TEACHING PRACTICE OF "ANALYSIS OF DATA" USING COMPUTER GAMES
- TEAM MAKING WITH QUALITY CONTROL PROBLEM SOLVING METHOD -

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The new Japanese curriculum of mathematics for high schools will be implemented, and University entrance examination will change in 2020. In particular, Education on Statistics has been strongly emphasized toward this knowledge-based society, and ability of expression in mathematical way is one of the new demands. This paper illustrates the lesson practice in high school. The theme of the lesson is analyzing data of football players of "Winning eleven" which is the title of TV game. They have tried to make a strong team through choosing some players from multi-variate data. I will demonstrate how to perform these lessons and student's activities in those lessons, and derive some implications for the future of statistics education in Japan.

BACKGROUND

Currently, the use of big data has spread, parameters are examined from data to solve actual problems, evidence-based decision making and improvement activities are being carried out. Also, in school education in Japan, problem solving skills were emphasized, and the process of problem solving was shown for revision of the next course of study guidelines.

"In the world, students learn whole picture of the process of problem solving first, the curriculum is organized in the form of incorporating individual analytical skills according to dividends" (Watanabe, 2011) and problem-solving learning has been done. "The necessity to deal with the comprehensive statistical inquiry process has also been pointed out in Japan" (for example, Aoyama, 2009), and practice has been started according to the problem-solving method.

On the other hand, PPDAC (Problem → Plan → Data → Analysis→ Conclusion) and PCPD (Plan → Collect → Process → Discuss) cycle, which have been adopted from overseas, are quality control methods used in Japanese companies since the end of World War II. Quality management is an improvement process of the entire process for improving the quality of products and services to be provided, not only the quality of products, but also the statistical cycle "PDCA (Plan → Do → Check → Action) ".

Also, in this quality control method, we decided the theme to solve the problem that we noticed, considered from the data of the facts why the problem is occurring, implement effective countermeasure against the true cause. It is called the Quality Control (QC) problem solving method and it can proceed with the following six steps (Imasato, 2009):

1. Think of problems that occur as a result of work as a problem (selection of themes)
2. Extract important issues from the actual situation of the problem (grasp the current situation)
3. Determine how far to solve the problem (setting goals)
4. Then, after clarifying the cause of the problem, identify the most important cause that is most influential (analysis of factors)
5. Take countermeasures against its important causes (examination and implementation of countermeasures)
6. After confirming whether it is really effective, stop braking so that problems due to the same cause will not be developed (confirmation of effect and standardization)

PURPOSE OF RESEARCH

Although the framework presented as a process of problem-solving learning is varied, it is necessary to analyze data, grasp the current situation, set goals, consider and implement countermeasures, this series of flows has an experimental aspect of deriving the optimal solution while changing the conditions and it can be said that the learner to show what to do to solve the problem.

Therefore, we developed a teaching material 'Winning Eleven', which solves problems according to the six steps of QC problem solution method and learns statistical cycle. In developing

the teaching materials, we refer to the teaching materials using Watanabe (2011b) football World Cup data. In this educational material, we aim to train the ability to make decisions based on data through experiences analyzing data diversely, but it is difficult for students to express using multivariable set of parameters. However, by taking advantage of technology and taking advantage of game data, they were able to make various thoughts, judgments, expressions and solutions (Masuda, 2016).

In this paper, we reported lessons following the six steps of the QC problem solving method. In each process, various thoughts, judgments and expressions of the students were derived.

TEACHING MATERIALS AND LESSON PLAN
About the educational material "Winning Eleven"

In this material, analyze the player data stored in PlayStation 3 "Winning Eleven 2013" with the theme of "Let's Sports on Data" and make original teams to win the World Cup winning team "Spain". There are 138 athletes to analyze, and these players have 29 parameters in total, 23 quantitative data items and 6 qualitative data items. After analyzing these by country and position category, considering characteristics of the team, positions and each country, the relationship of each parameter, then it is most desirable from the result of analyzing the total balance of the team and the characteristics of the players so far Choose 5 possible players and organize the original team. Although it is the purpose of the task to persuade the goodness of the organized team and the grounds for selecting the players based on the data in a convincing manner, we utilize the fact that it is a game of PlayStation three, a simulation game of the Spanish team is executed. Analysis of data was "utilizing technology", and the form of learning was "collaborative learning by group activities".

About parameters

Each parameter given as player data of the winning eleven is the data of the player obtained on the screen of Figure 1.

Figure 1.   The data of players

Lesson plan

We conducted in 8 hours (Mathematics I "Analysis of data") from October to November in the first grade of our school. The computer classroom and ordinary classroom were used, and in the ordinary classroom mainly the activities such as presentation were the most prominent. For analysis, we used graph creation software of teaching material contents "Science tool box" provided by the Japan Science and Technology Agency.

