CTA-M
Computational Thinking Abilities-Middle Grades Assessment

Validation paper for the combined CTt and Bebras items:

Wiebe, E., London, J., Aksit, O., Mott, B. W., Boyer, K. E., & Lester, J. C. (2019, February). Development of a Lean Computational Thinking Abilities Assessment for Middle Grades Students. In *Proceedings of the 50th ACM Technical Symposium on Computer Science Education* (pp. 456-461). ACM.

The CTA-M consists of items originally contained in the *CTt* and *Bebras UK 2016* instruments.

CTt was developed by M. Román-González and colleagues. CTt items below are redistributed with the permission of M. Román-González.

Appropriate development and validation citations include:

Román-González, M., Pérez-González, J.-C., & Jiménez-Fernández, C. (2016). Which cognitive abilities underlie computational thinking? Criterion validity of the Computational Thinking Test. *Computers in Human Behavior, 72*, 678-691. doi: http://dx.doi.org/10.1016/j.chb.2016.08.047

Román-González, M., Pérez-González, J.-C., Moreno-León, J., & Robles, G. (2018). Can computational talent be detected? Predictive validity of the Computational Thinking Test. *International Journal of Child-Computer Interaction, 18*, 47-58.

The Bebras UK 2016 items were developed by the Working Group for UK Bebras Computational Challenge and released through the following document:

Blokhuis, D., Millican, P., Roffey, C., Schrijvers, E., & Sentance, S. (2016). *UK Bebras Computational Thinking Challenge 2016*. Oxford, UK: University of Oxford. Accessed March, 2017 at http://www.bebras.uk/

Notes:
1. Two items, RG_Q23 and B_Q7, have been found to have less than optimal psychometric properties in subsequent analysis since the above paper was published. We are now recommending a 23-item instrument with these two items excluded.
2. Item codes for the items as used in our published research are on the left side
3. Correct answers to questions are also on the left (e.g., Key = 2 means the second option is the correct one)

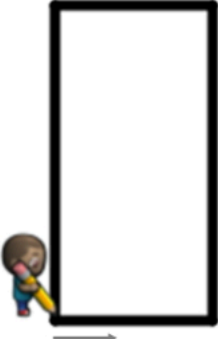| CTt items	
Item Number	Item
RG_3 Key = 4	## Question 3 The instructions should take 'Pac-Man' to the ghost by the path marked out. In which step of the instructions is there a mistake? *The instructions should take 'Pac-Man' to the ghost by the path marked out. In which step of the instructions is there a **mistake**?* move forward → Step A turn left ↺ ▼ → Step B move forward move forward → Step C turn left ↺ ▼ → Step D move forward ## Question 3 Select the step in which there is a mistake ○ A ○ B ○ C ○ D

RG_Q7
Key = 1

Question 7

The instructions should make the artist draw the following rectangle once (50 pixels wide and 100 pixels high). In which step of the instructions is there a mistake?

*The instructions should make the artist draw the following rectangle **once** (50 pixels wide and 100 pixels high). In which step of the instructions is there a **mistake**?*

Step A

```
repeat 4 times
do    move forward ▾ by 50 pixels
      turn left ▾ by 90 ▾ degrees          → Step B
      move forward ▾ by 100 pixels         → Step C
      turn left ▾ by 90 ▾ degrees          → Step D
```

Question 7

Select the step in which there is a mistake

○ A

○ B

○ C

○ D

Question 11

The instructions should take 'Pac-Man' to the ghost by the path marked out. In which step of the instructions is there a mistake?

The instructions should take 'Pac-Man' to the ghost by the path marked out. In which step of the instructions is there a *mistake*?

Step A
Step B
Step C
Step D

Repeat until the...

× 2

Question 11

Select the step in which there is a mistake

○ A

○ B

○ C

○ D

RG_Q12

Key = 1

Question 12

Which instructions should the artist follow to draw the ladder that reaches the flower? There are 30 pixels between each rung.

Which instructions should the artist follow to draw the ladder that reaches the flower? There are 30 pixels between each rung.

