

Creating the Original Bebras Tasks by High School Students

Hiroki MANABE¹, Seiichi TANI²,
Susumu KANEMUNE³, Yoshiki MANABE⁴

¹*Hakuyo High School*

²*Nihon University*

³*Osaka Electro-Communication University*

⁴*The University of Tokyo*

*e-mail: manaty2005@mh.scn-net.ne.jp, tani.seiichi@nihon-u.ac.jp,
kanemune@gmail.com, yoshiki-125.kanken-1@mh.scn-net.ne.jp*

Abstract. The Bebras Challenge is an International Challenge on Informatics and Computational Thinking (CT). The goal of the challenge is to make students interested in Computer Science (CS) and CT. The authors let students participate in Bebras in regular Informatics classes at a high school in Japan. Not only involving the challenge, but we also implemented a learning activity which students create original Bebras-like problems. The learning activity aims to make students recognize that materials for algorithmic thinking are around them. Most of the students worked well and produced idea full problems. They created many great works. And some of them were selected as Japanese representative questions for the International Bebras Task Workshop by the Japanese Committee for the IOI, which conducts the Bebras Challenge in Japan. Some of them were used in the actual Bebras Challenge. In this report, we show the students' original questions and discuss the educational effect of this learning activity.

Keywords: Bebras Challenge, informatics.

1. Introduction

The Bebras Challenge (ICICT, undated) is an international competition in computer science (CS) and computational thinking (CT). The goal of the challenge is to make students interested in CS and CT. The Bebras tasks are consists of Informatics comprehension, Algorithmic thinking, Using computer systems, Structures, patterns and arrangements, Puzzles, ICT and Society. It was initiated in Lithuania in 2004. Recently, the competition is being spread through more than 40 countries and expected to reach more than 40 countries this year. One of the reasons that the Bebras Challenge

has been widespread is that the competition sets are composed of good tasks which can motivate pupils to be more interested in informatics topics. The International Bebras Organizing Committee developed criteria for good Bebras tasks (Dagienė and Futschek, 2008).

Good tasks:

- are related to informatics, computer science or computer literacy
- allow learning experiences
- can be solved in 3 minutes
- have a difficulty level
- are adequate for the age of contestants
- are independent of any curriculum
- are independent of specific IT systems
- have easily understandable problem statements
- are presentable at a single screen page
- are solvable at a computer, without other hardware, additional software or paper and pencil
- are politically correct should be funny
- should have pictures
- should have interactive elements (simulations, solving activities, etc.)
- should give immediate feedback

Following these criteria, experts in each country create tasks and propose to Bebras Task Workshop held annually. The members of Bebras Task Workshop discuss and select the tasks for Bebras challenge carefully. After the Workshop, selected tasks are translated to each native language. And the task set for the competition is adjusted. Therefore, the Bebras Challenge is composed of high-quality tasks. In Japan, Bebras has four age groups:

1. Benjamin: grade 5 to 6.
2. Cadet: grade 7 to 8.
3. Junior: grade 9 to 10.
4. Senior: grade 11 to 12.

Bebras tasks are suitable CT teaching material (Izu *et al.*, 2017). Authors used Bebras tasks as educational material too and incorporated the Bebras Challenge into a high school informatics curriculum. Moreover, we also implemented a learning activity called ‘Creating Bebras Task’ units, and students create original Bebras-Like problems. Dagienė reported that creating Bebras Task gave teachers an opportunity to learn informatics concepts deeper (Dagienė *et al.*, 2016).

We considered that even high school students would be able to learn informatics through problem creation. Through the observation of the attitude of the students solving Bebras tasks, we hypothesized that they would work well, and they would learn computer science subjectively by themselves. And we expected that they create good tasks which would be suitable for actual Bebras Challenge. In this report, we show their progress and tasks and evaluate learning effect of ‘Creating Bebras Task’ units.

2. Background

2.1. Informatics Education in Japan

In Japan, all high school students learn the compulsory subject “Informatics”, which consists of two optional subjects named “Information Study for Participating Community (Society and Information)” and “Information Study by Scientific Approach (Information Science)” (Kanemune *et al.*, 2017).

In the subject ‘Information Science’, algorithmic thinking is treated. However, many teachers feel difficulty in guiding them.

2.2. Timeline of Preparation and Conduction of Bebras Challenge in Japan

The Japanese Committee for the IOI (JCIOI, undated) conducts the Bebras Challenge as below.

