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Design of a Programming Workshop to Update Gender Bias in Engineering Among Adults

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ABSTRACT

This study designed a programming workshop for adult women unfamiliar with programming and investigated how it could improve negative images of programming and electronic devices operated by programming. The workshop provided an opportunity to create sensor-activated message cards that play music, aiming to make programming more accessible and achievable for participants. In order to examine the workshop design, 4 participants joined the workshop and evaluated the impressions through the Semantic Differential method. Changes to their images were also asked using open-answer and multiple-choice questions. As a result, the workshop tended to shift the images of programming and electronic circuit boards toward more positive views, but their feedback also highlighted the need for more open-ended, creativity-driven content.

Keywords: Robot programming, Learning resource, Gender, Workshop design

INTRODUCTION

According to Japan's 2024 Sustainable Development Report (Sachs et al., 2024), one of the goals where progress has been notably slow in Japan is "Achieving Gender Equality". A 2021 survey by the Organisation for Economic Co-operation and Development (OECD, 2021) highlighted that the percentage of female tertiary entrants in the fields of engineering, manufacturing, and construction in Japan was 16%, the lowest among OECD countries (OECD average = 26%). This data underscores the need for significant efforts to encourage female participation in these traditionally male-dominated fields.

To increase female participation in these fields, it is crucial to encourage teenage female students to choose career paths in these areas. It is known that their career choices are influenced not only by their personal interests but also by the attitudes of adults around them, such as parents and teachers. In a survey conducted in Japan for 1,086 respondents (aged from 20 to 69) to investigate the public perception of gender roles, mechanical engineering and computer science were often perceived as unsuitable occupations for women (Ikkatai et al., 2020). It has been suggested that changing such negative images, could increase further support for teenage female students choosing engineering fields (Ikkatai et al., 2019). Thus, it is essential to implement initiatives not only to foster early interest in engineering among female students such as programming workshops targeting them (e.g., Basiglio et al., 2024), but also to improve the attitudes of surrounding adults. Furthermore, since mothers' opinions are known to have a particularly strong influence on female students' decisions to pursue science and engineering (Inoue, 2019), targeting female adults could be especially necessary. However, there has been little research on initiatives targeting them.

This study aimed to design a programming workshop for female adults who were unfamiliar with programming, with the goal of improving their negative perceptions of engineering. As the first stage of this study, the images they had regarding programming and the electronic devices operated by it were investigated, and how these images could have changed through women-oriented workshops was examined. This paper reports the outcomes of the impressions held by adult female participants in a women-focused workshop and discusses considerations for designing future workshops.

WORKSHOP DESIGN

Overview of the Workshop

The workshop was designed to be approachable and enjoyable for females. It has been said that females tend not to get interested in science fields due to the difficulty in imagining practical applications (Smail, 1984). Therefore, by connecting programming to subjects that are familiar with daily life, it could be possible to provide a new point of view for them.

In this workshop, message cards, which were often used for presents were focused on. The workshop was designed to create sensor-activated message cards that emit music using a programming kit. Through this workshop, participants can experience how programming enables them to add new and unique features to ordinary message cards. Additionally, while message cards that play sound when opened have become popular in shops recently, this workshop offers them the experience of creating such innovative items by themselves by learning several basic programming syntaxes. In addition to gaining such new knowledge, this workshop includes the process of decorating cards, aiming to enhance the engagement of females.

Workshop Contents

To make it easier for adults to participate, a short but achievable workshop of about an hour was designed. Its process is shown below.

STEP 1: Decoration

Initially, participants were instructed to decorate cards freely using prepared stickers and colored pens. The image of the card decoration is shown in Figure 1. A plastic box was provided, and participants decorated the paper to be attached to it. This step encourages participants to personalize their message cards, making them uniquely their own and inducing familiarity.

Figure 1: Card decoration.

