Activities for Cultivating Creativity in Statistics course

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Abstract: During the past ten years, the Internet has spread widely and quickly into our lives. In that period of time, we have had numerous chances to extract meaningful data from massive amounts of information and make decisions or create new ideas with these data. Additionally, it has become important to know how this data, through analysis and calculation, is to be characterized. For these activities, it is necessary to develop students' statistical literacy. In math education, statistics education is one facet that is focused upon. In Japan ,"Utilization of Data" at the junior high school level and "Data Aanalysis" at the high school level have been included in the new Courses of Study by MEXT (the Ministry of Education, Sports, Science, and Technology). Also, in Principles and Standards for School Mathematics (the National Council of Teachers of Mathematics, the U.S.) it has been stated that "Students need to know about data analysis and related aspects of probability in order to reason statistically—skills necessary to becoming informed citizens and intelligent consumers." However, many teachers appear to be at a loss as to how to teach statistics in math courses. One possible reason is that they have been taught statistics by basic statistical expression and calculation without the use of concrete examples by paper and pencil. Therefore it is difficult for teachers to teach statistical literacy and for students to understand statistical thinking. In this paper, a new type of educational activities to cultivate statistical literacy through the collection and analysis of data are shown; through these activities students seemed to use mobile data terminals effectively.

1. Introduction

In an advanced information-oriented society, people have many chances to extract meaningful data from massive amounts of information and to make decisions or create new ideas. For these activities, people need to think statistically and they need to know how to apply statistical knowledge and skills. Toward the fulfillment of these objectives, "Utilization of Data" in junior high schools and "Data Analysis" in high schools have been included in the new Course of Study by MEXT, the Ministry of Education, in Japan. Moreover, students are also expected to utilize a computer for such activities. Previously, statistics was taught mainly through the calculation of statistical skills. At present, however, it is thought that students should learn statistical thinking through statistical activities using real data. The Ministry of Internal Affairs and Communications published guidelines to promote the use of ICT (Information and Communication Technology) in education and started projects under the heading "Schools of the Future." In this project, from 2011, one tablet PC was distributed to each student in ten elementary schools and eight junior high schools, and two special support education schools were selected to conduct research on how to make use of this ICT. New activities in statistics educations are also expected to use ICT; relevant educational materials for them are very important.

The objective of this study is to evaluate an educational activity developed for cultivating statistical literacy and creativity with ICT. The method used in carrying out this research was to observe two classes and analyze students' activities from the point of view of cultivating statistical literacy and creativity.

2. Statistical Literacy and Creativity

According to the course of study published by MEXT for the junior high school level, the educational goal of statistics for the first grade is to collect data, organize it into a table or graph, and read trends of the data by focusing on statistical representative values or variation within the data. At the second grade level, the goal is to understand the meaning of probability and the necessity of doing so, as well as to explain an uncertain event, using probability, through observation or an experiment. As for the third grade, the goal is to understand the concepts of population and sampling of data. For high school students, the educational goal is to get basic statistical knowledge and skills for organizing data, analyzing it, and investigating its tendencies through variance, standard deviation, scatter charts, and correlation coefficients. This means the most important educational goals in the course of study are to get statistical knowledge and skills and to find the tendencies of the data. Iddo (2012) said there are three goals involved in the learning of statistics. The first one is to become acquainted with statistics as a field of study/ research, the second one is to become a specialist in statistics, and the last one is to come into contact with statistical information in their daily lives, understand its meaning, and use it for making decisions or creating new ideas. For the last goal, people have to pose critical questions concerning statistical results, i.e., Is the size of the data too small, or enough, or too big? How are the data selected? Is the method of data collection proper? Was the method of data collection proper? Is the sample representative of all data? And so on. He said it is important to have not only statistical knowledge and skills, but also use informal reasoning. Similarly, Kimura (2003) also said the goal of learning statistics in the 21st century is to cultivate the abilities of getting ideas, thinking logically, making decisions, and/or creating new ideas. Moreover, it is to cultivate the ability of persuading people. In math education, students are expected to be creative in the process of problem solving, by reasoning from or categorizing concrete facts/data to finding general principles (Shimizu, 2010). In the learning of statistics, creativity will be cultivated through collecting data, organizing it graphically or numerically, and reasoning with these results. In statistics courses at the school level, it is often conducted by using small amounts of data and focusing on the definition and calculation of statistics. By using ICT, one can treat larger amounts of data even in a school and let students experience more realistic statistic activities. The goal of our statistical activities is the third goal of Iddo and we expect to cultivate the abilities described by Kimura.