Option A

```
Repeat until the flower
do   repeat 4 times
     do   move forward ▾ by 30 pixels
          turn right ▾ by 90 ▾ degrees
     jump forward ▾ by 30 pixels
```

Option B

```
Repeat until the flower
do   repeat 4 times
     do   move forward ▾ by 120 pixels
          turn right ▾ by 90 ▾ degrees
     jump forward ▾ by 30 pixels
```

Option C

```
Repeat until the flower
do   repeat 4 times
     do   move forward ▾ by 30 pixels
          turn right ▾ by 90 ▾ degrees
     jump forward ▾ by 210 pixels
```

Option D

```
Repeat until the flower
do   repeat 7 times
     do   move forward ▾ by 30 pixels
          turn right ▾ by 90 ▾ degrees
     jump forward ▾ by 30 pixels
```

Question 12

Select the correct answer

○ A

○ B

○ C

○ D

RG_Q13

Key = 2

Question 13

Which instructions take 'Pac-Man' to the ghost by the path marked out?

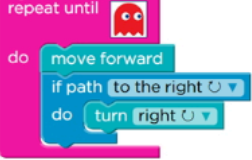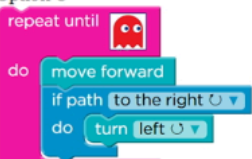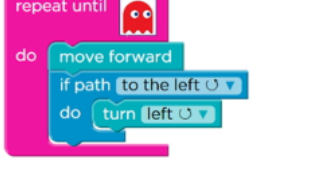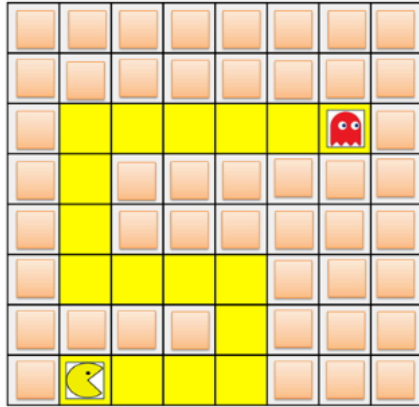| Which instructions take 'Pac-Man' to the ghost by the path marked out?	Option A	Option B
	Repeat until the...	Repeat until the...
	If on...	If on...
	Option C	Option D
	Repeat until the...	Repeat until the...
	If on...	If on...

Question 13

Select the correct answer
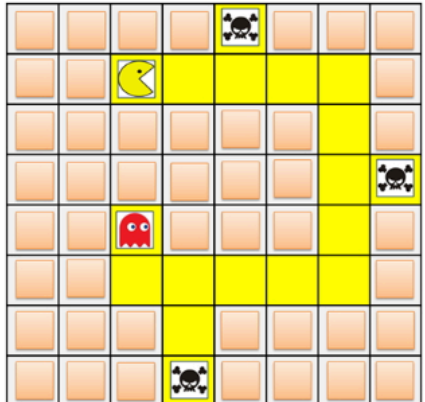
○ A

○ B

○ C

○ D

RG_Q14

Key = 1

Question 14

Which instructions take 'Pac-Man' to the ghost by the path marked out?

Which instructions take 'Pac-Man' to the ghost by the path marked out?

Option A
```
repeat until
do  move forward
    if path to the right ↻ ▾
    do  turn right ↻ ▾
```

Option B
```
repeat until
do  turn right ↻ ▾
    if path to the right ↻ ▾
    do  move forward
```

Option C
```
repeat until
do  move forward
    if path to the right ↻ ▾
    do  turn left ↻ ▾
```

Option D
```
repeat until
do  move forward
    if path to the left ↻ ▾
    do  turn left ↻ ▾
```

Question 14

Select the correct answer

○ A

○ B

○ C

○ D

RG_Q16

Key = 4

Question 16

The instructions should take 'Pac-Man' to the ghost by the path marked out. In which step of the instructions is there a mistake?

