

USING BOX-AND-WHISKER PLOT IN PROBLEM SOLVING LEARNING

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In Japan, the course study was announced in March 2017. The main object of this reform was a promotion of statistics education. In November 2017, we conducted the consciousness survey on junior high school Japanese teacher's understanding of statistics education. As a result, it has revealed that their consciousness to the goal of the guidelines is weak. For that reason, we proposed our class plan to solve problems concerning the new content of the junior high school: "Box-and-Whisker Plot", and, will show the result of guidance through practical lesson.

INTRODUCTION

In March 2017, new Courses of Study for elementary and junior high schools were announced in Japan. "Making Use of Data", the area related to probability and statistics, was already established in the current Course of Study for junior high schools announced in 2008. In the new Course of Study announced in 2017, "Making Use of Data" has been revised to further enhance statistical education. For example, the "Representative value" section has been moved from the junior high school level to the elementary school level, and the "Box-and-Whisker Plot" has been moved from the high school level to the junior high school level. Furthermore, in the "Making Use of Data" lesson, the problem discovery and resolution processes have been emphasized (Ministry of Education, 2017). However, some junior high school teachers have voiced confusion and unease. Further, it is difficult to conduct lessons that focus on problem-solving because of a lack of teaching materials and a lack of statistical knowledge and experience on the part of teachers.

It goes without saying that statistical education aimed at problem-solving using data is incredibly important in contemporary society. However, through listening to the perspectives of junior high school teachers, and observing actual situations, it is important to also consider what constitutes fulfilling learning for children and what kind of guidance is necessary to facilitate this kind of leaning. This study aims to carry out a questionnaire survey to investigate junior high school teachers' awareness and actual experiences teaching the "Making Use of Data" section of the new Course of Study. Through consideration of the questionnaire survey results for the "Box-and-Whisker Plot" lesson, new teaching content in junior high schools, we offer a problem-solving type model lesson, and demonstrate its actual results in class settings.

QUESTIONNAIRE SURVEY

We conducted a questionnaire survey to investigate junior high school teachers' awareness and actual experience of teaching the contents of the "Making Use of Data" section in the new Course of Study. The questionnaire used for the survey was prepared based on a questionnaire survey conducted by the Tokyo Jr. High School Committee of Mathematics Study on Probability and Statistics (Tokyo Jr. High School Committee of Mathematics Study on Probability and Statistics, 2017).

Overview

- Survey method: Questionnaire survey (by mail)
- Survey target: Junior high school teachers in Fukui Prefecture specializing in mathematics
- Survey period: October 24, 2017 to November 15, 2017
- Number of responses: 187 people at 68 schools
- Question contents:
 - Question 1. The school where the respondent teaches
 - Question 2. The respondent
 - Question 3. The new terms indicated in the new Course of Study
 - Question 4. Statistical terms
 - Question 5. Open description of teaching the "Making Use of Data" section

Result

Table 1. Age range of questionnaire respondents (percentage)

Age Range	20's	30's	40's	50's
Percentage	23.0	26.2	29.9	20.9

Table 2. Question 3 results (percentage)

	1. Can be taught	2. Anxiety about teaching	3. Know the term	4. Do not know the term
Counter Example	74.9	20.3	3.7	1.1
Cumulative Frequency	39.6	24.1	25.7	10.7
Interquartile Range	11.8	21.9	30.5	35.8
Box-and-Whisker Plot	11.3	19.9	33.9	34.9

Discussion

In Question 3 (Table 2), the percentage of respondents who answered "4. Do not know the term" is 1.1% for "Counter example", while the percentage of respondents who answered "4. Do not know the term" is 10.7% for "Cumulative frequency", 35.8% for "Interquartile range", and 35.0% for "Box-and-Whisker Plot". In Japan, a "Counter example" is content taught in the 8th grade under "Geometrical Figures" and also as part of "Numbers and Algebraic Expressions". The new Course of Study notes that it is important to give guidance on this theme properly, based on context. In the current Course of Study, teachers often teach the "Counter example" in the context of teaching "Reverse" in the 8th grade. Therefore, even in the new Course of Study, the "Counter example" is content that many teachers can teach with confidence. Nonetheless, we found that teachers are concerned about teaching the statistical terms (Cumulative frequency, Interquartile range, and Box-and-Whisker Plot) specified in the new Course of Study.