1. Creating tasks for submission to Bebras Task Workshop.
2. Selecting Japanese representative tasks for Bebras Task Workshop.
3. Preparation for proposal for Bebras Task Workshop.
4. Participation in Bebras Task Workshop.
5. Selection tasks for the Bebras Challenge in Japan and translating them into Japanese.
6. Conduction of the Bebras Challenge.

3. Research Method

‘Creating Bebras Task’ units were implemented from 2014 to 2016 in ‘Information Science’ classes, and about 320 grade 10 students joined every year. In Japan, school year starts at April and ends in March, and there is a two week “winter break” including the end and beginning of the year.

The Bebras Challenge is held in ‘Bebras week’ in November. Students tried Junior tasks of the previous Bebras Challenges which were published on the website before Bebras week, and participated in the actual Bebras Challenge.

By teachers interview after the challenge, most of the students commented: “I enjoyed the Bebras.” In the class after the Bebras Challenge, the teacher explained the connection between each problem and topic of the computer science, and implemented ‘Creating Bebras Task’ units as homework during the winter break to the students.

3.1. Expecting to 'Creating Bebras Task' Units

The units had an aim for students' learning of computer science through the implementation from 2014 to 2016, and the other aim is added in 2016. In actual Bebras, there are many tasks using familiar stories and backgrounds such as nature or living around us. Therefore, we considered that students would look for the task theme around them and inspire creativity. We expected that they would learn computer science by themselves to create tasks. We also hypothesized that watching other students' tasks enhance learning effect. If he/she watch his/her friends' task, he/she would solve it. Through solving other tasks and watching other topics of computer science, students would increase their knowledge. Therefore, we planned in a lesson to take time to watch other tasks.

Though committee members of JCIOI, which consists of university faculty members and high school and junior high school teachers, make task candidates for submission to BTW, students may have different views from computer science experts and be expected to create excellent tasks. Therefore, we chose good tasks among students' tasks and proposed them to the meeting of JCIOI in 2014 and 2015. Some tasks were selected to submit BTW and used in actual Bebras Challenge. Since we realized that it is encouraging the students that there is the chance of being used in actual contests around the world, we showed the possibility to students as another aim of the units in 2016.

3.2. Instructions to the Students

He handed out an a4 size worksheet and instructed to write below items to each student.

- 1) Title, Question, Choice for answer, Age category.
- 2) Pictures to explain the problem.
- 3) Answer and explanation of the problem.
- 4) Explanation of the connection to computer science.
- 5) Time for work, Comment.

The teacher also indicated the evaluation points of the task.

- 1) Quality of the task (i.e. whether pupils can enjoy or not).
- 2) Originality.
- 3) Understandability.

In order to make students learn, the teacher introduced the following items.

- The previous Bebras tasks.
- The booklet for beginners in informatics.

The teacher informed the students that the tasks would be used as 'Aim for education' and 'Aim for suggested tasks.'

3.3. Class after Suggestions of the Tasks

After the winter break, the students submitted Bebras-Like tasks they created. In each class, the teacher scanned them into one PDF file (about 40 pages) and handed out to the students. Moreover, the teacher made a booklet including excellent 15 tasks he selected. He handed out the booklet to all the students in the classes and explained selected tasks.

3.4. Suggestion to the Selection Meeting of Japan IOI Committee

We suggested excellent tasks to the selection meeting of Japan IOI Committee and asked judgements whether each task can be used as Japanese suggested tasks or not. In the meeting, experts discussed which task was suitable for all the candidate tasks including experts created and students created. The selected tasks were translated into English and suggested to the Bebras Task Workshop.

4. Results

4.1. Implementation Status

As a sample, we indicate a student task (Fig.1). The problem requires participants to think about RGB color representation by KADOMATSU, one of the Japanese symbol

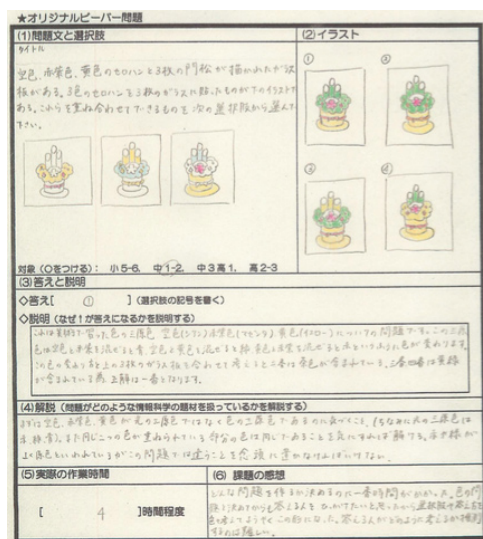


Fig. 1. Example of students' Bebras-Like task.

used in the new year. The problem is understandable, and it was fun to think the answer. Therefore, it has high quality can be used as a Bebras task directly. In the time entry, '4 hours' was written as the time for work. And in the comment entry, 'It spent much time to decide a type of the problem' and 'I thought I would like to doubt solutionists' were written.