The instructions should take 'Pac-Man' to the ghost by the path marked out. In which step of the instructions is there a *mistake*?

repeat until
do   move forward
      if path to the left ↻ ▼   → Step A
      do   turn left ↻ ▼   → Step B
      if path to the right ↻ ▼   → Step C
      do   move forward   → Step D

Question 16

Select the step in which there is a mistake

○ A

○ B

○ C

○ D

RG_Q17

Key = 2

Question 17

Which instructions take 'Pac-Man' to the ghost by the path marked out?

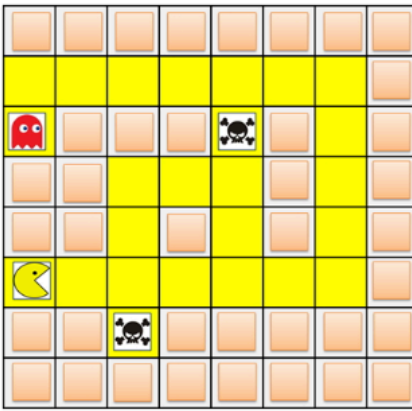| Which instructions take 'Pac-Man' to the ghost by the path marked out?	Option A	Option B
	repeat until 👻 do if path ahead ▾ do move forward else turn left ↺ ▾	repeat until 👻 do if path ahead ▾ do move forward else turn right ↺ ▾
	Option C	**Option D**
	repeat until 👻 do if path to the right ↺ ▾ do turn right ↺ ▾ else move forward	repeat until 👻 do if path to the left ↺ ▾ do turn left ↺ ▾ else move forward

Question 17

Select the correct answer

○ A

○ B

○ C

○ D

RG_Q18

Key = 1

Question 18

Which instructions take 'Pac-Man' to the ghost by the path marked out?

Which instructions take 'Pac-Man' to the ghost by the path marked out?
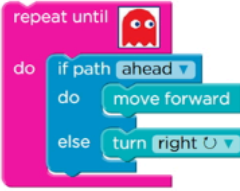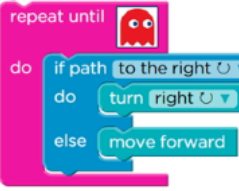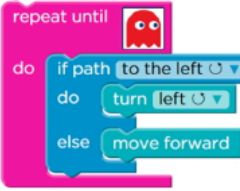
Option A
repeat until
do if path ahead ▼
    do move forward
    else turn left ↻ ▼

Option B
repeat until
do if path ahead ▼
    do move forward
    else turn right ↻ ▼

Option C
repeat until
do if path to the right ↻ ▼
    do turn right ↻ ▼
    else move forward

Option D
repeat until
do if path to the left ↻ ▼
    do turn left ↻ ▼
    else move forward

Question 18

Select the correct answer

○ A

○ B

○ C

○ D

RG_Q19

Key = 2

Question 19

The instructions should take 'Pac-Man' to the ghost by the path marked out. In which step of the instructions is there a mistake?

The instructions should take 'Pac-Man' to the ghost by the path marked out. In which step of the instructions is there a *mistake*?

repeat until
do if path ahead ▾
do move forward → **Step A**
else if path to the right ↻ ▾ → **Step B**
do turn left ↻ ▾ → **Step C**
else turn right ↻ ▾ → **Step D**

Question 19

Select the step in which there is a mistake

○ A

○ B

○ C

○ D
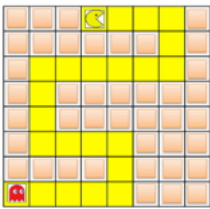
RG_Q20

Key = 3

Question 20

Which step is missing in the instructions below to take 'Pac-Man' to the ghost by the path marked out?

