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ASSESSING JAPANESE FEMALE COLLEGE STUDENT FEELINGS ABOUT MATHEMATICS LEARNING AREA CONTENTS

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Abstract

This study was designed to examine Japanese female college students' feelings toward mathematics that they had learned before beginning college study. The 235 surveyed participants were all Japanese college students from the humanities course of a two-year junior college in a local city in Japan. For this investigation, respondents were divided into groups based on their feelings about mathematics. They were scrutinized using conjoint analysis for their learning anxieties about specific learning contents. The analysis consisted of assessing these students' awareness of 'being good at', 'neutral', and 'being not good at' one specific aspect of mathematics relative to others. These groups were characterized. Results revealed differences in the perceptions of difficulty specific to the learning areas. These findings suggest the importance of providing female students with appropriate learning content from elementary school to high school, depending on their feelings about mathematics. These findings might help teachers plan mathematics learning classes for secondary education.

Keywords

Conjoint Analysis, Female Students, Students' Feelings, Learning Contents, Learning Area

1. Introduction

When children learn mathematics at school, they acquire the basic knowledge necessary to live. Mathematics proficiency is regarded as an important factor contributing to success in modern society (Mata, Monteiro, & Peixoto, 2012). Most students, on the other hand, face immoderate pressure to succeed in mathematics in their learning (Nasayao & Goyena, 2020). Students have to develop self-concept and positive attitudes toward mathematics to acquire skills, concepts, and processes for mathematics effectively (Kojigili, 2020).

In Japan, primary education institutions provide elementary mathematics education. Elementary school students are required to study elementary mathematics; even in lower secondary education institutions, junior high school students must take mathematics courses (MEXT: Ministry of Education, Culture, Sports, Science and Technology, 2008, 2010; Nishikawa & Izuta, 2018). In upper secondary education institutions also, first-year high school students must take mathematics courses as compulsory subjects, irrespective of their study plan, depending upon the type of high school (MEXT: Ministry of Education, Culture, Sports, Science and Technology, 2009; Nishikawa & Izuta, 2018). Imai (2019) described that Japanese children work diligently to study mathematics despite their low interest and desire for mathematics, based on the results of an international survey: TIMSS2015 (TIMSS & PIRLS International Study Center, 2015) and PISA2012 (OECD, 2012). Several studies of the feelings of junior high school students about three main areas of mathematics learning have revealed that differences in student feelings depend on gender and academic year by learning area (Izuta & Nishikawa, 2017; Nishikawa & Izuta, 2017b, 2017a, 2019a).

1.1 Literature Review

Some studies have highlighted that gender stereotypes for mathematics form during the early school years of elementary school (Cvencek, Meltzoff, & Greenwald, 2011; Isa & Chinen, 2014; Tomasetto, Alparone, & Cadinu, 2011). Furthermore, gender stereotypes strengthen as school years progress. Gradually, they come to reflect mathematics academic achievement and motivation to learn (Isa & Chinen, 2014). Leibham, Alexander, and Johnson (2013) argued that girls' early scientific interest is an important factor leading to the formation of a positive self-concept and higher science achievement scores. Spencer, Steele, and Quinn (1999) claimed that negative stereotypes of women having weak mathematics ability might underlie gender differences in advanced mathematics performance. Other studies have pointed out that when female high school students' mathematics test show a good record, a gender-stereotyped remark from a teacher, such as

“You are a girl, but that’s impressive,” demotivate female students from studying mathematics (Morinaga, Sakata, Furukawa, & Fukudome, 2017). Steegh, Höffler, Keller, and Parchmann (2019) reported that gender stereotypes play a crucially important role in mechanisms leading to a low participation rate of young women in mathematics and science competitions. For understanding that attitudes about mathematics are making a gender difference in college and career choices, it is necessary to elucidate the development of mathematical attitudes from early childhood (Gunderson, Ramirez, Levine, & Beilock, 2012).