In this study, we will show two case studies conducted in the first grade of junior high school. These studies use two versions of a set of educational materials prepared with Excel worksheets.

3. Two Case Studies on Statistical Activities to Cultivate Creativity

3.1 The background of each class

Case Study A: The teacher, Atsumi, is not used to using computers, but nevertheless conducted this class in a computer lab. She prepared a spreadsheet in which a histogram and a boxplot diagram generated after inputting data and functions for the parameters to draw the graph. Furthermore, she prepared a worksheet instructing students how to determine the results. She asked the students to write their own character to be impressed, and then analyze these characters by using the statistical results gathered through the activities.

Case Study B: This study was done after Case Study A had been carried out. The teacher in this case, Takumi, often uses computers, so this activity was conducted in a normal classroom with tablet PCs. He updated the spreadsheet that Atsumi had used. For the histogram, students could change only the number of classes and he protected the parts which students should not change. Also, the boxplot diagram was drawn automatically after inputting data. Students did not need to input the function for the boxplot. In his class, students discussed in a group after each student had input own data and

organized it statistically. After this, one student who was the most suitable for delicate handworks was chosen from each group and each group made a presentation on how decisions had been made. Both examples were conducted in three lessons after learning basic statistical knowledge from the textbook; this basic statistical knowledge learned during the lessons included understanding the meaning of an average, a frequency table, a histogram, and a boxplot.

3.2 Problem and Activities

(1) Setting a problem:

We thought it was important to create a hypothetical problem in which making decisions or creating some new ideas was necessary. In this study, both teachers used the following situation: “You are the owner of a manufacturing factory. You have to employ a person who is suited to delicate handwork. Use the following activities to determine this individual.”

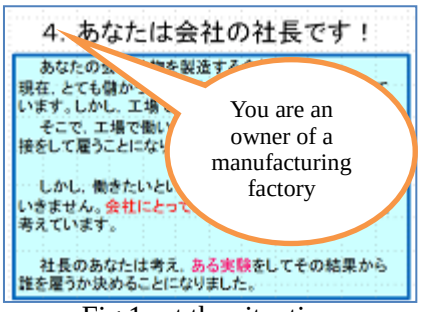

Fig.1 set the situation

(2) Collecting data:

Cut thirty strips of tape 10cm long by eye after seeing an example of a 10cm strip of tape, then measure each strip and input these measurements into a spreadsheet prepared by the teacher.


Fig.2 collecting data

(3) Organization and analysis of data:

Students could organize the data by using a spreadsheet that was prepared by the teacher. They drew several histograms by changing the class intervals for the histogram and analyzed which class intervals was the best to present own data. Also, own boxplot was drawn and compared with friends’ boxplots.