STEP 2: Programming

Next, participants programmed the message cards to emit sound and light when opened. Each participant was provided with a computer and a programming tool. The programming tool used was the Measurement Control Programmer (Vstone Co., Ltd., 2020), an electronic device measuring 12 mm (W) × 68 mm (D) as shown in Figure 2. This small circuit board is equipped with input features such as a temperature sensor and an illuminance sensor, as well as output features such as LED lights and a sound buzzer. It was used by inserting it into the groove portion of the message card. Using dedicated software: Beauto Builder P, participants can create programs that utilize the onboard sensors to read environmental data, such as temperature or brightness, and to control the LED lights and sound output. In this workshop, participants programmed the device to detect brightness levels using the illuminance sensor, and upon exceeding a predefined brightness threshold, to emit sound and light.

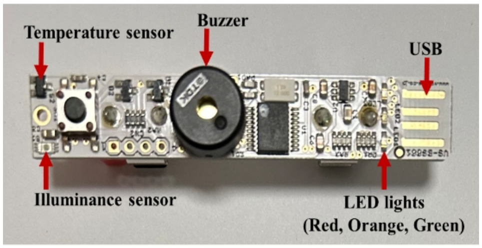

Figure 2: Device features.

To create sound-emitting message cards, participants followed the programming steps below. First, participants were instructed to arrange icons so that sound was emitted when the illuminance increased, using the “IF” icon as shown in Figure 3. The threshold value in the “IF” icon was set individually by monitoring the illuminance sensor’s real-time readings. Next, participants downloaded the program shown in Figure 3 to the device and tested its functionality. When the start button was pressed, the program played a sound if the environment was bright and remained silent if it was dark. However, this program only executes once when the start button is pressed.

To address this limitation, participants were instructed to use a “LOOP” icon, as shown in Figure 4, so the light sensor continuously reads values while the message card is opened and closed. The program was then downloaded to the device again, and its functionality was re-tested. Through this process, participants were encouraged to learn the functions of the “IF” and “LOOP” icons. Finally, participants selected one melody from five prepared options and arranged the program according to the corresponding pitch pattern. They could also customize the LED icons to the desired places. This process enabled participants to program the message card so that, upon opening, it emitted the selected melody and customized LED lights.

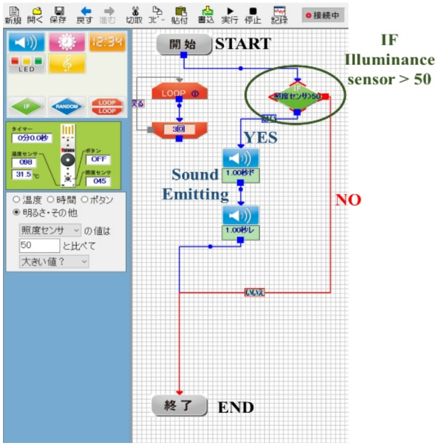

Figure 3: Illuminance detection with IF icon.

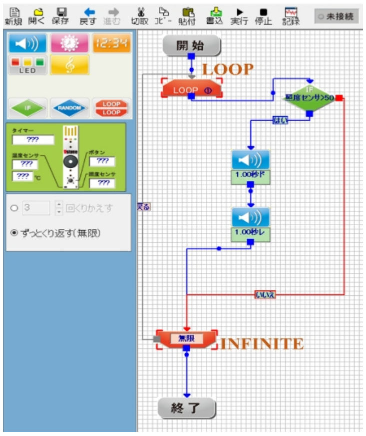

Figure 4: Repeat with LOOP icon.

STEP 3: Video Recording

Each participant recorded a video of their completed project using their smartphones. This activity was intended to enhance participants’ sense of accomplishment by documenting their finished creations.

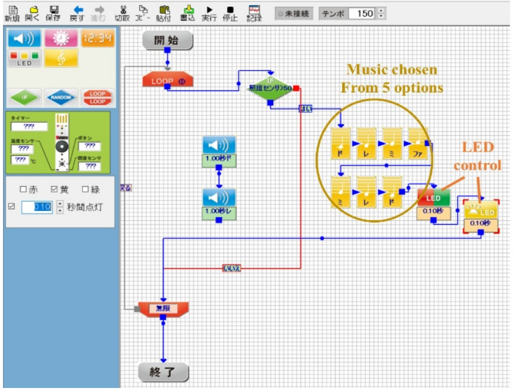

Figure 5: Customize of music and LED lights.

