

**Analysis of the Usefulness
of Teaching Materials Including Sound
Created by KeTCindy**

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Purpose of this research

In order to make students understand mathematical concepts, we study what kind of teaching method is effective. In this reserach, we analyse the usefulness of teaching materials including sound created by KeTCindy.

Teaching materials including sound

Flow of making teaching materials

1. We make teaching materials including graphics by KeTCindy.
2. We create voice data for each page by Audacity which is a digital audio editor.

These materials are made of **PDF files**.

Experimental study

- Cognitive Detection Clicker system
- Implementation
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- Statistical analysis of CDC Data

Cognitive Detection Clicker system

- The Cognitive Detection Clicker system which we created utilises a personal computer as a master device and a clicker as a slave device.
- It records the question number and **the answer**, as well as **the timing of the button press**.
- A record of the button choice and response timing is saved as a CSV file on the linked personal computer.

Cognitive Detection Clicker (CDC)



Implementation

- Date : December 14, 2017
- Place : National Institute of Technology,
Numazu College, Japan
- Participants : 38 4th-year students from the
Department of mechanical engineering

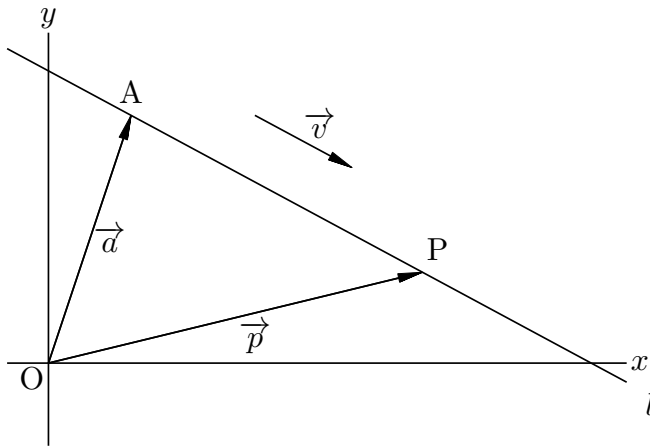
Implementation

Flow of the experiment

1. Pretest (P1 ~ P3)
2. Learning by teaching materials including sound
3. Test (Q1 ~ Q5)

Problems Q1 to Q3 are replications of P1 to P3.
Q4 and Q5 are application problems.

P1



A vector equation of a straight line passing through the point A and parallel to the vector $\vec{v}$ is expressed as follows.

$$\boxed{(1)} = \boxed{(2)} + \boxed{(3)} \boxed{(4)}$$

1. Choose $\boxed{(1)}$ from (1 - 1) ~ (1 - 4).

(1 - 1) $\vec{a}$ (1 - 2) $\vec{v}$ (1 - 3) $\vec{p}$ (1 - 4) t

2. Choose $\boxed{(2)}$ from (2 - 1) ~ (2 - 4).

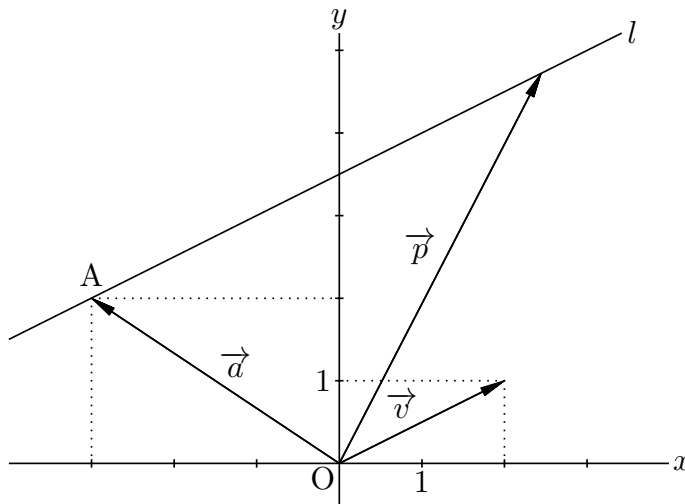
(2 - 1) $\vec{a}$ (2 - 2) $\vec{v}$ (2 - 3) $\vec{p}$ (2 - 4) t