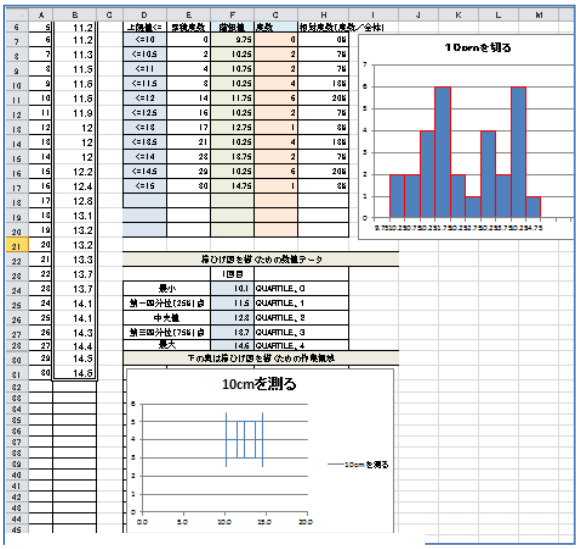

Fig.3 The prepared spreadsheet in Case A

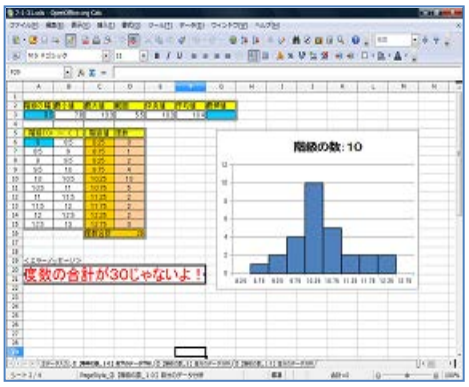

Fig.4 updated spreadsheet in

(4) Reading the results:

(A) Case Study A: the comments from the students’ worksheets on how to read the results of their data are categorized into three groups. In the first group, short notes were written. “The box tends to the right”, “There are more pieces of about 11cm.” Students in the second group wrote more details with their results. For example, “Most of the data is between 8.5cm and 9.5cm. There are only three

bars on the histogram. The h*ige* (whiskers) are short (In Japan, a box plot is called *hako-hige zu* (box-whisker diagram)). As a result, the data was not analyzed so extensively (Fig.5)". In the case of the third group, they wrote more creative ideas by evaluating their results in accordance with their characters. For example, "I am able to adhere to the 10-cm requirement, so I must be employed." Another student wrote "Most of my pieces of tape were shorter than 10 cm. Also, my cutting is not steady, therefore I am not well-suited to delicate work." Another student wrote, "The data of friends who belong to the music circle did not take part much in such delicate work." Students needed more time to discuss these ideas. After the classes, the teacher said "The students appeared to be enjoying themselves during these activities and they analyzed data enthusiastically because the data was collected by the students themselves. Also, they seemed to understand about boxplots well through these activities. But it took too much time to operate the PCs, so I wonder if the students understood the goal of these activities. They analyzed their own characters in accordance with their own data but they did not have enough time to discuss who was suited to the delicate work required by the company, which was the goal of this activity."

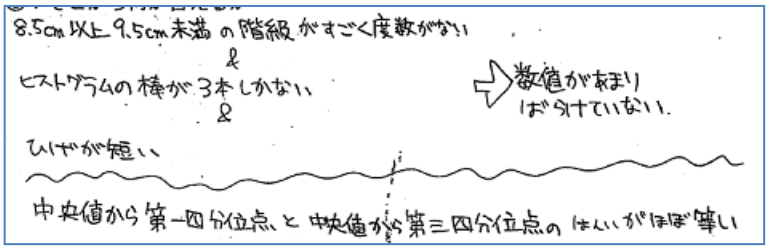

Fig.5 worksheet of the second group

(B) Case Study B Case Study A was completed,

After Case Study A was completed, the teacher in Case B updated the spreadsheet. Therefore the students did not need to input the function of parameters to draw a histogram and a boxplot. The students then had much time to investigate the data and discuss the results. They could select the person who was the best-suited to be employed. They formed groups of four and selected one person among them to be employed. They compared the histogram on the screen of the table PC in every way (Fig.6). The use of mobile PCs was helpful in their discussions about results. Also, they were able to discuss about and select the most suitable person for the job in each group. All groups focused on not only the averages of the data, but also the distribution of the data and the median or range of the data, as they had learned in their textbook. One group said that it had selected the person whose data had the smallest range and whose average was the closest to 10 cm. Another group gave the order for the median, the average, and the range for the group data. Also, this group provided a point total for each item. Then the person whose point total was the smallest was selected for the position. Each group decided the most suitable person for the job in its own way using the statistical results.