WORKSHOP IMPLEMENTATION

Workshops were held twice in November 2024 to evaluate the possibility of its effectiveness. The study design was approved by the Ethics Review Committee of the Graduate School of Energy Science, Kyoto University in advance. Each workshop had 2 participants, making a total of 4 participants. The participants were females aged from 40s to 50s. The schedule of the workshop is shown in Table 1.

Table 1. Workshop schedule.

Contents	Time
Experimental explanation and informed consent	15 min
Questionnaire before the workshop	
STEP 1: Card decoration	10 min
STEP 2: Programming for illuminance sensor, sound, and LED lights	25 min
STEP 3: Video shooting for finished works	5 min
Questionnaire after the workshop	10 min
Honorarium Procedure	

EVALUATION

Questionnaire Before the Workshop

To investigate participants' experiences and their pre-existing impressions of programming and electronic circuit boards operated by it, the following 8 items shown in Table 2 were asked before the workshop.

Table 2. Question items before the workshop.

No.	Question Item	Answer Format
A1	Do you use a computer regularly in your daily life? Choose from "Use it daily", "Use it several times a week", or "Hardly use it".	Multiple choice

(Continued)

Table 2. Continued

No.	Question Item	Answer Format
A2	Do you have any experience with programming? Choose from "Do it regularly", Have tried it a few times", or "Have never tried".	Multiple choice
A3	What images do you have about programming?	Open answer
A4	What images do you have of the electronic circuit boards shown in Figure 2?	Open answer
A5	Do you think many **female** students would be interested in programming to control electronic circuit boards? Choose one on the 7-point scale from 1 (strongly disagree) to 7 (strongly agree).	Multiple choice
A6	Do you think many **male** students would be interested in programming to control electronic circuit boards? Choose one on the 7-point scale from 1 (strongly disagree) to 7 (strongly agree).	Multiple choice
A7	Have you ever sent a message card? Choose from "Multiple times", "Once or twice", or "Never"	Multiple choice
A8	Have you ever seen or received a musical message card that plays music when opened? Choose from "Yes" or "No".	Multiple choice

Questionnaire After the Workshop

After the workshop, participants' impressions of the workshop were assessed using the Semantic Differential (SD) method, which measures an individual's impressions of a subject using pairs of contrasting adjectives. As shown in Figure 7, 16 items were evaluated. 8 adjective pairs related to intrinsic motivation from the ARCS model (Kogo and Suzuki, 2000) were included. The ARCS model is a framework to capture learners' intrinsic motivation from four aspects: Attention (A), Relevance (R), Confidence (C), and Satisfaction (S), and these were evaluated using two questions for each. Additionally, 7 items related to the perceived friendliness of the robot (Yoshida et al., 2015) and 1 item assessing whether the workshop was perceived as "masculine" or "feminine" were included. These 16 items were presented in a randomized order on the questionnaire.

Furthermore, to investigate changes in participants' images after the workshop, 5 items with open-answer and multiple-choice questions shown in Table 3, were also asked.

Table 3. Question items after the workshop.

No.	Question Item	Answer Format
B1	If there are any aspects of your pre-existing images of programming that have changed, please describe them.	Open answer
B2	If there are any aspects of your pre-existing images of electronic circuit boards that have changed, please describe them.	Open answer
B3	(Same item with **A5**)	Multiple choice
B4	(Same item with **A6**)	Multiple choice
B5	If there are any additional comments, please describe them.	Open answer

RESULTS

Completed Works

Participants A and B extended the Card Decoration activity, in Step 2 of Table 1, by 10 minutes. Other activities proceeded as scheduled. The completed works of each participant are shown in Figure 6. They created original designs for the card exteriors and completed their programming works as instructed.

Figure 6: Pictures of completed works.

Participants' Experience Before the Workshop

Question items **A1**, **A2**, **A7**, and **A8** were questions about participants experience. For Question **A1**, Participants A and B answered "Use it daily", Participant C answered "Use it several times a week", and Participant D answered "Hardly use it". For Question **A2**, all participants answered "Have never tried." For Question **A7**, Participant A answered "Once or twice," and the other participants answered "Multiple times." For Question **A8**, all participants answered "Yes."

