school level deals with only function of one variable at present. In the teaching contents, the degree goes up like linear function, quadratic function and cubic function, but problems within our daily life often include several variables in them, rather various factors are complexly intertwined in our social problems. The use of computers makes simulation for the solution to these problems so easy that they can also become teaching materials familiar to pupils. Here, we picked up the problem of illegally parked bicycles as our teaching material for function of several variables. In formulating this into function of several variables, we referred to the theory of system dynamics. System dynamics regards the environment surrounding real problems as a system and systematize the causal relationship inherent in it. And with time as an axis, the future state is to predicted from the relationship between the past state and the present state. Here, a formula is made based on a difference equation as shown below.

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 (the present state)
  = (the past state) + (period of time)
                       * (the amount of increase-the amount of
decrease)

 (the amount of increase)=(function indicating positive causal
relationship)

 (the amount of decrease)=(function indicating negative causal
relationship)
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Let us look at the problem of illegally parked bicycles in connection with the above. The factors in the causal relationship we extracted from it are:

- the number of illegally parked bicycles
- bicycle parking charges
- bus fares
- the area of parking lots for bicycles

As you pay more for bus fare than for parking charge, more people use bicycles. Thus, the area of parking lots becomes insufficient and illegally parked bicycles increase. (positive causal relationship)

On the other hand, when the number of bicycles used increases more as against the area of bicycle parking lots, you find it difficult to use bicycle parking lots and those using bicycles decrease. As a result, illegally parked bicycles begin to decrease.(negative causal relationship)

We define variables as follows:

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    x: the number of the bicycles used at j point of time
    y: the number of the bicycles used at k point of time
    t: the time lag between j point of time and k point of time
   bf: bus fare per month
   pc: bicycle parking charge per month
    s: the area of bicycle parking lots
    i: the amount of increase in the bicycles used at a unit time
    d: the amount of decrease in the bicycles used at a unit time
   r1: an increasing rate of bicycles
   r2: a decreasing rate of bicycles

              y = x + t * ( i - d ) .................. .(1)
              i = x * ( bf / pc ) * r1 .................(2)
              d =x * (x / s) * r2 ......................(3)
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What we need to be careful about in formulating as above is to make the dimensions of both members the same. Each of the expressions from (1) to (3) is represented by the number of bicycles. The expression (3) can represent the size of the area of bicycle parking lots from the idea of "parking one bicycle per one square meter."

When you find a yearly rate of increase of bicycles r1 with an annual decreasing rate of bicycles r2 as 0.1 and 0.2 from the data of Neyagawa city, Osaka Prefecture(Table 1), you get 0.135326 and 0.062551 for the value of r1 by (1), (2) and (3).

Table 1

year	bus fare per month	bicycle parking charge per month	the area of bicycle parking lots	the number of the bicycle used
1986	7140 Yen	2000 Yen	12054 m^2	31317
1987	7140 Yen	2000 Yen	12054 m^2	30174

The number of illegally parked bicycles can be calculated as the difference in number between the bicycles used and the bicycles in bicycle parking lots. Based on the above, we can look at the way the number of illegally parked bicycles will change in the future through simulation and investigate countermeasures to reduce those bicycles.

2) The research experiment

The subject: in total, 7 first- and second- year students of senior high school in Neyagawa City

Guidance plan:

1. Teaching computer programing (6 hours)
2. Extracting factors in the problem of illegally parked bicycles and formulating based on them (5 hours)
3. Programing for simulation (1 hour)
4. Analyzing ways of improving the bicycle disruption in Neyagawa City

3) The results of the students' analysis

They could examine the changes in illegally parked bicycles by varying bus fares, bicycle parking charges and the area of bicycle parking lots. These are the measures and their results the students came up with.

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The measure 1: to enlarge the area of bicycle parking lots
The result   : Temporarily illegally parked bicycles decrease
               but then continue to increase again, until they are more
               in number then they were at first.