Many other students worked well and suggested high quality tasks. The mean time to work was about 1.8 hours, and the maximum was 12 hours. Topics as informatics were diverse. Cipher, Barcode, Binary Numbers, Programming, Math(Probability and Combination) were popular.

4.2. Aim for Education

To evaluate the educational effect of 'Creating Bebras Task' units, we used two data sets. One set was comments data they suggested. The other set was questionnaire data after watching tasks those other students created.

4.2.1. Creating Task Process

In the process of creating tasks, we show how students learned and wrote their impressions.

First, we asked following questions:

1) Did you learn computer science by yourself?

Yes 246 (77.4%)

No 72 (22.6%)

2) How did you learn? (Multiple answers are possible)

1. Previous Bebras Tasks 179

2. Web Pages 95

3. Books 85

4. Others (ie. Asked family) 36

Next, we analyzed student comments written in prints. The most frequently used word was 'difficult'. 146 students (46%) used it. The reasons were 'To get an idea', 'To explain in understandable terms' and so on. Second frequently used word was 'interesting'. 87 students (27%) were used it.

Some comments are below:

1. It was difficult to think what is computer science.
2. The time I was looked for task theme was most interesting.
3. When I was gazing a clock, I suddenly got an idea. I realized inspiring.
4. After solving many Bebras Tasks, I began to create my task.
5. I felt creating task was interesting rather than solving. It was very difficult to write sentences understandable. I was interested in thinking how could I beguile others.
6. I worked very hard. After due consideration not to make some patterns of answers, I created my task.

4.2.2. Mutual Inspection of Submitted Tasks

In a lesson after the task submission, students watched many others' tasks. As a result, many students noticed that there were many topics in computer science field and realized that idea was important. 54 student (17%) commented on other students' tasks like 'What a wonderful Idea!' and 'Solving was fun'. Some comments are below:

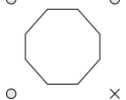
1. I realized there were many topics in computer science around us. It was enjoyable to solve good tasks those the teacher selected. This lesson was a good chance to notice a connection between informatics and mathematics.
2. Creating task was challenging. But classmates created good tasks, and I understood that even high school student could create good ones by inspiration.
3. I was delighted!!!! My task was chosen as a good one.
4. Classmates' tasks were difficult than I expected. So, I was very interested in.

4.3. Good Tasks

There are eight students' tasks those were submitted to Bebras Task Workshop as Japanese representative tasks, including ones selected as 'Favorite Task' in the workshop and were used in actual Bebras Challenge in several countries. In this section, we introduce four tasks used in Japanese Bebras Challenge and two tasks selected as 'Favorite Task' in the Workshop.

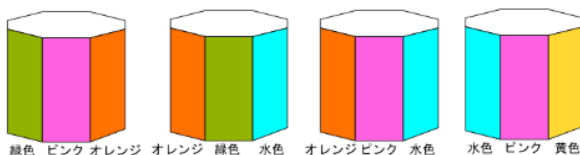
4.3.1. Four Tasks Used in Japanese Bebras Challenge

Task 1. Colorful Building

○ ○ [Q] There is a colorful octagonal pillar (the left picture) building in the Bebras City. Each side wall of the building is painted with different colors, red, blue, yellow, green, purple, pink, orange and black.


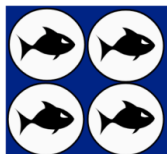
- From the point A, you see the blue, purple and black walls.
- From the point B, you see the pink, yellow and purple walls.
- From the point C, you see the green, pink, and orange walls.

Choose the image which you can see from a point:



The Colorful Building task deals with the concept of permutation. To find out correct answer, organizing and classifying information are required. The student who was an author commented "I spent 30 minutes to create this. It was difficult to explain the problem in text.

Task2. Fish



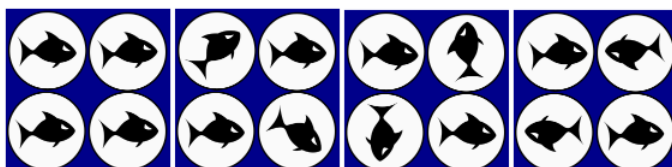
[Q] Four toy fish are placed as shown in the left picture.