Which step is missing in the instructions below to take 'Pac-Man' to the ghost by the path marked out?
 	
repeat until 👻
do — if path `ahead ▾`
  do — `move forward`
  else — if path `to the right ↻ ▾`
    do — turn `right ↻ ▾`
    else — `??????????`
 	
[grid with Pac-Man and ghost]
	Option A
	
	`move forward`
		Option B
		
		turn `right ↻ ▾`

	Option C turn `left ↻ ▾`	**Option D** *Not missing any step*

Question 20

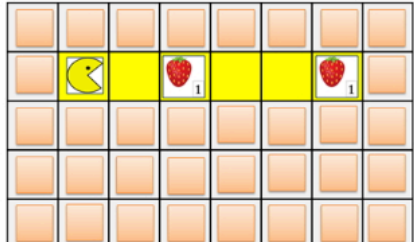Select the correct answer

○ A

○ B

○ C

○ D

RG_Q23
*Removed
for the 23-
item
instrument

Key = 1

Question 23

What is missing in the instructions below to take 'Pac-Man' to the strawberries by the path marked out and tell 'Pac-Man' to eat all the strawberries shown?

What is missing in the instructions below to take 'Pac-Man' to the strawberries by the path marked out and tell 'Pac-Man' to eat all the strawberries shown?	Option A 1 *time*
while path ahead do repeat ???????????? do move forward if any strawberries do Eat 1 strawberry	Option B 2 *times*
	Option C 3 *times*
	Option D 5 *times*

Question 23

Select the correct answer
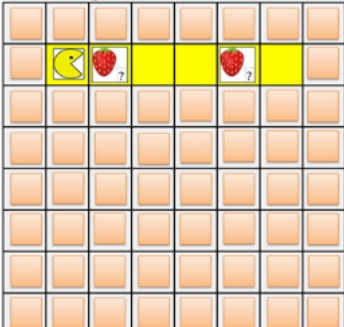
○ A

○ B

○ C

○ D

Question 24

Which step is missing in the instructions below to take 'Pac-Man' to the strawberries by the path marked out and tell 'Pac-Man' to eat all the strawberries (unknown number)?

Which step is missing in the instructions below to take 'Pac-Man' to the strawberries by the path marked out and tell 'Pac-Man' to eat all the strawberries (unknown number)?

```
while path ahead
  do  move forward
      if  any strawberries
        do  ???????????????????
            do  Eat 1 strawberry
```

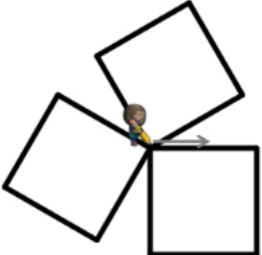|	
Option A	**While path ahead**
Option B	**While no path ahead**
Option C	**While any strawberries**
Option D	**While no strawberries**

Question 24

Select the correct answer

○ A

○ B

○ C

○ D

RG_Q25

Key = 2

Question 25

Which instructions should the artist follow to draw the following design? Each side of each square measures 100 pixels.

The following set of instructions is called '**my function**', and draws one square of 100 pixels each side:

Function
my function
repeat 4 times
do   move forward ▼ by 100 pixels
      turn right ▼ by 90 degrees

Which instructions should the artist follow to draw the following design? Each side of each square measures 100 pixels.

Option A
repeat 3 times
do   my function
turn right ▼ by 120 degrees

Option B
repeat 3 times
do   my function
      turn right ▼ by 120 degrees

Option C
repeat 4 times
do   my function
turn right ▼ by 90 degrees

Option D
repeat 4 times
do   my function
      turn right ▼ by 90 degrees

Question 25

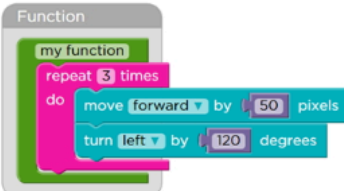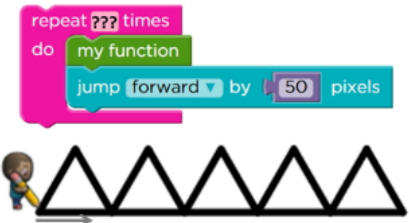Select the correct answer

○ A

○ B

○ C

○ D

RG_Q26

Key = 2

Question 26

The instructions below should make the artist draw the following design. Each side of each triangle measures 50 pixels. What is missing in the instructions?