Fig.6 comparing each other's data and discussing by using tablet

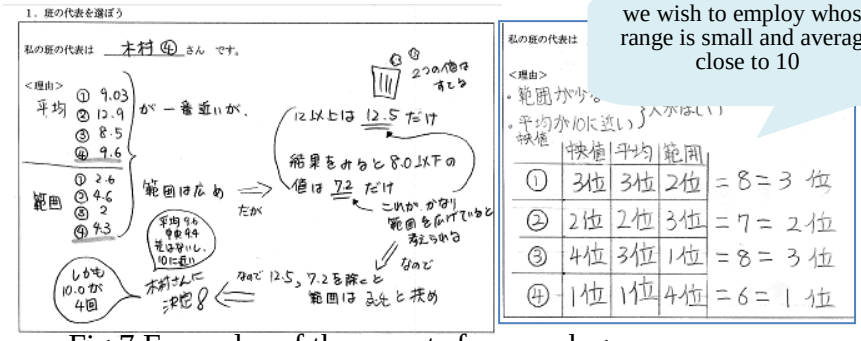

Fig.7 Examples of the reports from each group

Fig.8 Each group presents its results.

(5) Presenting their decisions

In Case Study A, the students wrote their results on the worksheet by using statistical terms and judging their own characters in accordance with their own results. With Case Study B, each group presented its results and ideas on how students had gotten the results logically using statistical terminology, using electronic blackboards that they had brought on their own PC (Fig.8). Then for their final goal, they selected the most suitable person to be employed in their class.

4. Results and Discussion

4.1 A tablet PC helps students' activities

Case Study A is the most popular activity in junior high school classes. This means that many Japanese teachers are not accustomed to using computers and do not want to use them in their math classes. Sometimes the computer lab is unavailable, as it is being used by other classes. However, using computers is indispensable in treating real data in a statistics course. Case Study A showed that students learned actively by using prepared spreadsheets and enjoyed their activities even if the teacher was not accustomed to using computers. Case Study B showed more effective activities because the spreadsheet was updated and the tablet PCs in a normal classroom were more helpful to statistical activities. Students could move tablets to compare their data with the data of classmates. Through these two cases, it is seen that it is important to prepare a spreadsheet into which students input as little as possible, and which has protected parts that students cannot change, such as Takumi prepared.

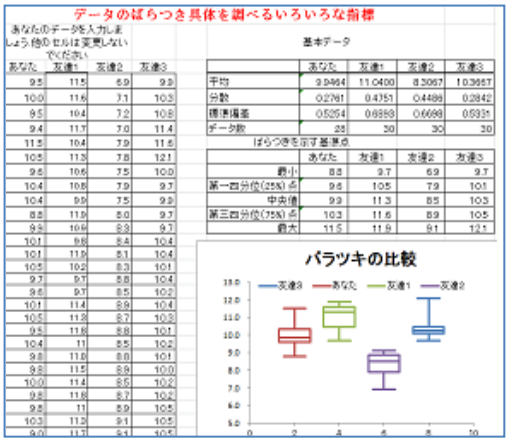

Fig.9 the updated spreadsheet

After these trials, we modified the spreadsheet (Fig. 3) to accept input of four sets of data and to draw four boxplot diagrams on the same screen (Fig. 9), and we separated the histogram from the boxplot chart, as in Takumi's spreadsheet. There are many kinds of software that can be used for statistics activities. However, a spreadsheet is easy to use in school if it is prepared for an activity. It can also be used on mobile devices, which are convenient in ordinary classrooms.

4.2 This activity can be expanded for upper grade classes

This educational activity can be used in upper grade classes as well. Students can see that the histogram of each data set has its own shape (Fig. 10) and the shape of the histogram becomes

bell-shaped when they draw the graph by using all classmates' data (Fig.11). Therefore, students can learn the central limit theorem visually by examining their own data. Also, in the high school statistics class or university basic statistics course, each student's data is used to estimate the average of the population and students can learn about differences between estimations based on sampling. Furthermore, each student's data can be used to learn about t-tests for comparing between one's own average and the 10-cm standard.

