STATISTICAL CONTENTS AND LESSONS IN THE JAPANESE CURRICULUM OF MATHEMATICS FOR UPPER SECONDARY SCHOOLS

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The statistical content was included in the Japanese curriculum of mathematics for upper secondary schools which was implemented in 2013. The aims of statistics education were to enable students to understand the basic concepts of statistics, and to arrange and analyze data using their concepts, and to grasp trends in the data correctly. In statistical lessons, we deal with the concepts of interquartile deviation, variance, standard deviation and box-and-whisker plot to grasp the variability of data, and the concepts of scatterplot and correlation coefficient to grasp the correlation of data. This paper illustrates the characteristic of statistical contents in the Japanese curriculum and the statistical lesson focused on the box-and-whisker plot.

STATISTICAL CONTENTS OF COURSE OF STUDY IN JAPAN

In the Japanese curriculum implemented in 2013, the box-and-whisker plot was introduced to secondary school mathematics for the first time. We illustrate the characteristic of statistical contents of course of study for secondary schools in Japan.

Table 1. Statistical Contents of Course of Study for Secondary Schools in Japan

Grade	*Course of Study*
7	To enable students to understand the necessity and the meaning of histogram and representative values. To enable students to grasp trends in the data using histogram and representative values, and to explain them. *Terms:* Mean Median Mode Relative frequency Range Class
8	To enable students to understand the necessity and the meaning of probability, and to find the probability of an event in a simple case. To enable students to grasp the trend of an uncertain event using probability, and to explain it.
9	To enable students to understand the necessity and the meaning of sample survey. To enable students to do the sample survey in a simple case and to grasp the trend of population, and to explain it. *Terms:* Census
10 Math I	To enable students to understand the meaning of interquartile deviation, variance and standard deviation, and to grasp the trend in the data using them and to explain it. To enable students to understand the meaning of scatterplot and correlation coefficient, and to grasp the correlation between two data using them and to explain it.
11 Math B	To enable students to understand random variable and probability distribution, and to grasp the characteristics of probability distribution using the mean, variance and standard deviation of random variable. To enable students to understand a binominal distribution, and apply it to consider an event. To enable students to understand a normal distribution and to know to be able to approximate a binominal distribution by a normal distribution, and to apply them to consider an event. To enable students to understand the idea of sample survey and to know to be able to infer the trend of population. To enable students to understand statistical inference of the mean of population, and to apply it to consider an event.

In M. A. Sorto, A. White, & L. Guyot (Eds.), *Looking back, looking forward. Proceedings of the Tenth International Conference on Teaching Statistics (ICOTS10, July, 2018), Kyoto, Japan.* Voorburg, The Netherlands: International Statistical Institute. iase-web.org

SEQUENCE OF STATISTICAL LESSONS

A) The Aims of Lessons

To enable students to understand the necessity and the meaning of an interquartile range and a box-and-whisker plot, and to arrange and express data using them.

To enable students to compare the trends of data distributions, and to consider critically and to judge using an interquartile range and a box-and-whisker plot.

B) Participants

The teaching plan was conducted by 4 lessons to 38 students at the Ibaraki University attached secondary school in November 2017.

The post test was conducted after 4 lessons in December 2017.

C) Contents and Instruction

We illustrate the plan of teaching statistical contents.

Table 2. Contents and instruction

Lesson	*Contents*	*Instruction*
1	Interquartile range	To enable students to calculate quartiles and an interquartile range, and to express five number summaries of data.
2	Box-and-whisker plot	To enable students to draw a box-and-whisker plot based on five number summaries. To enable students to compare data distributions using parallel box-and-whisker plots.
3	Box-and-whisker plot and Histogram	To enable students to read the trends of data distributions using a box-and-whisker plot. To enable students to understand that a box-and-whisker plot corresponds to a histogram, and to grasp data distribution.
④	Analysis of data	To enable students to grasp the trends of data distributions of some groups using parallel box-and-whisker plots, etc. and to consider critically and to judge.

STATISTICAL LESSON FOCUSED ON THE BOX-AND-WHISKER PLOT

The aim of 4th lesson is to enable students to compare the trends of data distributions of some groups using parallel box-and-whisker plots, etc., and to consider critically and judge.

Table 3. Lesson Plan

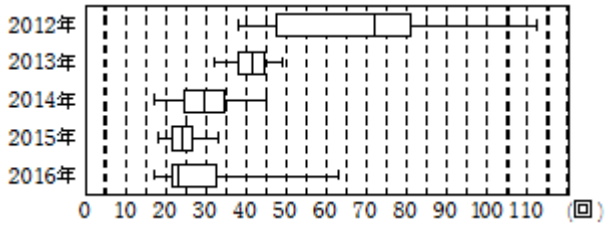
Student's Activities
1. Grasp a problem situation. How many times have you observed earthquakes in Ibaraki Prefecture and Miyagi Prefecture after the East Japan Big Earthquake in 2011? Do you think that the earthquake has decreased during these five years? <Student's expected reaction >, I think that the earthquake has decreased, since there are few earthquakes which are felt to our bodies.
2. Pose a problem Do you think that the aftershock activity of the East Japan Big Earthquake has decreased? 

Fig. 1 Data A: The number of times of earthquakes monthly observed in Ibaraki Prefecture.