QC problem solution (Method of analysis), theme of learning
1. Setting the theme: "Can you make a strategy to strengthen the team by looking at the data?"
2. Grasp the current situation (Histogram): "Verification of differences in features between Japan and the world team"
3. Grasp the current situation (Box whisker picture): "How do you compare features by team and position other than histograms?"
4. Intermediate presentation group announcements - Share analysis

5. Analysis of factors (Fish bone figure/scatter chart): "Choose items to focus for team formation"
6. Study and implement countermeasures "Decide on a player"
7. 8. Final announcement - Confirmation of effect Group announcement - Validation by simulation

PRACTICE AND ITS ANALYSIS
About setting theme
Currently, statistical analysis is adopted in various sports such as volleyball, baseball, soccer and so on. Students learned the usefulness of problem solving by using the teaching material of this teaching material after that. They observed Japan versus Spanish games on video clips. "Make a strong team, win over Spain!" as a common theme.
About grasp of current situation
The graph is optimal for the reader to understand easily, and it can express what the analyst of the data wishes to claim. Students thought about the variables selected for each group, analyzing them while exploiting the graph creation software of "science tool box", and thinking about whether they are appropriate for expressing their arguments. Moreover, students could capture its characteristics by stratification by "country" "position" etc.

By notating the box whisker, they noticed that it was easy to compare the teams that were hard to see. Also, they analyzed and expressed the data using mean, mode, median, maximum, minimum, hinge and so on.
About the interim presentation
Each group presented what they considered in 5 minutes and evaluated other groups. We shared what sort of group's presentation was good, why it was good, what it was helpful for.
Analysis of factors
They devised a team-making plan aimed at the group and made a fishbone diagram to organize their thoughts. Furthermore, they analyzed it using scatter plot and correlation coefficient. Depending on what kind of team they are aiming for, the variable of interest will change. Based on what they have analyzed so far, they aim to build a strong team.
About consideration and implementation of measures
Position of GK, FW and DF are fixed, and MF 5 people (F to J in Figure 2) are chosen from teams other than Spain. For the presentation, they aimed to present mathematical grounds and reasons, and to explain others to convince others.
Confirmation of effect
They made a presentation using the graph effectively. They also evaluated presentations and considerations of other groups. At the end of the presentation, Teacher distributed the simulation results with a video clip and looked back on whether the team they made was "a team that can win against Spain". This teaching material uses the data of PlayStation game "Winning Eleven". The team that was selected by the students can be made to compete against the Spanish team. Teacher took videos of the results of 5 games of each group and made a digest version of about 5 minutes for viewing.
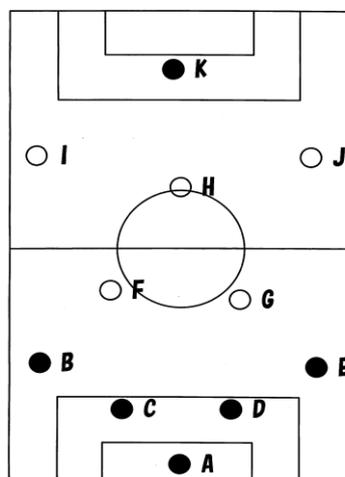
Figure 2. Election of players

Aspects of student activities

On the handling of analysis of scatter plot and two variables of correlation coefficient, the following remarks were made by the students.

There were remarks on how to make use of the analysis result of 2 variables in the decision of the players. There were mainly four ways of students thinking, judging and expressing.

S: Excuse me. I have a question.
T: Sure. What is it?
S: We don't know what scatter plot can derive?
   Isn't it strange? Everyone, I think they should consider each other a bit.
T: I see. For example, I got a strong positive correlation.
   Like this (slide). Everyone concluded that this item is relevant.
   You say that you should consider thinking more properly about what kind of mathematical
   method or way of thinking to use afterwards.
S: That's right.

Figure 3. Remarks

There were remarks on how to make use of the analysis result of 2 variables in the decision of the players. There were mainly four ways of students thinking, judging and expressing.
1. Because of the strong correlation, we selected players with high ability of 2 items
2. The stratification of the correlation and the two variables and expressed the player selection by using the position on the scatter plot
3. The group of items with strong relationships was given using the correlation
    Since there is a strong positive correlation between offense $\Leftrightarrow$ dribble accuracy $\Leftrightarrow$ trapping system $\Leftrightarrow$ short path accuracy respectively, these four items are said to be "a group of items deeply related to the offense ability".
4. Deciding items to use because there is no correlation
    "There is no correlation between the kicking power and the dribble speed", one student said, "The players with high capabilities of these two items are strong (they meet the purpose of team building)."

CONCLUSION

In this educational material based on the QC problem solving method, we showed part of various students' thinking, judgment and expression. What kind of decision to make from the correlation of two variables was raised as a topic. How to teach is the next future task.

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