Regarding Japanese female students, some research elucidating attitudes about mathematics held by female college students enrolled in humanities and social science courses revealed that more than 60% of the students felt a feeling of dislike (Awazu & Takeuchi, 2007; Sakino, 2014). Imai (2013) reported that female college students who studied in science courses during high school and who went on to a science department tended to have a more positive attitude about mathematics than non-scientific female college students who studied in liberal arts courses while in high school. Tanaka, Aoyagi, and Hirata (2014) reported that a positive attitude about the mathematics of high school female students who were studying in science courses would be a stronger interest precedent for mathematics rather than mathematics test results or achievements. In contrast, a positive attitude toward mathematics of high school female students studying in liberal arts courses was affected more by mathematics test scores and achievement rather than an interest in mathematics.

1.2 Research Objective

Today, some universities and colleges in Japan that have humanities departments do not impose mathematics as a requirement for entrance examinations. Also, in some humanities courses, the academic requirements for graduation do not include mathematics. Therefore, some college students have no chance to experience any mathematics class after college entrance examinations despite the similar curriculum backgrounds of students from elementary school to high school. This work elucidates feelings of Japanese female college students who have no opportunity to take mathematics classes related to the mathematics that they had learned during their pre-university years. This study also examines the contents of the respective mathematics learning areas. To cope with this issue, survey studies based on conjoint analysis were conducted of female students majoring in humanities at a Japanese women’s junior college. Students were grouped according to their feelings about mathematics. These groups were then analyzed and characterized by conjoint analysis. The findings demonstrated that differences exist in feelings about learning contents

according to the mathematics learning areas, despite the similar academic backgrounds of the students. This research work contributes to the understanding of Japanese female students' feelings about mathematics.

2. Methodology

2.1 Questionnaire Survey

A questionnaire survey was administered at a women's junior college of humanities in a rural city in Japan in October 2016. The questionnaire survey included two groups of questions. One was a question about students' feelings related to mathematics. The options were evaluated on a five-point Likert scale: 1. Being not good at mathematics; 2. Being somewhat not good at mathematics; 3. Neutral; 4. Being somewhat good at mathematics; 5. Being good at mathematics. The other questions were intended to rank each of the nine conjoint cards based on conjoint analysis.

The nine conjoint cards are shown in Table 1 described students' feelings with three responses for contents of learning in the four learning areas that they learned in mathematics classes from elementary to high school: Algebra calculations, Geometrical figures, Functions, and Organizing and using data. The four attributes, the four areas they studied in the mathematics classes, and three responses were allocated to an orthogonal table. The nine conjoint cards were created based on the orthogonal tables (Kan, 2013). Each attribute had three levels of response: 'I am good at it', 'I am neutral', and 'I am not good at it'. We presented the nine conjoint cards and asked participants to evaluate the conjoint cards. Participants ranked the conjoint cards from first to ninth in order from the closest conjoint card to their feelings.

2.2 Sample

A total of 235 female students aged 18–22 who were enrolled in the humanities and social science departments at a women's junior college responded to a questionnaire survey. After removing respondents who had not filled out their answer forms, the final data comprised those of 233 respondents.

Table 1: Conjoint Cards used for the Questionnaire Survey

Card 1	[Algebra calculations] What do you think about solving calculation problems? I am good at it.	[Geometrical figures] What do you think about solving problems of plane figures or space figures? I am good at it.	[Functions] What do you think about solving function problems such as linear and quadratic functions? I am good at it.	[Organizing and using data] What do you think about working on organizing and analyzing data and understanding data trends? I am neutral.
Card 2	[Algebra calculations] What do you think about solving calculation problems? I am neutral.	[Geometrical figures] What do you think about solving problems of plane figures or space figures? I am neutral.	[Functions] What do you think about solving function problems such as linear and quadratic functions? I am good at it.	[Organizing and using data] What do you think about working on organizing and analyzing data and understanding data trends? I am not good at it.
Card 3	[Algebra calculations] What do you think about solving calculation problems? I am not good at it.	[Geometrical figures] What do you think about solving problems of plane figures or space figures? I am not good at it.	[Functions] What do you think about solving function problems such as linear and quadratic functions? I am good at it.	[Organizing and using data] What do you think about working on organizing and analyzing data and understanding data trends? I am good at it.
Card 4	[Algebra calculations] What do you think about solving calculation problems? I am neutral.	[Geometrical figures] What do you think about solving problems of plane figures or space figures? I am good at it.	[Functions] What do you think about solving function problems such as linear and quadratic functions? I am neutral.	[Organizing and using data] What do you think about working on organizing and analyzing data and understanding data trends? I am good at it.
Card 5	[Algebra calculations] What do you think about solving calculation problems?	[Geometrical figures] What do you think about solving problems of plane figures or space figures?	[Functions] What do you think about solving function problems such as linear and quadratic functions?	[Organizing and using data] What do you think about working on organizing and analyzing data and understanding data trends?