The following set of instructions is called 'my function', and draws one triangle of 50 pixels each side:

Function
my function
repeat 3 times
do
  move forward by 50 pixels
  turn left by 120 degrees

Option A		Option B	
15		5	

The instructions below should make the artist draw the following design. Each side of each triangle measures 50 pixels. What is missing in the instructions?
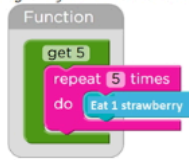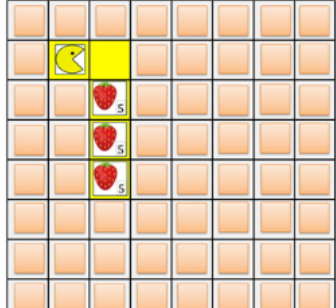
repeat ??? times
do my function
  jump forward by 50 pixels

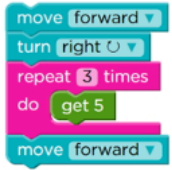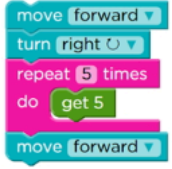| Option C		Option D	
4		3	

Question 26

Select the correct answer

○ A

○ B

○ C

○ D

RG_Q27

Key = 1

Question 27

Which instructions take 'Pac-Man' to the strawberries by the path marked out and tell 'Pac-Man' to eat all the strawberries shown?

Question 27

Select the correct answer

○ A

○ B

○ C

○ D

Bebras items

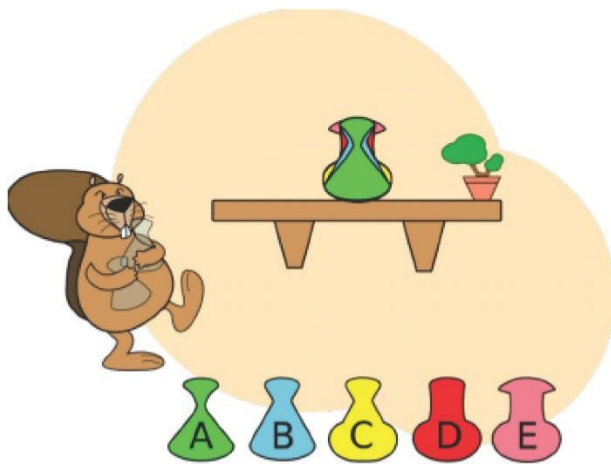| B_Q1	## Question 1
Key = 1	A Beaver puts five bottles on a table. He places them so that every bottle has a bit showing. He places the first bottle at the back of the table and puts each new bottle in front of those already placed. What could be the right order of bottles from first to last? ## Question 1 Select the correct answer ○ E D C B A ○ D B C A E ○ E C D A B ○ D C E B A

B_Q6	## Question 2
Key = 3	Help the green robot to exit the maze.
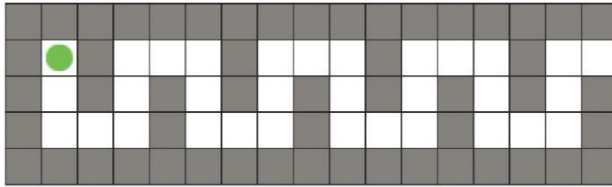
The arrows below represent the instructions that the green robot can follow.

Choose the correct set of instructions that will take the green robot to the exit. The robot will repeat these instructions 4 times.

Question 2

Select the correct answer

4x

4x

4x

4x

Question 3

Beaver Bert has a long strip of colored paper for a party.
The strip has three different colors (yellow, red, blue) in a regularly repeating pattern.
Bert's friend, James, has cut out a section of the paper, as shown in the diagram below.

| Y | R | R | B | Y | R | R | B | Y | R | R | ... | R | B | Y | R | R | B |

James says that he will give back the missing piece of paper if Bert can correctly guess the size of the piece cut out.

Question:
How many colored squares does the missing piece of paper have?