When asked about the "statistical terms" listed in Question 4, the percentage of respondents who answered "4. Do not know the term" is 23.1% for "Cumulative relative frequency", 46.2% for "Quartile", 79.6% for "Five-number summary", 61.3% for "Quartile deviation", and 61.3% for "Dot plot". These are all high percentages for "4. Do not know the term".

The open response question 5, yielded many positive opinions such as the use of data is important learning for children who live in a diverse modern society. However, many reactions also showed confusion about changes in the Course of Study.

"USING DATA" CLASS PRACTICE

The results of the questionnaire survey show that, overall, junior high school teachers are concerned about conducting classes on statistics and data science, and have insufficient knowledge and understanding of the basic terms used in statistics education. Based on these findings, we offer the below guidance guidelines and, propose and practice the lesson plans in consultation with teachers.

- The New Course of Study includes many statistical terms. We will not introduce students to these concepts as "terms", but, assist them in learning technical terms through using them.
- The purpose of teaching here is to support learning activities that students themselves comprehensively evaluate and examine by using data, rather than to teach "knowledges".

Practice, Subject, and Class theme

- Date: December 6 - December 22, 2017
- Subject: 11 students, 7th grade, Koshino Junior High School, Fukui City
- Teacher: Mr. Yohei Fujikawa, Koshino Junior High School, Fukui City
- Lesson theme: "Let's think about global warming in the Koshino area"

The subject school, designated as a rural area in Fukui prefecture, has 34 students over all. The students thus sincerely hope to enrich Koshino in collaboration with local citizens. They have discussed their area's present situation and how to revitalize the area and have carried out various community activities. The students are very interested in the Koshino area.

Our aim in teaching statistics is to show the validity of our approach and fosters students' ability to solve problems by sorting and analyzing information through understanding distribution concepts (histogram, Box-and-Whisker Plot etc.).

Lesson plans and the emphasis on teaching (11 hours total)

- Lesson 1: Frequency distribution and Histogram (2 hours)
- Lesson 2: Representative Value and Relative Frequency (2 hours)
- Lesson 3: Use of Data (2 hours)
- Lesson 4: Box-and-Whisker Plot (3 hours)
- Lesson 5: Use of Box-and-Whisker Plot (2 hours)

Lesson 4 and 5 are based on Lessons 1, 2, and 3. In Lesson 4, when comparing with the histogram and the Box-and-Whisker Plot, students learn to know how to approach surface distribution (Fig. 1) in a multifaceted manner. Students also examine features of the Box-and-Whisker Plot corresponding to different types of histograms. In Lesson 5, returning to the issue of global warming in the Koshino area, students compare five samples of August Temperature Data (2017, 2007, 1997, 1987 and 1982) by using the Box-and-Whisker Plot. Students experience the usefulness of the Box-and-Whisker Plot in becoming more aware of the problem of global warming.

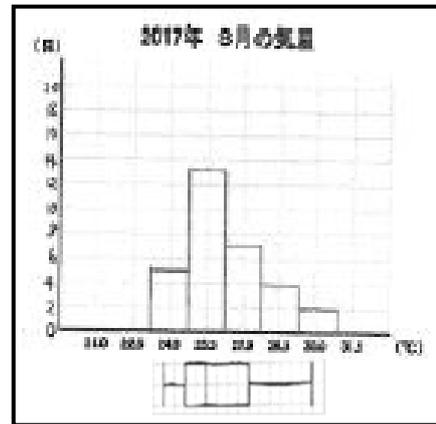


Figure 1. Relationship between histogram and the Box-and-Whisker Plot

Practice class and students' reaction

○資料(気温)をヒストグラム(柱状グラフ)に整理してみよう。 出席番号(7)

○整理して分かったこと、さらにわかりやすく表すためにはどうするといいか

2017年のほうが気温が高い。かまねてみる(色をかえて)

Lesson 1: Organizing temperature data using a histogram. Student Number (7)
 What do you find after organizing the data?
 How can you express your finding more clearly?