3. Choose $\boxed{(3)}$ from (3 - 1) ~ (3 - 4).

(3 - 1) $\vec{a}$ (3 - 2) $\vec{v}$ (3 - 3) $\vec{p}$ (3 - 4) t

4. Choose $\boxed{(4)}$ from (4 - 1) ~ (4 - 4).

(4 - 1) $\vec{a}$ (4 - 2) $\vec{v}$ (4 - 3) $\vec{p}$ (4 - 4) t

P2

1. For the position vector $\vec{a}$ at the point A in the figure, $\vec{a} = \boxed{(1)}$ holds.

Choose $\boxed{(1)}$ from **(1 - 1)** $\sim$ **(1 - 4)**.

(1 - 1) $(-3, 0)$ **(1 - 2)** $(-3, 2)$ **(1 - 3)** $(0, 2)$ **(1 - 4)** $(2, -3)$

2. For the direction vector $\vec{v}$ of the straight line l in the figure, $\vec{v} = \boxed{(2)}$ holds.

Choose $\boxed{(2)}$ from **(2 - 1)** $\sim$ **(2 - 4)**.

(2 - 1) $(0, 1)$ **(2 - 2)** $(1, 2)$ **(2 - 3)** $(2, 0)$ **(2 - 4)** $(2, 1)$

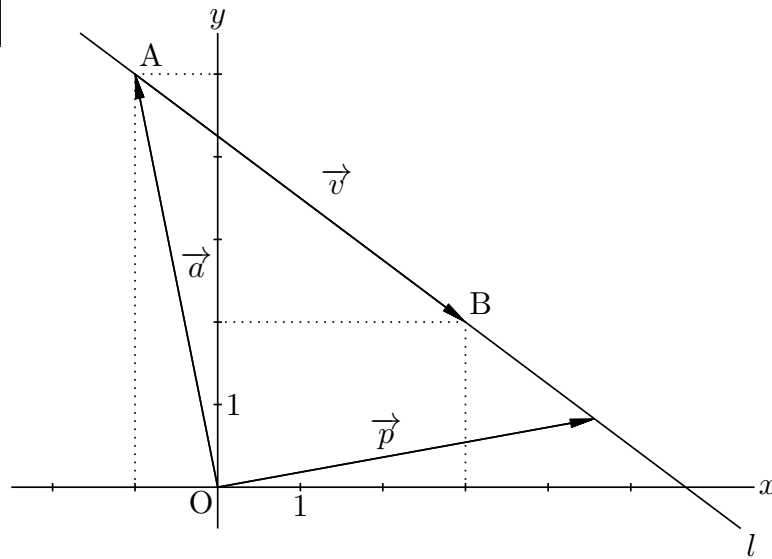
3. Let $\vec{p}$ be the position vector of any point on the line l . Then, the vector equation of the straight line l is expressed as $\boxed{(3)}$. Choose $\boxed{(3)}$ from **(3 - 1)** $\sim$ **(3 - 4)**.

(3 - 1) $\vec{v} = \vec{a} + t\vec{p}$

(3 - 2) $\vec{v} = \vec{p} + t\vec{a}$

(3 - 3) $\vec{p} = \vec{a} + t\vec{v}$

(3 - 4) $\vec{p} = \vec{v} + t\vec{a}$

P3

1. For the position vector $\vec{a}$ at the point A in the figure, $\vec{a} = \boxed{(1)}$ holds.

Choose $\boxed{(1)}$ from **(1 - 1)** ~ **(1 - 4)**.

(1 - 1) $(-1, 0)$ **(1 - 2)** $(5, -1)$ **(1 - 3)** $(0, 5)$ **(1 - 4)** $(-1, 5)$

2. For the direction vector $\vec{v} = \overrightarrow{AB}$ of the straight line l in the figure, $\vec{v} = \boxed{(2)}$ holds. Choose $\boxed{(2)}$ from **(2 - 1)** ~ **(2 - 4)**.