Question 3

Select the correct answer

○ 31

○ 32

○ 33

○ 34

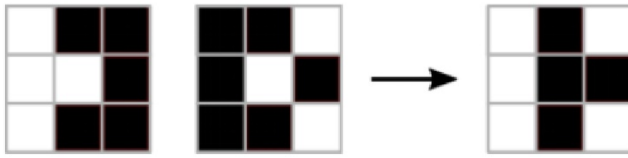| B_Q8 | # Question 4 |
| Key = 1 | |

Question 4

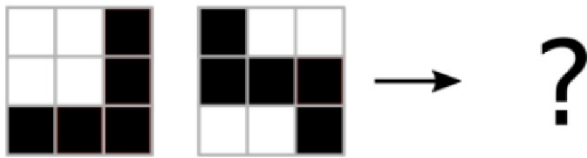Combining Card A and Card B, you get Card C:

Card A   Card B   Card C

Question:
How many black cells will Card F have after combining Card D and Card E?

Question 4

Select the correct answer

- ○ 3
- ○ 4
- ○ 5
- ○ 6

Question 5

Jane is playing a computer game.
First, the computer secretly chooses colors for five buds. The available colors for each flower are blue, orange, and pink. Jane has to guess which flower has which color. She makes her first five guesses and presses the Blossom button.

The buds, whose colors she guessed correctly, break into flowers. The others remain as buds.

Jane's first go:

| orange | pink | blue | orange | orange |
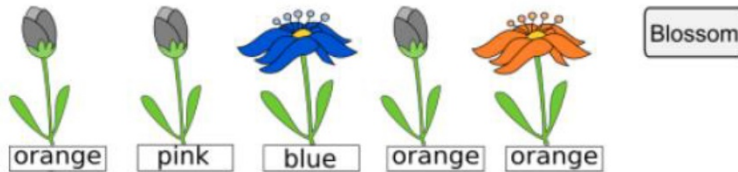
Jane then has another go at guessing and presses the Blossom button again.

Jane's second go:

| pink | orange | blue | blue | orange |
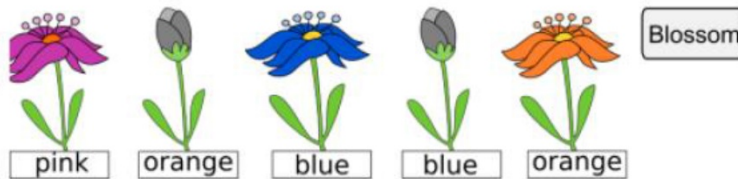
Question:
What colors did the computer choose for the flowers?

Question 5

Select the correct answer

○ blue pink blue orange orange

○ pink blue blue blue orange

○ pink blue blue pink orange

○ pink pink blue pink orange

B_Q10	# Question 6
Key = 4	

Betaro Beaver has discovered five new magic potions:
- one makes ears longer
- another makes teeth longer
- another makes whiskers curly
- another turns the nose white
- the last one turns eyes white.

Betaro put each magic potion into a separate beaker. He put pure water into another beaker, so there are six beakers in total. The beakers are labeled A to F. The problem is, he forgot to record which beaker contains which magic potion!
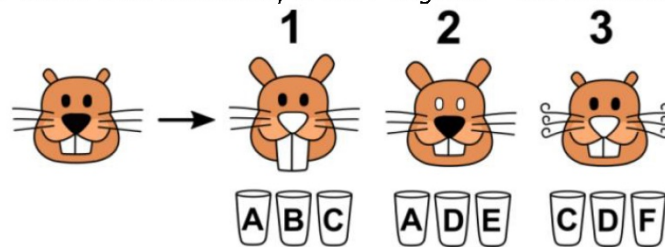

To find out which potion is in each beaker, Betaro set up the following experiments:

Expt 1: A beaver drinks from beakers A, B and C together - the effects are shown in Figure 1.
Expt 2: A beaver drinks from beakers A, D and E together - the effects are shown in Figure 2 .
Expt 3: A beaver drinks from beakers C, D and F together - the effects are shown in Figure 3.