If you turn a toy x degrees clockwise, the toy on the diagonal turns $(360 - x)$ degrees clockwise.

You operate as follows:

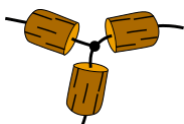
1. Turn the toy in the upper left 45 degrees clockwise.
2. Turn the toy in the lower left 90 degrees clockwise.
3. Turn the toy in the lower right 90 degrees clockwise.
4. Turn the toy in the upper left 45 degrees clockwise.

Choose the correct figure:



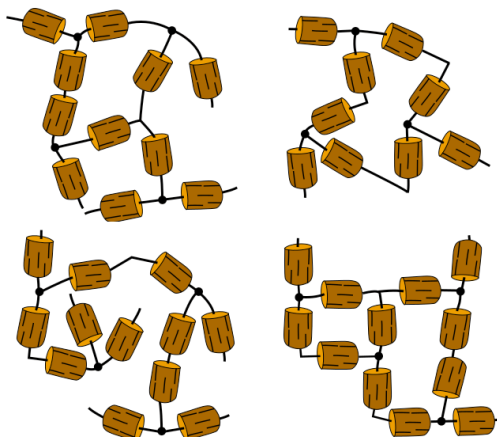
The Fish task deals with computer programs – sequences of instructions. To solve this problem using the arrows notation involves a lot of abstraction. The student who was an author commented “I spent 1 hour to create it. It was difficult to conceive the idea.”

Task3. Log Works



[Q] A beaver creates some works which consist of the log parts (the left picture). The log part consists of three logs and two ropes connected with each other. Therefore, the log part has three ropes which is connected to another log part.

What work the beaver cannot make from the parts?



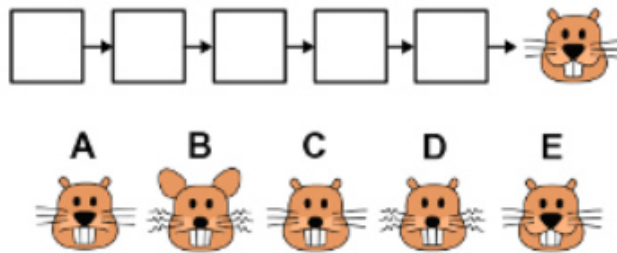
The Log Works task deals with the possibility of composition and combination using specific parts. Problems of construction such as ‘syntactic parsing’ are widely found out on informatics. A student who was an author commented “The idea came to me suddenly”.

4.3.2. Two Tasks Selected as ‘Favorite Task’ in the Workshop

At some Bebras Task Workshops, the members voted “Favorite Task” among all of the tasks. Many members selected the following two student tasks.

Task 4. Animation

[Q] B-taro is planning an animation, which shows a sequence of pictures of a face. The animation should run smoothly. Therefore, the order of the pictures is correct, if only one attribute of the face changes from one picture to the next. Unfortunately, the pictures got mixed up (picture below). Now B-taro must find the correct order again. Luckily, he knows which picture is last. He labels the five other pictures with letters A to E.



This task is introduced as sample task on the Bebras Web site. This task deals with data structure concepts, in particular with class which is a very important concept in object oriented programming (Dagienė, 2016).

Task 5. Sword and Shield

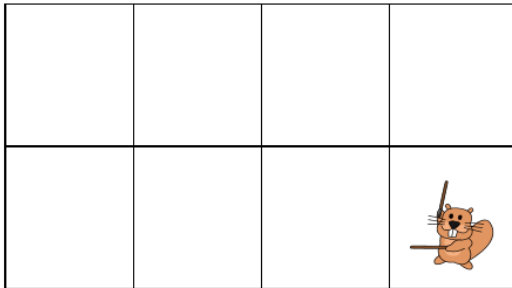
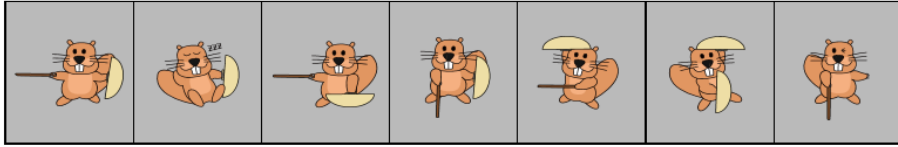
[Q] Luke Bevwalker adores swordsmanship. He attends a swordsmanship dojo. He finds 7 friends who also like swordsmanship. The eight beavers always train together. One day, the master of the dojo get them to strike poses as shown below:



The master says “you can make a legendary formation if you enter the boxes observing the following two conditions simultaneously:

- There is another beaver at the end of the sword.
- The shield is positioned to block the sword.