(2 - 1) $(4, -3)$ **(2 - 2)** $(4, 3)$ **(2 - 3)** $(3, 2)$ **(2 - 4)** $(-1, 5)$

3. Let $\vec{p}$ be the position vector of any point on the line l . Then, the vector equation of the straight line l is expressed as $\boxed{(3)}$. Choose $\boxed{(3)}$ from **(3 - 1)** ~ **(3 - 4)**.

(3 - 1) $\vec{v} = \vec{a} + t\vec{p}$

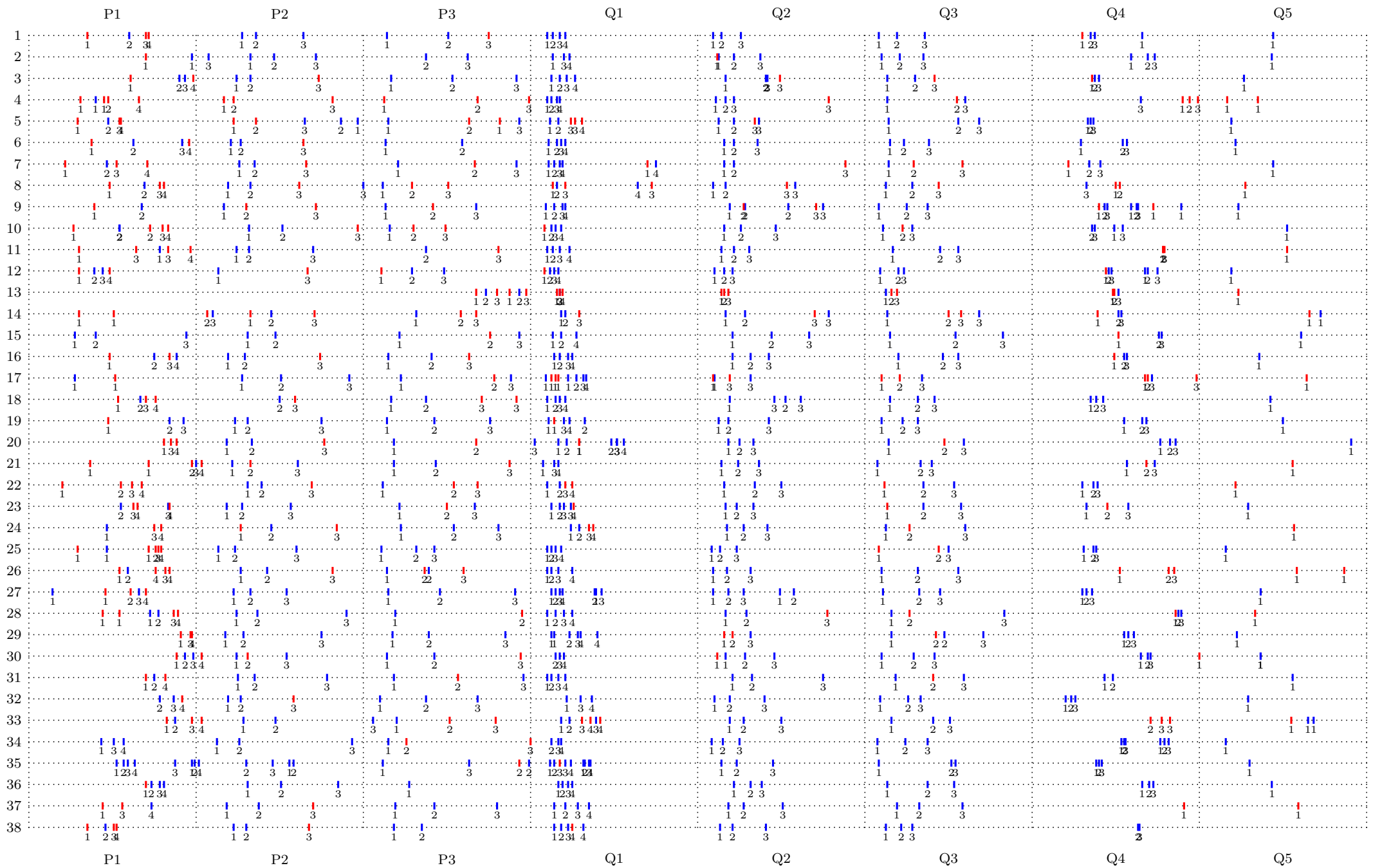
(3 - 2) $\vec{v} = \vec{p} + t\vec{a}$

(3 - 3) $\vec{p} = \vec{a} + t\vec{v}$

(3 - 4) $\vec{p} = \vec{v} + t\vec{a}$

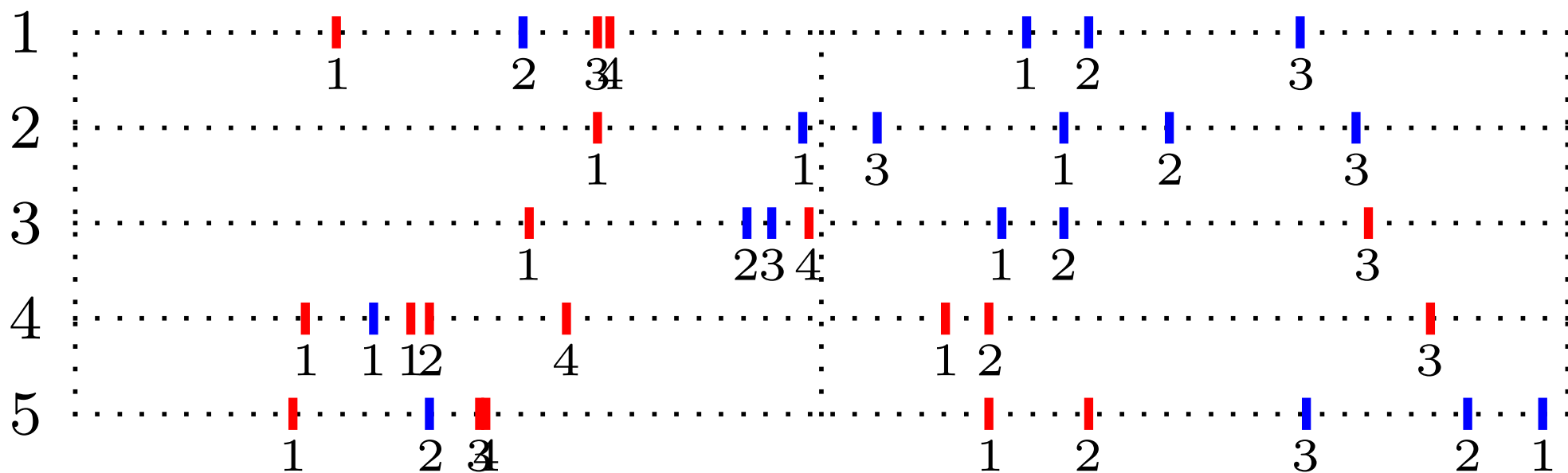
Results

The CSV data from the CDC included the CDC number, the time at which the button was pressed, and the answer selected. Scripts for processing the data were written in KeTCindy, which charted the responses of the participants showing the pattern of the answers over time.



P1

P2



blue : correct , red : incorrect

Statistical analysis of CDC Data

1. Comparison of proportions of correct answers
2. Comparison of response times for correct answers

Statistical analysis of CDC Data

Paired t-test (proportions of correct answers)

X_1 : the number of correct answers of pretset

X_2 : the number of correct answers of tset

$X = X_2 - X_1$, μ : population mean

null hypothesis $H_0 : \mu = 0$

alternative hypothesis $H_1 : \mu > 0$

$$\Rightarrow \overline{X} = 1.237$$

p-value : 1.098e-08

H_0 is rejected.