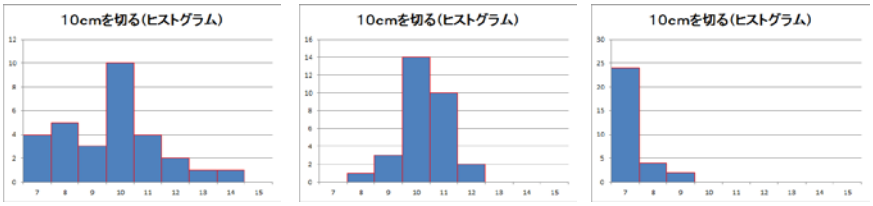

Fig.10 there are many kinds of shape for each data (i.e. sample)

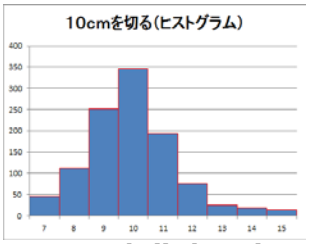

Fig.11 bell-shaped graph using all data

4.3 Collecting one's own data is effective in developing statistical literacy

To collect one's own data is effective in motivating students to solve statistical problems by themselves. Situations or scenarios can also be created to suit the data. .In this study, the teacher created the situation, "You are the owner of a manufacturing factory. You have to employ a person who is suited to delicate hand work." Statistical activities start with a concrete problem. We try to develop these kinds of materials. When we develop educational materials for learning statistics, collected data plays a big role. These days a lot of data is published by governments. If you want to use such data in class, you have to select one set of data from a mountain of data. Furthermore, sometimes the data has been organized before the students use it. Cutting tape in this study was very easy to prepare for class for collecting data and for getting students' results. This educational activity can be used by any teacher; every class has its own data. A teacher can create his or her own situation for use in each class.

5. Conclusion

One educational activity to cultivate statistical literacy was presented in this study. Students seemed to enjoy it and their creative ideas came forth in their reports. We would like to develop more materials for statistical literacy and creativity using activities that involve everything from data-collection to getting new ideas. Furthermore, these days, websites are increasingly helpful for teachers and students and a digital textbook is getting popular. Therefore, we are planning to develop a digital textbook for statistical literacy that includes spreadsheets for any teacher to be able to use in their own classes. And it must be published on the web.

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Reference

Iddo Gal(2012)、translated by Aoyama, Kazuhiro, The future of statistical literacy – the challenge for its education and evaluation- Japan Mathematics Education Vol .84,No5.pp.2-10

Kakihana, K., Watanabe, S. (2012), An Educational Material on "Uncertainty" in Statistics Education, The Proceeding of the 35th Annual Meeting of the Japan Science Education, Japan Society for Science Education, pp.43-44.

Kakihana, K., (2012), An Educational Activity for Developing Creativity in Statistics Education, The Bulletin of Tsukuba Gakuin University, pp. 35-41

Kimura, S(2003) , Math Education in a Sophisticated Information Society in Terms of Statistics Education, The Proceedings for the Spring Meeting of the Society for the Education of Mathematics

Kimura, S(2003), Web Educational Materials, A Statistics Course for Students of Elementary School, Junior and Senior High School, Teachers, and Citizens, http://www.naruto-u.ac.jp/kyozai/toukei/estat.html（2013.03）

Kimura, S（2005）, edited by Kakihana, K and Murase, K, Statistical Literacy in a Sophisticated Information Society, Toyokan Syuppan

MEXT (2009), The Course of Study for Senior High School

MEXT (2008), The Course of Study for Junior High School

The National Institute for Educational Policy Research (2006), The Framework for the Evaluation of the Survey of PISA 2006, pp.67-115, Gyosei

The National Institute for Educational Policy Research (2012), Problems and Examples of the Correct Answers and Explanations for the National Survey on Academic Performance for the Academic Year 2012 pp.85-89, http://www.nier.go.jp/12chousa/12chousa.html

Shimizu(2008) The Importance of Cultivating Ability for Problem Solving Using Computers, The Proceedings of the 32th Annual Meeting of the Japan Science Education, the Japan Society for Science Education, pp.401-402