The measure 2: to raise bus fares
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The result   : You can reduce the number of illegally parked
bicycles to some
               extent.

The measure 3: to lower bus fares  and reduce the area of bicycle
parking lots
The result   : You see fewer illegally parked bicycles than in the
case of the
               measure 2.

The measure 4: to lower bus fares, raise bicycle parking charges
and reduce the
               area of bicycle parking lots
The results  : This is the best measure of all those presented
here.
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(2) Forecast of Olympic records - look for a relationship from data close to us-

1) In guidance

The data dealt with in mathematics education in class are always "just for the world of mathematics" and rarely numerical values with errors and latitude.

In the lesson in this kind of the world alone, it is difficult to search for any relationship from the data in our real daily life. There are rather more cases around us where it is not exactly easy to make clear whether there is a relationship between two data, compared to data whose relationship can be clarified by expression. It is important, in our actual life, to infer that relationship and then forecast new results from that.

With the eighth graders in middle school as our subjects, we conducted the research to find the relationship out of two kinds of data familiar to us. We made them approximate forecasts of Olympic records by function with graphic calculators. The students used them for the first time in life.

2) The research experiment

The subject: second-year students of Hirano-Middle School affiliated to Osaka Kyoiku University (1 class)

Guidance plan:

1. Drawing function with a graphic calculator (2 hours)
2. Examining a relationship between a hand and a foot in size(1 hour)
3. Forecasting records of Olympic field and track events (2 hours)

3) The students' comments

Let us introduce one of their impressions on our experiment as follows. " I have never experienced this kind of lesson using a machine (a graphics calculator for that matter) to forecast the future. So, I was extremely excited. I'm not at all sure whether the records of the discus throw will really be 70.49m as machines are not everything, but I found this calculator does have very interesting functions. I'm looking forward to seeing a record close to 70.47m really made in Atlanta."

(3) Networks -Graph-

1) In guidance

The word "network" has now become such a household word that most pupils know of the word. The concept of the network is important in computer communications and other distribution systems. At the time of the Great Hanshin Earthquake, especially in the Kansai district, pupils heard the term "volunteers' networks " so often that networks have become closer even to them.

However, they have little notion as to what kind of problems exist there, nor how one might approach the creation of better network systems.

Here, we made the fifth graders in primary school as our subjects present models of "newspaper delivery routes" and " routes for rubbish collection " as problems of networks within their daily life.

2) The research experiment

The subject: fifth graders in primary school (1 class)

Guidance plan :

1. How to connect air routes and "string telephones" - shapes and characteristics of networks- (2 hours)
2. Newspaper delivery routes and routes for rubbish collection - making a stroke with a pen and Hamilton routes- (3 hours)
3. Planning group activities - effective network systems - (2 hours)

3) The observations of how the pupils were during the experiment

As for the problem of thinking of networks, calculation does not matter so much. Rather, they need to grasp a situation in its totality and think logically. Some of the pupils who had been so far poor at arithmetic because they could not calculate quickly and correctly were positively taking the lead among the other classmates in thinking of this network problem.

3. Conclusion

The experiments above provided support for the following.

1. Mathematics living within our daily life extends beyond the school mathematics today. There are problems pupils can be interested in trying to solve, such as problems related to function of several variables, data analysis and problems of approximation. Thus, it is necessary to continue to

investigate and systematize these undeveloped resources from now on. In solving the problems close to our daily life using real data as shown in the experiments 1 and 2, computers are quite naturally needed as a tool for simulation and a calculator.

2. It will become more important than ever that the computer itself, including problems concerning information processing by computer, that is, computer science related problems, should be studied as our subject of learning. We must start considering now what kind of mathematical capacity should form the basis then. For example, we wonder if information processing by computer may provide insights on a new look at human problem-solving approaches. Logical thinking and the identification of what makes things regardless of calculation or manipulative skills will come to be much more emphasized in there.