	I am not good at it.	I am neutral.	I am neutral.	I am neutral.
Card 6	[Algebra calculations] What do you think about solving calculation problems? I am good at it.	[Geometrical figures] What do you think about solving problems of plane figures or space figures? I am not good at it.	[Functions] What do you think about solving function problems such as linear and quadratic functions? I am neutral.	[Organizing and using data] What do you think about working on organizing and analyzing data and understanding data trends? I am not good at it.
Card 7	[Algebra calculations] What do you think about solving calculation problems? I am not good at it.	[Geometrical figures] What do you think about solving problems of plane figures or space figures? I am good at it.	[Functions] What do you think about solving function problems such as linear and quadratic functions? I am not good at it.	[Organizing and using data] What do you think about working on organizing and analyzing data and understanding data trends? I am not good at it.
Card 8	[Algebra calculations] What do you think about solving calculation problems? I am good at it.	[Geometrical figures] What do you think about solving problems of plane figures or space figures? I am neutral.	[Functions] What do you think about solving function problems such as linear and quadratic functions? I am not good at it.	[Organizing and using data] What do you think about working on organizing and analyzing data and understanding data trends? I am good at it.
Card 9	[Algebra calculations] What do you think about solving calculation problems? I am neutral.	[Geometrical figures] What do you think about solving problems of plane figures or space figures? I am not good at it.	[Functions] What do you think about solving function problems such as linear and quadratic functions? I am not good at it.	[Organizing and using data] What do you think about working on organizing and analyzing data and understanding data trends? I am neutral.

2.3 Data Analysis

Software R ver.3.6.2 for Windows (R Core Team, 2019) was used for all analyses and data processing. Several packages written for that software (Wickham et al., 2019) were used for data processing and display.

We implemented a traditional conjoint analysis (see Kan, 2013; Orme, 2014; Steiner & Meißner, 2018) by programming using the software. Because the collected data of conjoint cards ranked by respondents included four attributes with three responses, we created multiple categorical variables.

Before conducting the conjoint analysis, respondents were classified into three groups based on the five responses of female students' feelings about mathematics. Both 'Being not good at mathematics' and 'Being somewhat not good at mathematics' respondents were combined and designated as Group 1. The 'Being somewhat good at mathematics' and 'Being good at mathematics' respondents were combined and designated as Group 3. We designated 'Neutral' respondents as Group 2. Conjoint analysis was conducted for each of the three groups.

3. Results

3.1 Students' Feelings about Mathematics

The responses of female students' feelings about mathematics are presented in Table 2. Although most respondents were either 'Being not good at mathematics' (52.8%) or 'Being somewhat not good at mathematics' (21.5%), a small percentage chose 'Being good at mathematics' (1.7%).