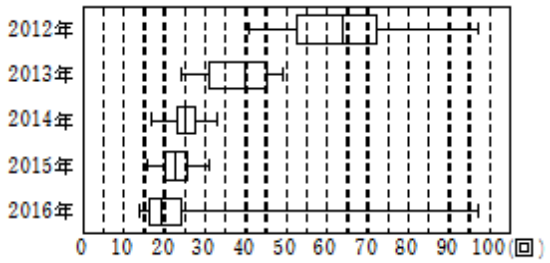


Fig. 2 Data B: The number of times of earthquakes monthly observed in Miyagi Prefecture.

3. Make temporary judgments based on data A and B.

(1) First Judgments in small groups

<Student's expected reactions>

Since the boxes move gradually to the left, we think the earthquake has decreased in Ibaraki Prefecture and Miyagi Prefecture.

Since the median of current year is smaller than it of previous year, we think the earthquake has decreased in Ibaraki Prefecture and Miyagi Prefecture.

Since there is the whisker in the right side, the earthquake hasn't decreased.

Since the interquartile range becomes large and there is the scatter of data, the earthquake hasn't decreased.

(2) Share the first judgments in class.

4. Consider based on the data C and D, and make second judgments.

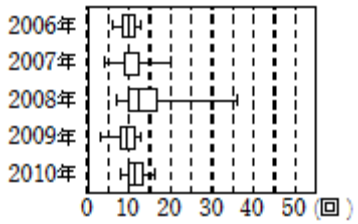


Fig. 3 Data C: The number of times of earthquakes observed in Ibaraki Prefecture before 2011.

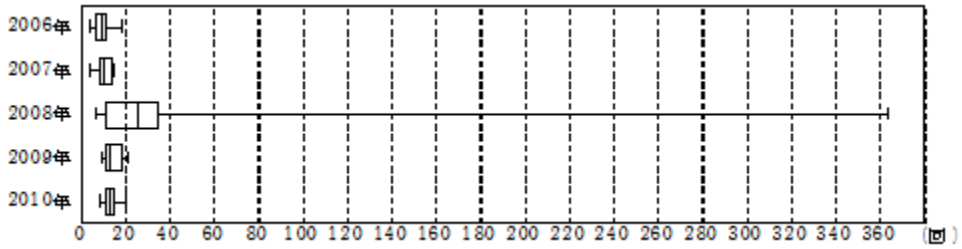


Fig. 4 Data D: The number of times of earthquakes observed in Miyagi Prefecture before 2011.

(1) Second judgments in small groups.

<Student's expected reactions >

Since the boxes of the data A and B distribute over 20 times, and the boxes of the data C and D distribute under 20 times, the earthquake hasn't decreased in Ibaraki Prefecture and Miyagi Prefecture.

Since the interquartile range of the data A and B is larger than it of the data C and D, the earthquake hasn't decreased in Ibaraki Prefecture and Miyagi Prefecture.

Since the whisker of the data A and B is longer to the right side than it of the data C and D, the earthquake hasn't decreased in Ibaraki Prefecture and Miyagi Prefecture.

(2) Share the second judgments in class.

5. Consider the data E and find out better judgments.

Table 1 The number of times of earthquakes in Ibaraki Prefecture after 2011.

Year	*Mag.1*	*Mag.2*	*Mag.3*	*Mag.4*	*Mag.5*	*Mag.6*	*Total*
2011	1960	1029	320	81	13	4	3407
2012	479	248	81	21	5	0	834
2013	292	145	38	15	5	0	495
2014	217	102	328	0	0	0	359
2015	191	71	24	5	1	0	292
2016	230	95	24	11	3	1	364
Total	3369	1690	519	141	27	5	5751

<Examples of final judgments>

We feel that the earthquake has decreased, since many earthquakes are magnitude 1 on the Japanese scale. But we think that the aftershock activity is still active.

6. Look back about today's study.

RESULTS

By using an interquartile range and box-and-whisker plots, were the students able to consider the trends of data distribution critically?

At first, students judged the trends of data about earthquakes in Ibaraki prefecture and Miyagi prefecture based on data A and B. Secondary, they judged them based on data A, B, C and D. All the small groups changed from first judgments to second judgments. The judgment of each group is shown in table 4. In the stage of reconsideration about first judgments, students made the new judgments to improve first judgments using the data C and D. They changed the reasons of their judgments and examined the validity of them. Therefore, students carried out high quality judgments and thought critically. In addition, students thought that the problem of statistics had various conclusions. Finally, we illustrate some judgments in small groups.

Table 4. Judgments in small groups

Group	*First Judgements*	*Second Judgments*
1	The earthquake has decreased, since the median in 2016 is smaller than in 2012.	The earthquake has been decreasing, but not perfect.
2	The earthquake has decreased, since there are box-and-whisker plots in the left side.	The earthquake hasn't decreased, since there are box-and-whisker plots in the right side after the East Japan Big Earthquake.
3	The earthquake has decreased, since the maximum in 2016 is smaller than in 2012.	The earthquake has been decreasing year by year gradually to the level of 2010.
4	The earthquake has decreased, since there are the median and box-and-whisker plots in the left side.	The earthquake hasn't decreased, since the medians from 2012 to 2016 are in the right side after the East Japan Big Earthquake.

DISCUSSION

Did our lessons facilitate student's ability of statistical problem solving? Students clarified the reasons about their predictions and judgments, explained them. We were able to give students the training of statistical problem-solving in lessons, since we found better judgments in the stage of looking back. On the other hand, student's performances showed poor abilities about statistical literacy based on the results of post-test. We thought that it was necessary to make a terminological definition and an acquisition of the meaning of various statistical concepts to facilitate student's ability of statistical problem-solving.

REFERENCES

Ministry of Education, Science, Sports and Culture (2013). *The Course of Study for Upper Secondary Schools*.