The master arranges the beaver (3) to the box (h).
Which beaver is in the box (b)?



The Sword and Shield task is a complex puzzle. The backtrack algorithm which checks all the combinations requires an enormous amount of calculation. However, appropriate logical thinking could reduce it dramatically. A student who was an author commented “I tried various forms of conditions and branches to form a formation. If it has another solutions or not? I cannot verify it.”.

5. Consideration

We consider the effectiveness of ‘Creating Bebras Task’ units as following three points.

1. Students’ Efforts.
2. Influence to the learning of computer science.
3. Practical use to Bebras Challenge.

5.1. Students’ Efforts

Many students worked this activity seriously and created high-quality tasks. Some students created original tasks in short time by inspiration. Others created tasks in long time seriously. Through participating to the Bebras Challenge and trying to solve previous Bebras tasks, the students realized the features Bebras tasks have. They tried to direct the feature inside their tasks. Such considering were difficult but fun for them.

5.2. Influence on the Learning of Computer Science

By being imposed this learning activity in winter break, the students learned computer science voluntarily by using previous Bebras tasks or textbooks. Moreover, by watching other students' tasks, they could realize there are many topics in computer science field. The previous Bebras tasks and other students' tasks were made from items around them. Therefore, they would feel computer science close to them.

5.3. Practical Use to Bebras Challenge

Some students' tasks were submitted to the Bebras Task Workshop. They were used in Japanese Bebras Challenge and selected as "Favorite Task" at the Workshop. Therefore, we recognized that even high school students can create high quality tasks which could be used in actual Bebras Challenge.

'Creating Bebras Task' units were an activity to be able to contribute Bebras Challenge. For a student, the task he/she created was used in many countries and hundreds of thousands of pupils/students tried to solve it. We consider such dreamful learning activity was realized.

6. Conclusion

In a Japanese high school, we implemented a learning activity called 'Creating Bebras Task'. Creating task is more difficult than solving tasks. However, we gave an opportunity for the students to learn CS and made them feel the activity was fun. The future works of this research are to analyze the students' tasks more deeply and suggest as an educational method in CS.

References

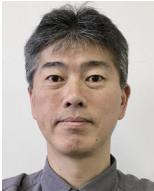
- Dagienė, V., Futschek, G. (2008). Bebras international contest on informatics and computer literacy: Criteria for good tasks. In: *ISSEP 2008: Informatics Education – Supporting Computational Thinking*. 19–30.
- Dagienė, V., Futschek, G., Stupurienė, G. (2016). Teachers' constructionist and deconstructionist learning by creating Bebras tasks: Constructionism in action. *Proceedings of Constructionism 2016*, 257–264.
- Dagienė, V., Stupurienė, G. (2016). Informatics concepts and computational thinking in K-12 education: A Lithuanian perspective. *Journal of Information Processing*, 24(4), 732–739.
- ICICT (undated). *International Challenge on Informatics and Computational Thinking*.
<http://bebras.org/>
- Izu, C., Mirolo, C., Settle, A., Mannila, L., Stupurienė, G. (2017). Exploring Bebras tasks content and performance: A multinational study. *Informatics in Education*, 16 (1), 39–59.
- JCIOI (undated). *Japanese Committee for the IOI*. <http://bebras.eplang.jp/>
- Kanemune, S., Shirai, S., Tani, S. (2017). Informatics and programming education at Primary and Secondary schools in Japan. *Olympiads in Informatics*, 11, 133–140.



H. Manabe is a teacher at Hakuyo High School. He received Ph.D. degrees from Osaka Electro-Communication University in 2013. He is a member of JCIOI since 2013. He has been working on programming education, algorithm education and statistics education.



S. Tani has been an executive director of the Japanese Committee for IOI (JCIOI) since 2009, and before this was a director of JCIOI since 2005. He received the BSc, MSc, and Ph.D. degrees from Waseda University, Tokyo, Japan, in 1987, 1990 and 1996, respectively. He is currently a professor at Department of Information Science, Nihon University. His research interests include computational complexity theory, computational topology, and complex network analysis.



S. Kanemune is a professor at Department of Electro-Mechanical Engineering, Osaka Electro-Communication University. He received Ph.D. in Systems Management from Tsukuba University. He is a director of JCIOI since 2016. He has been working on database, information system, programming education and robotics education.



Y. Manabe is an undergraduate student at The University of Tokyo. He had participated JCIOI annual events for kids. He developed Kanji (Chinese character) learning software and published a journal paper during he was in high school. His research focuses on Japanese Kanji education.