Table 2: *Feelings toward Mathematics by Answer Options*

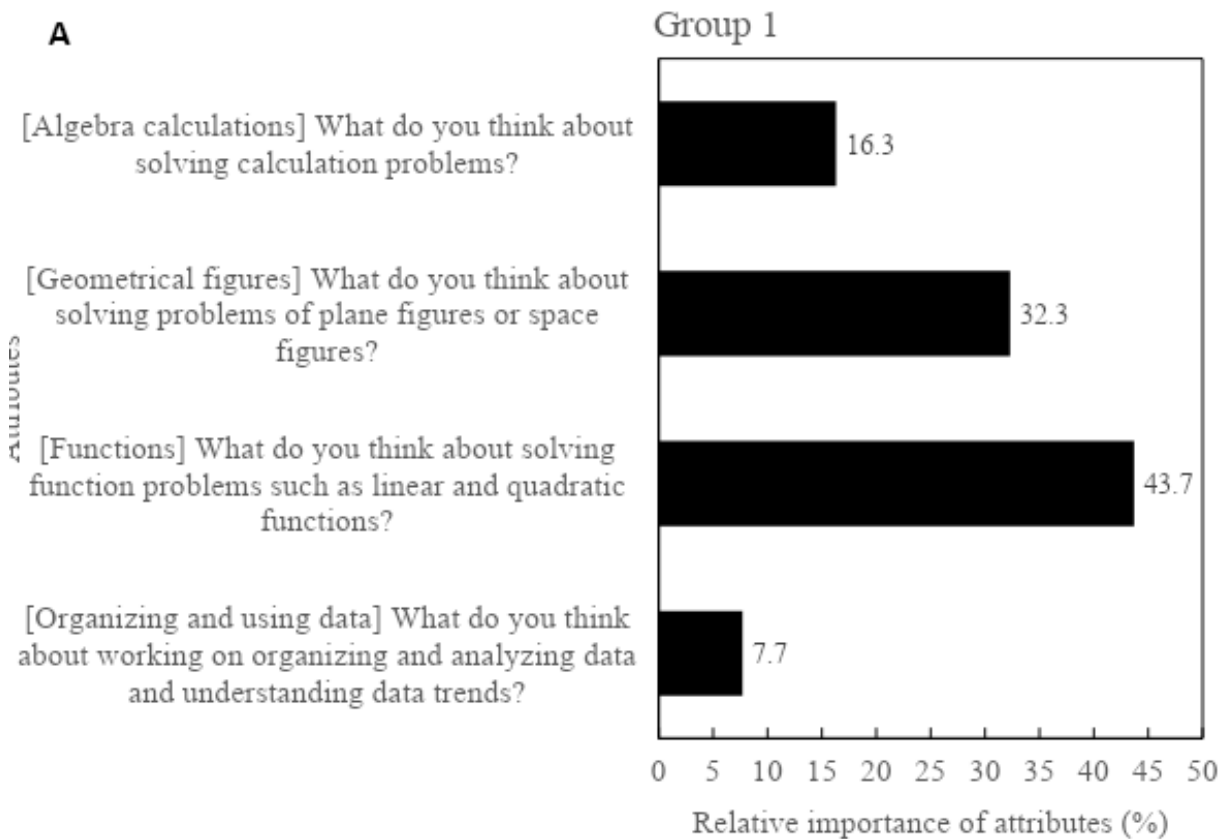
Answer Option	n	%
Being not good at mathematics	123	52.8
Being somewhat not good at mathematics	50	21.5
Neutral	33	14.2
Being somewhat good at mathematics	23	9.9
Being good at mathematics	4	1.7

3.2 Students' Feelings for Contents of Learning in Mathematics

This section presents the results of the conjoint analysis of the respective groups. They are grouped by respondents' feelings toward mathematics.