- The temperature in 2017 is higher.
- Try fitting two graphs (by changing a color).

数学で分析しよう! (箱ひげ図で比較)

越後は~越後の気温(5年分)を比較し考えよう~ (12)

Lesson 5: Organizing temperature data using a Box-and-Whisker Plot. Student Number (12)
 What do you think? What do you understand?

- In 1982 the median was lowest.
- Since the maximum value in 1987 to 2017 is 31.5, global warming is accelerating.

結果&考察

- 1982年は中央値が一番低い
- 1987年~2017年は最大値が31.5度だから、温暖化が進んでいる。

Figure 2. Students' worksheets for Lesson 1(left) and Lesson 5(right) (Temperature comparison, August in 1982 - 2017)

As an example, we will students' responses to lesson 5 "Is the Koshino area warming? Use the conclusions for the Koshino PR".

In Lesson 1, students studied the theme "global warming in the Koshino area" using frequency distribution and histogram. In Lesson 5 they considered the same subject again, and purpose "Koshino PR, making use of the conclusions". To do this, students showed August temperatures in the Koshino area over 5 years (2017, 2007, 1997, 1987 and 1982 (the oldest data available)) in a Box-and-Whisker Plot. The following are examples of student responses:

- "The median does not change very much, but the maximum and the minimum are increasing. Therefore, I think that global warming is progressing."
- "I think that the maximum has been constant since 1987, but the minimum is gradually increasing."

Since it was possible to compare further the minimum, the median, the maximum, and the 50% position etc., students believed that it was better to compare more data in order to draw a conclusion.

Changing students' task consciousness about the theme

After the completion of the entire lesson plan, students had to following reactions. Their problem awareness increased since the beginning of the lesson plan. Additionally, students could study changes in the Koshino area which may be caused by global warming and proposals for a future "Koshino PR".

- "The number of people who come to swim at Koshino beaches will increase due to global warming. It is good to improve beach facilities."
- "Due to global warming, more people will come to camp in the mountains. I think it would be nice to renovate "Garagara-yama Mountain Campground"."
- "We will be able to grow more Koshino oranges in the northernmost orange producing area in Japan."

LESSON PLAN RESULTS AND REMAINING UNRESOLVED ISSUES

The aims of this research are, on the basis of a survey of teachers' consciousness about statistical education, to propose a problem-solving lesson plan to teach the Box-and-Whisker Plot in accordance with the revised contents of the new Course of Study and to practically demonstrate the validity of our lesson plan.

We presented the students with data and the aims each lesson as teaching material. For example, in the 1st and 2nd lessons, as materials, we presented students with past data from the months of 2017 with a different histogram shape and a different median, but with a same average. Students reacted to this lesson as follows. For instance, in the fifth lesson, students said that:

- "The maximum and the median are gradually increasing. So global warming is progressing."
- "I think that it is becoming warmer as 2017 continues."
- "The minimum value is gradually increasing."

Through our guidance which emphasized the use of terms, students used statistical terms such as "the median, the maximum and the minimum" on their own. Students could also understand changes in time series when examining the distribution.

Future tasks include:

- In further work with teachers, we will try to share guidance guidelines that emphasize using terms and supporting students' learning activities to make judgments and think comprehensively using data.
- Even though teachers believe that the relationship between the histogram and the Box-and-Whisker Plot is difficult to teach, we will try to create a teaching model to correctly grasp the concept of distribution.

REFERENCES

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