Statistical analysis of CDC data

T-test (response times for correct answers)

X : the time required for giving correct answers to P2

μ_1 : population mean

Y : the time required for giving correct answers to Q2

μ_2 : population mean

null hypothesis $H_0 : \mu_1 = \mu_2$

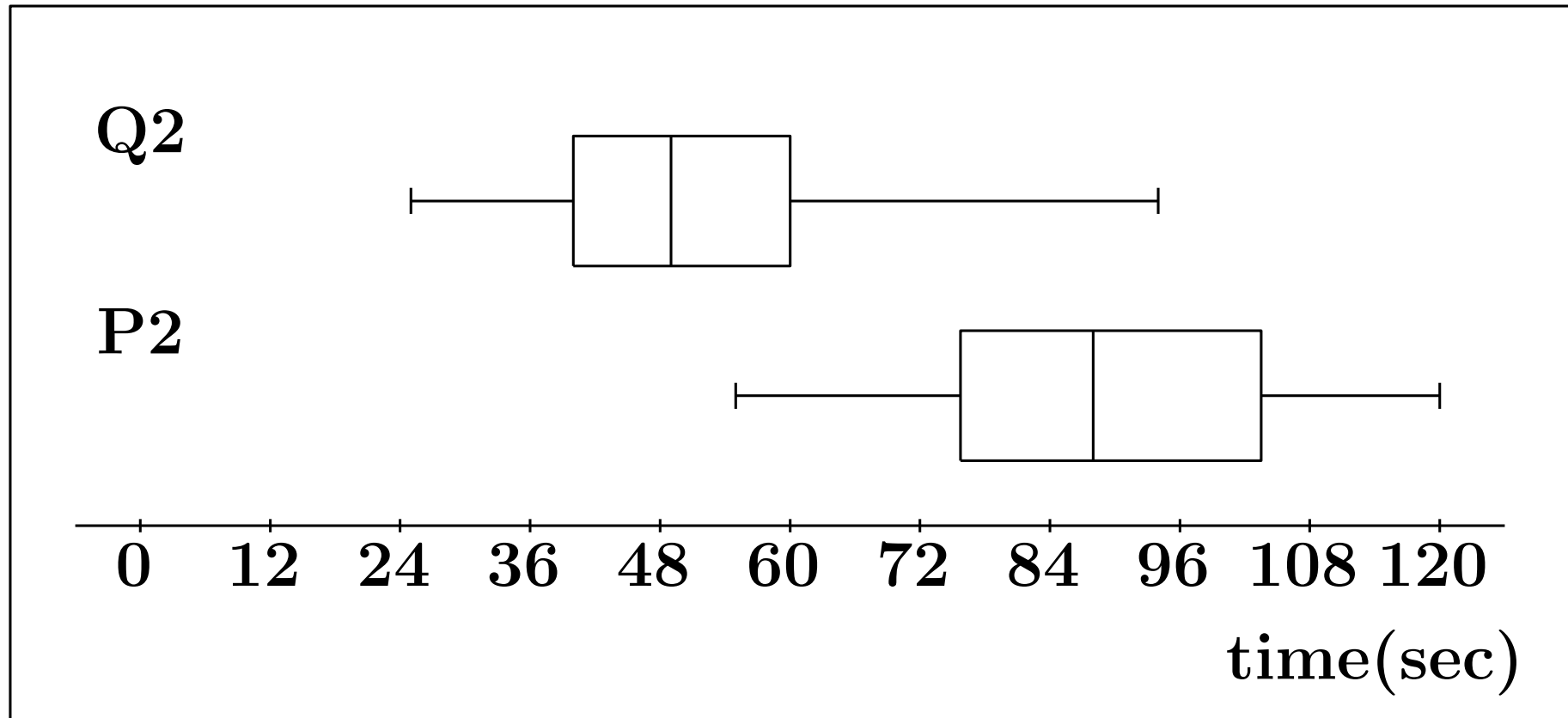
alternative hypothesis $H_1 : \mu_1 > \mu_2$

$$\Rightarrow \bar{X} = 88.19, \bar{Y} = 52.16$$

p-value : 4.913e-08

H_0 is rejected.