3.2.1 Group 1

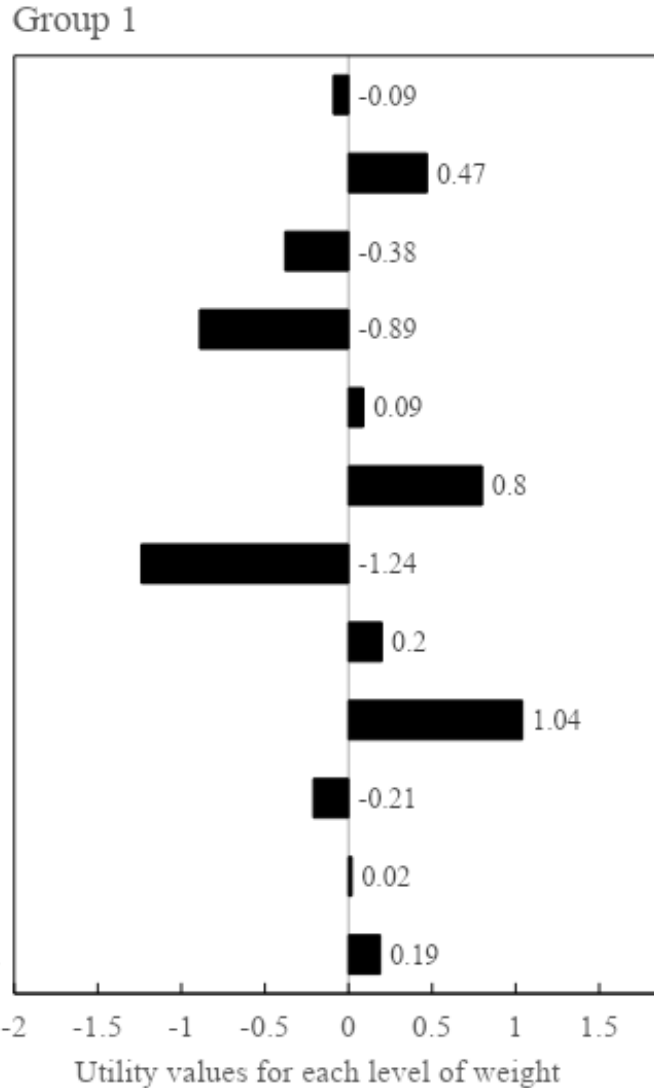
Figure 1 provides Group 1 responses from 173 female students (74.2%). The importance graph shows that the attribute with the highest importance value was ‘[Functions] What do you think about solving function problems such as linear and quadratic functions?’ (43.7%), which had the level ‘I am not good at it’ as the highest partial utility value. The attribute ‘[Geometrical figures] What do you think about solving problems of plane figures or space figures?’ was listed the second with 32.3%, with its level ‘I am not good at it’ standing out. Group 1 students measured 16.3% of importance for ‘[Algebra calculations] What do you think about solving calculation problems?’ in which its attribute level was ‘I am Neutral’. The attribute ‘[Organizing and using data] What do you think about working on organizing and analyzing data and understanding data trends?’ had the lowest importance with 7.7%, which had the level ‘I am not good at it’ standing out.



(A) *The Relative Importance of Attributes*

B

[Algebra calculations] I am good at it.
 [Algebra calculations] I am neutral.
 [Algebra calculations] I am not good at it.
 [Geometrical figures] I am good at it.
 [Geometrical figures] I am neutral.
 [Geometrical figures] I am not good at it.
 [Functions] I am good at it.
 [Functions] I am neutral.
 [Functions] I am not good at it.
 [Organizing and using data] I am good at it.
 [Organizing and using data] I am neutral.
 [Organizing and using data] I am not good at it.