Although individual differences in the frequency of computer use were observed, all participants had no prior programming experience and were familiar with message cards.

Perceived Impression of the Workshop With SD Method

The result of the perceived impression evaluation using the SD method is shown in Figure 7. Regarding the 8 items related to ARCS, Participant A rated the workshop as relatively Monotonous, and Participant D strongly rated it as Unclear. For these two items, other participants responded on the center or the left side. However, compared to other items, responses in these two items tended to lean relatively more to the right.

For the following 8 items, Participants B and C responded on the center for the Simple-Complex item. For the other items, all participants responded on the left side.

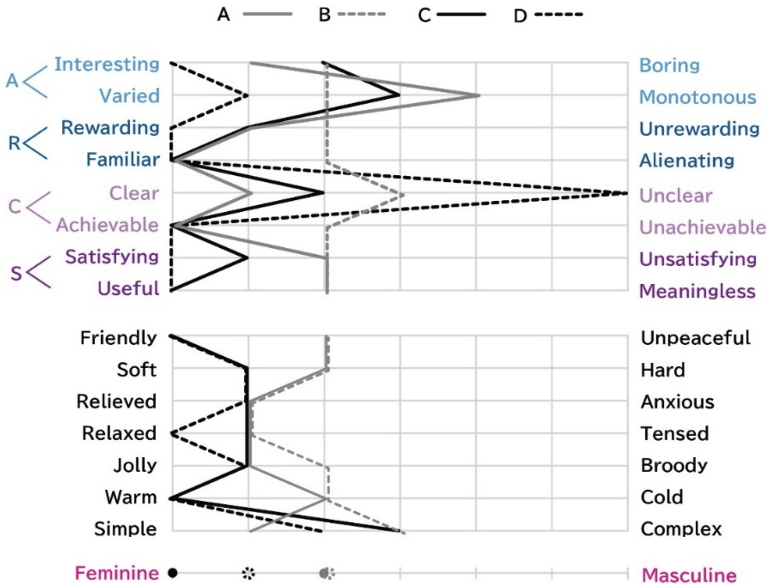

Figure 7: Perceived impression evaluation.

Changes in the Image of Programming and Electronic Circuit Boards

The image of programming was asked before the workshop in Question **A3**, and after the workshop in Question **B1**. Each participant's answer is shown below as (**A3**) → (**B1**).

- **Participant A:** Difficult, hard to understand, requires specialized knowledge.
  → It was easy to understand.
- **Participant B:** Calculations, challenging, something I wish I could do.
  → While the image of carefully following detailed instructions hasn't changed, I realized that the final product requires creativity.
- **Participant C:** Filled with symbols, looks complicated, related to games, popular among today's elementary school students.
  → My previous impression of programming languages was confusing, but this experience made programming approachable and enjoyable.
- **Participant D:** Not something I hear about often, so it seems difficult.
  → It was simple, educational, and fun.

Except for Participant B, the participants' negative impressions, such as difficulty, shifted to positive impressions, such as simplicity and enjoyment. However, Participant B's negative impressions did not improve significantly. In a post-workshop interview, Participant B explained that while the workshop itself was easy, she was not able to imagine how to program what she wanted to create.

The image of the electronic circuit board operated by programming in the workshop was asked before the workshop in Question **A4**, and after the workshop in Question **B2**. Each participant's answer is shown below as (**A4**) → (**B2**).

- **Participant A:** Fragile, contains rare metals, valuable.
  → I was surprised at how small they were.
- **Participant B:** Precision machinery, scary, semiconductors.
  → They are small, but depending on how they're used, they offer various possibilities.
- **Participant C:** Seems complicated.
  → No significant change.
- **Participant D:** A familiar term, but I don't really understand it.
  → When I tried working with them, I found them simpler than I had thought.

Participant B's impression of scare changed to one of expectation, and Participant D's impression of uncertainty shifted to simplicity. On the other hand, Participant A mentioned its size and didn't express significant positive impressions, and Participant C's impression remained unchanged.