Question:
Which beaker contains pure water?

Question 6

Select the correct answer

○ A

○ B

○ C

○ D

○ E

○ F

B_Q13	# Question 7
	In a warehouse, three robots always work as a team.
Key = 2	

When the team gets a direction instruction (N, S, E, W), all robots in the grid will move one square in that direction at the same time.

After following a list of instructions, the robots all pick up the object found in their final square.
For example, if we give the list N, N, S, S, E to the team, then robot A will pick up a cone, robot B will pick up a ring, and robot C will pick up a cone.
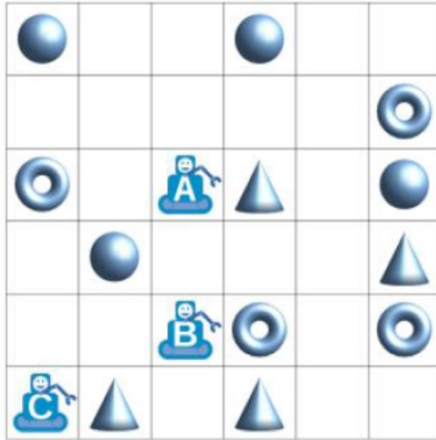
Question:
Which list of instructions can be sent to the robots so that the team picks up exactly a sphere, a cone, and a ring?

Question 7

Select the correct answer

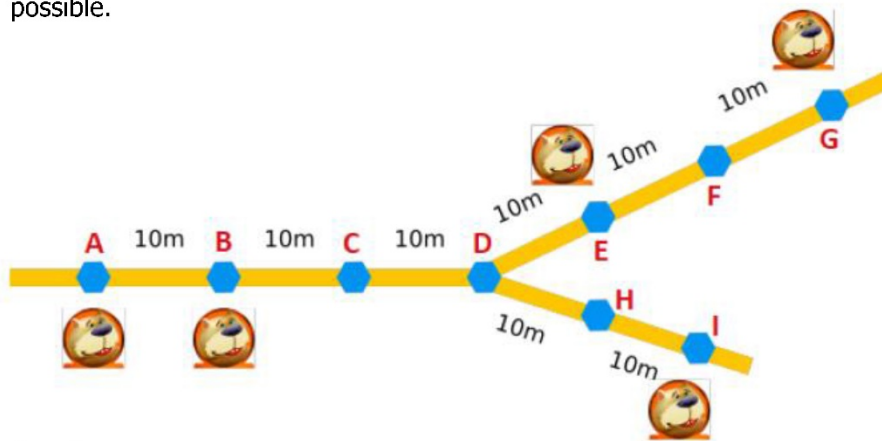- ○ N, E, E, E
- ○ N, E, E, S, E
- ○ N, N, S, E, N
- ○ N, E, E, S, W

Question 8

The lodges of five beavers are shown on the map below.

The Beavers want to put a bus stop in one of the places marked by blue hexagons. All the hexagons are 10m apart.

The beavers decide that the sum of the distances from their lodges to the bus stop must be as small as possible.

Question:
Which is the best place for the bus stop?

Question 8

Select the correct answer

○ A

○ B

○ C

○ D

○ E

○ F

○ G

○ H

○ I

Question 9

Agents Boris and Bertha communicate using secret messages.
Boris wants to send Bertha the secret message:
    MEETBILLYBEAVERAT6

He writes each character in a 4 column grid from left to right and row by row starting from the top. He puts an X in any unused spaces. The result is shown below.

Then he creates the secret message by reading the characters from top to bottom and column by column starting from the left:
    MBYVTEIBE6ELERXTLAAX

Bertha then uses the same method to reply to Boris. The secret message she sends him is:
    OIERKLTEILH!WBEX

Question:
What message does Bertha send back?

Question 9

Select the correct answer

○ OKWHERETOMEET!

○ OKIWILLBETHERE!

○ WILLYOUBETHERETOO?

○ OKIWILLMEETHIM!