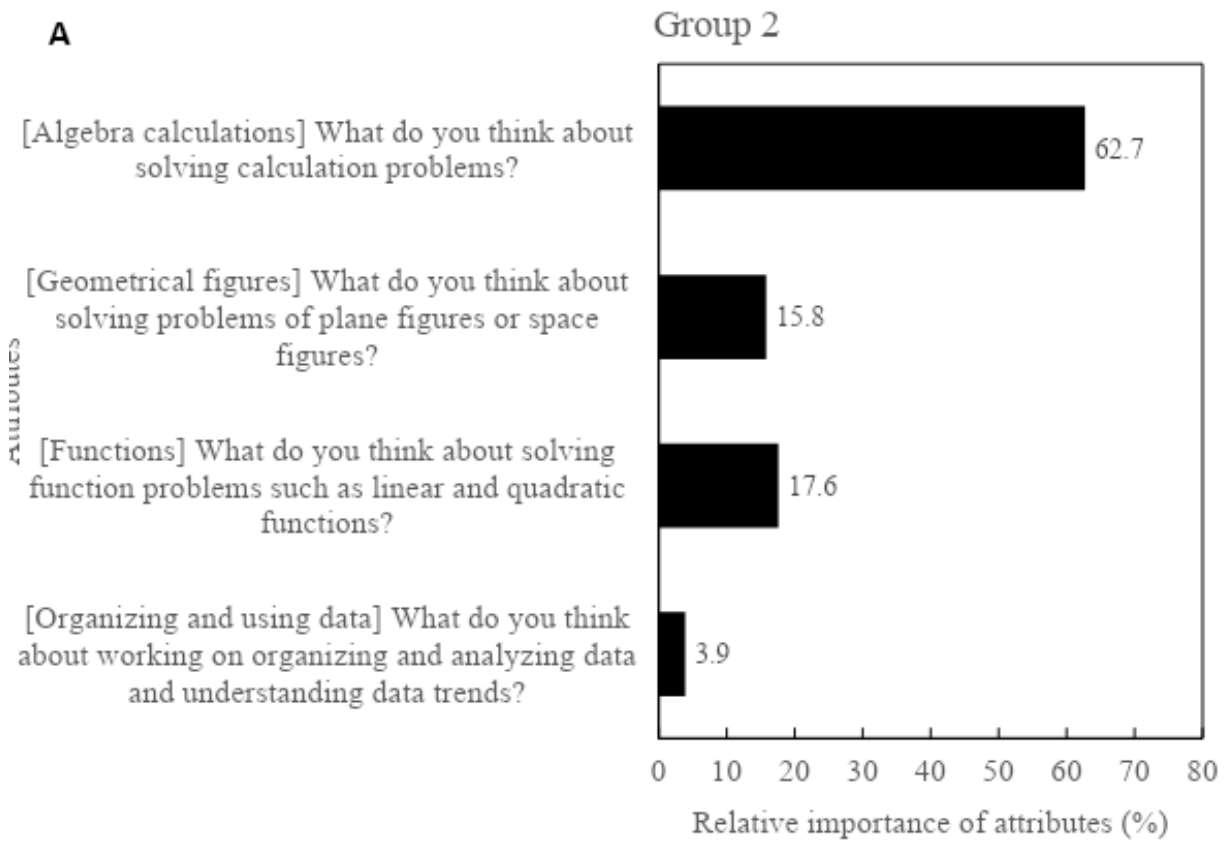
(B) Utility Values for the Respective Level

Figure 1: Results of Conjoint Analysis for Group 1; $R\text{-squared} = 0.23$; $F(8, 1548) = 56.88$; $p < .001$

3.2.2 Group 2

Results of conjoint analysis for Group 2’s 33 students (14.2%) are shown in Figure 2. These charts clarify that the attribute ‘[Algebra calculations] What do you think about solving calculation problems?’ (62.7%) was the main focus of this group with the level ‘I am good at it’ scoring the highest partial utility. The importance values for the attribute ‘[Functions] What do you think about solving function problems such as linear and quadratic functions?’ (17.6%) and ‘[Geometrical figures] What do you think about solving problems of plane figures or space figures?’ (15.8%) were of roughly equal importance for Group 2 respondents. The partial utility in the attribute ‘[Functions]