Boxplot of changes in response times for correct answers



Statistical analysis of CDC data

T-test (response times for correct answers)

X : the time required for giving correct answers to P3

μ_1 : population mean

Y : the time required for giving correct answers to Q3

μ_2 : population mean

null hypothesis $H_0 : \mu_1 = \mu_2$

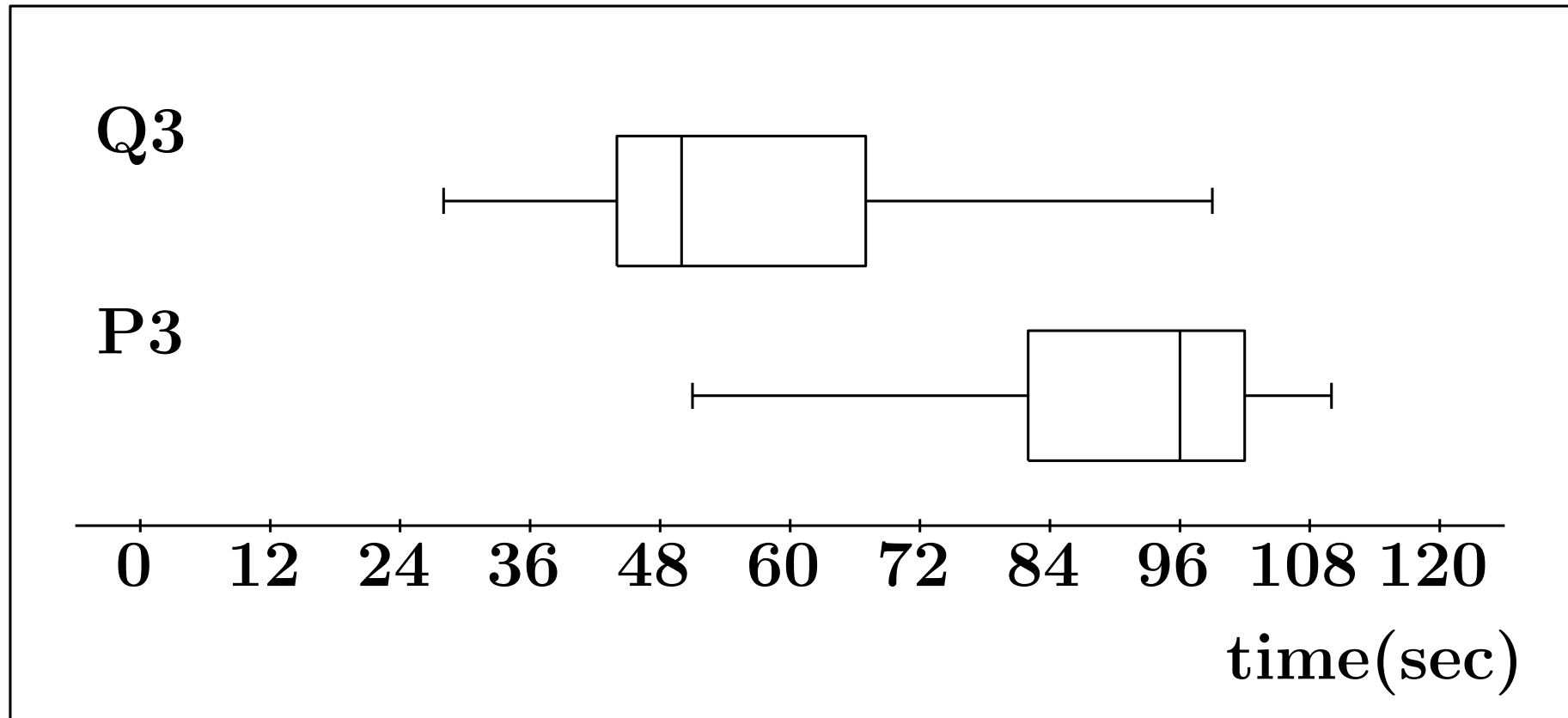
alternative hypothesis $H_1 : \mu_1 > \mu_2$

$$\Rightarrow \bar{X} = 90.44, \bar{Y} = 56.09$$

p-value : 1.566e-05

H_0 is rejected.

Boxplot of changes in response times for correct answers



Concluding remarks

- It is easy to edit voice data of teaching materials because we are able to create it for each page.
- There was a statistically significant improvement in the proportions of correct answers after working with the teaching materials including sound.

Concluding remarks

- There was a statistically significant improvement in the response times for correct answers after working with the teaching materials including sound.
- It is necessary to verify the difference in effect between audio-attached teaching materials and audio-less teaching materials.

Thank you for your kind attention.