Changes in the Image of Students' Interest

The image of female students' interest before the workshop was asked in Question **A5**, and after the workshop in Question **B3**. Its result is shown in Figure 7. Similarly, the image of male students' interest was also asked in the following questions, and its result is shown in Figure 8. Overall, before the workshop, the values of female students tended to be lower. After the workshop, participants A and D showed an increase to the same levels of male students, while participant C rated lower than male students. Participant B, rated female students' interest lower after the workshop compared to before.

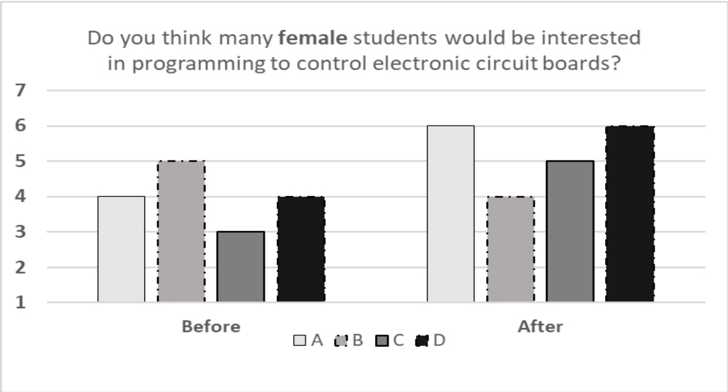

Figure 8: The image of female students' interest.

An Open Answer Question for Any Additional Comments

In Question **B5**, Participants A and C comment that the text on the programming icon is too small to read.

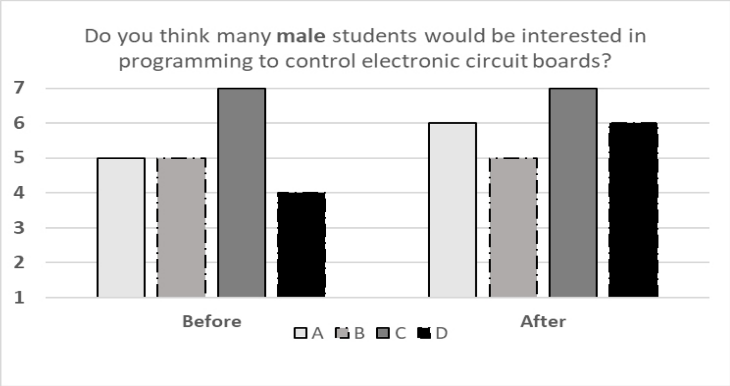

Figure 9: The image of male students' interest.

DISCUSSION

In this study, a programming workshop was introduced to females with no prior experience by having them create message cards, a product familiar to them. Negative preconceived notions about programming and electronic circuit boards were observed, such as perceptions that they were difficult, intimidating, and that female students were less likely to show interest compared to male students. However, the workshop tended to shift these perceptions in a more positive direction. In the perceived impression evaluation with the SD method, the workshop was recognized for being friendly and feminine, and this might have contributed to a change in the participants' views.

However, Participant B's perception of programming remained negative, stating after the workshop that programming seemed even less appealing to female students. According to her post-workshop interview, while she could follow the instructions to complete the programming tasks, she found it difficult to imagine how to program what she wanted to create. In addition, in the perceived impression evaluation with the SD method, the workshop tended to be rated as "monotonous" side. This may suggest the need to include more open-ended content that stimulates creativity. Furthermore, the workshop tended to be rated as "complex" and "unclear". It might be possible that these impressions could improve by encouraging deeper understanding by steps that allow participants to express their own ideas through programming.

CONCLUSION

This study investigated generational perceptions of programming and electronic circuits and examined how these perceptions could be changed through a workshop. It was indicated that participants tended to have negative impressions before the workshop, highlighting the need to work on improving such perceptions withapproachable workshops. Future research could focus more on what elements should be included to foster positive impressions. Additionally, participants pointed out that the small text size on the programming interface made it difficult to read. Enhancing the workshop to be more user-friendly in such aspects would be essential for its improvement.

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