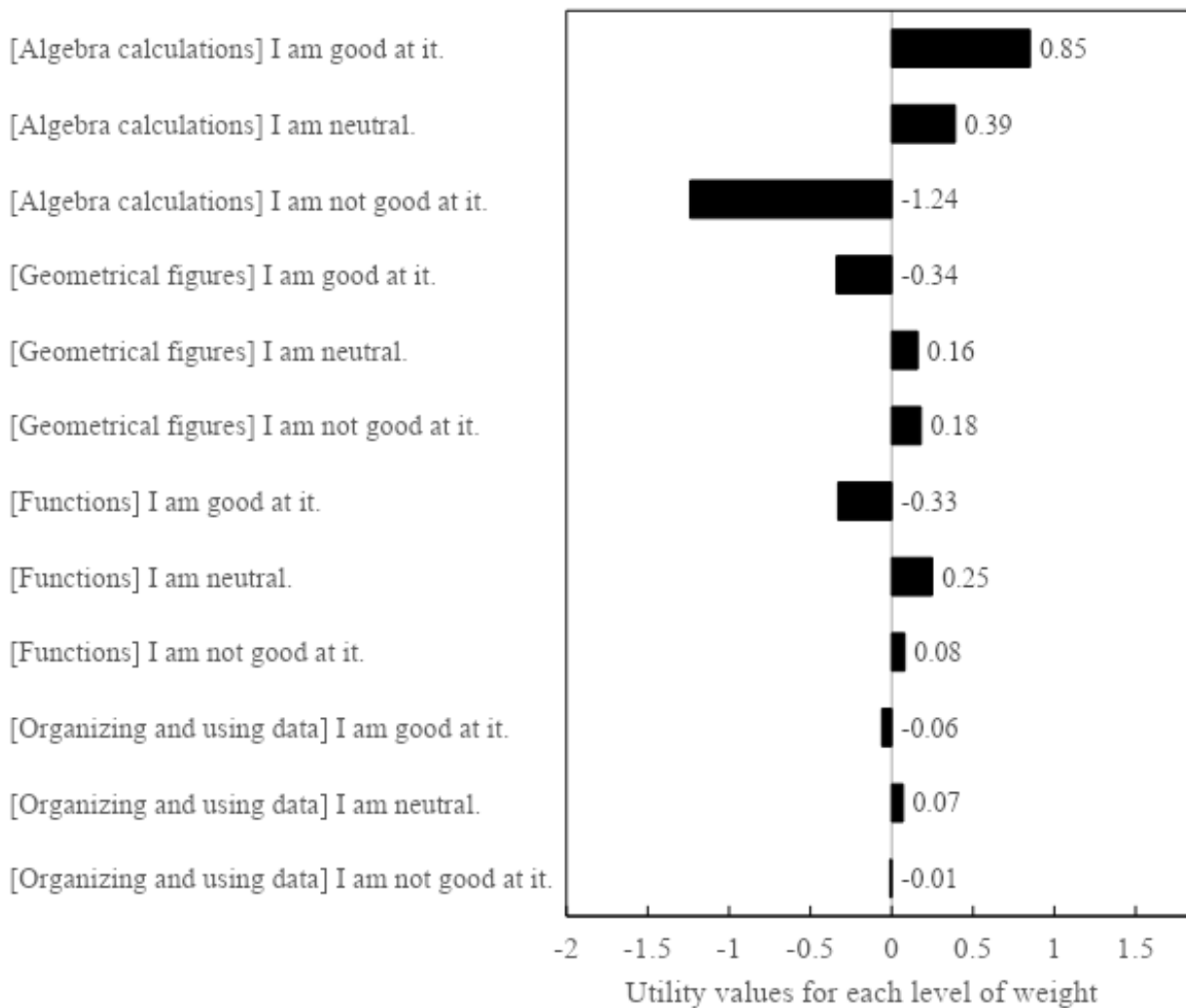
What do you think about solving function problems such as linear and quadratic functions?’ had ‘I am Neutral’ as its most representative level. Regarding utility values for the attribute ‘[Geometrical figures] What do you think about solving problems of plane figures or space figures?’, the level ‘I am not good at it’ was slightly higher than ‘I am neutral’. They ranked last was the attribute ‘[Organizing and using data] What do you think about working on organizing and analyzing data and understanding data trends?’ (3.9%) whose level ‘I am neutral’ stuck out in the partial utility.



(A) Relative Importance of Attributes

B

Group 2



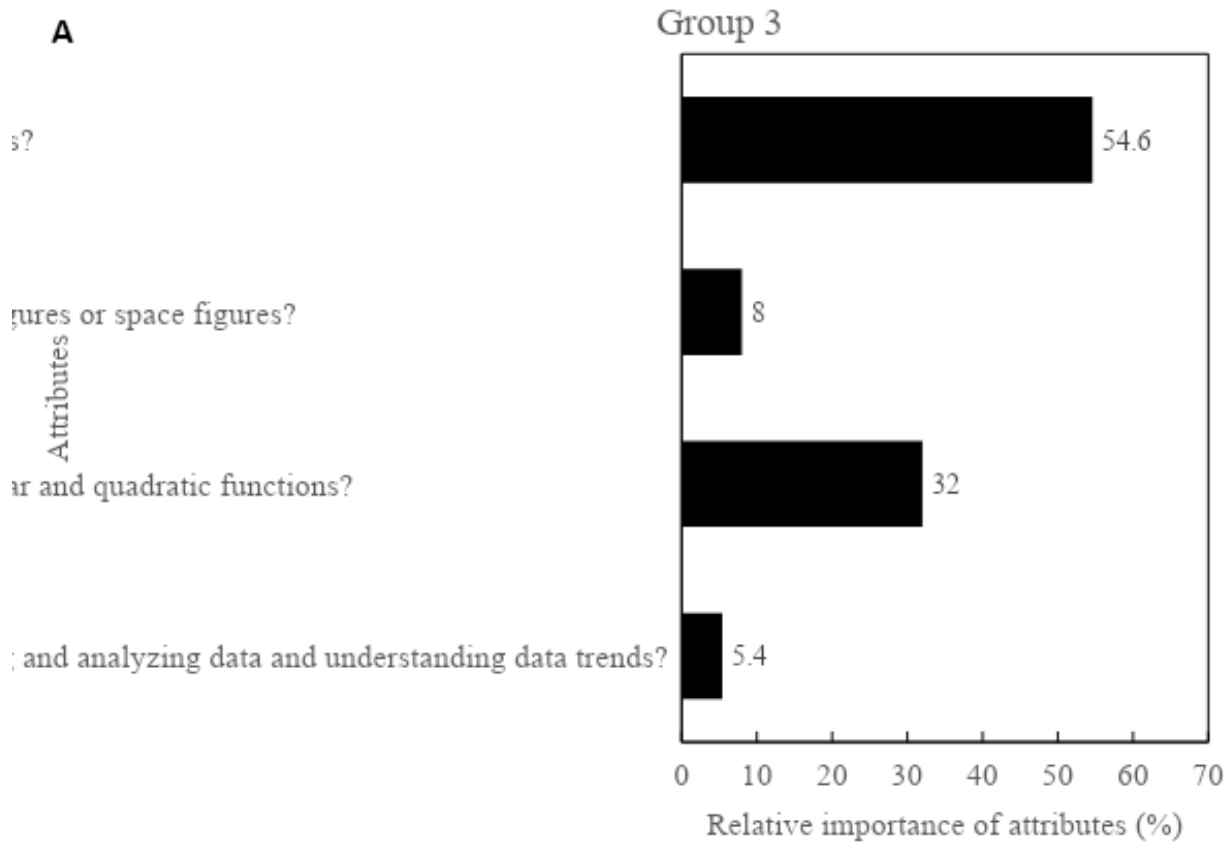
(B) Utility Values for the Respective Level

Figure 2: Results of Conjoint Analysis for Group 2; $R\text{-squared} = 0.14$; $F(8, 288) = 5.83$; $p < .001$.

3.2.3 Group 3

Figure 3 yields conjoint analysis of Group 3, which consisted of 27 students (11.6% of the total number). The attribute ‘[Algebra calculations] What do you think about solving calculation problems?’ was prominent in importance with 54.6% and its level ‘I am good at it’ had the highest partial utility score within the attribute. The second attribute in the importance of the graph was ‘[Functions] What do you think about solving function problems such as linear and quadratic functions?’ (32.0%). Its level of ‘I am good at it’ was its most representative level. The attributes ‘[Geometrical figures] What do you think about solving problems of plane figures or

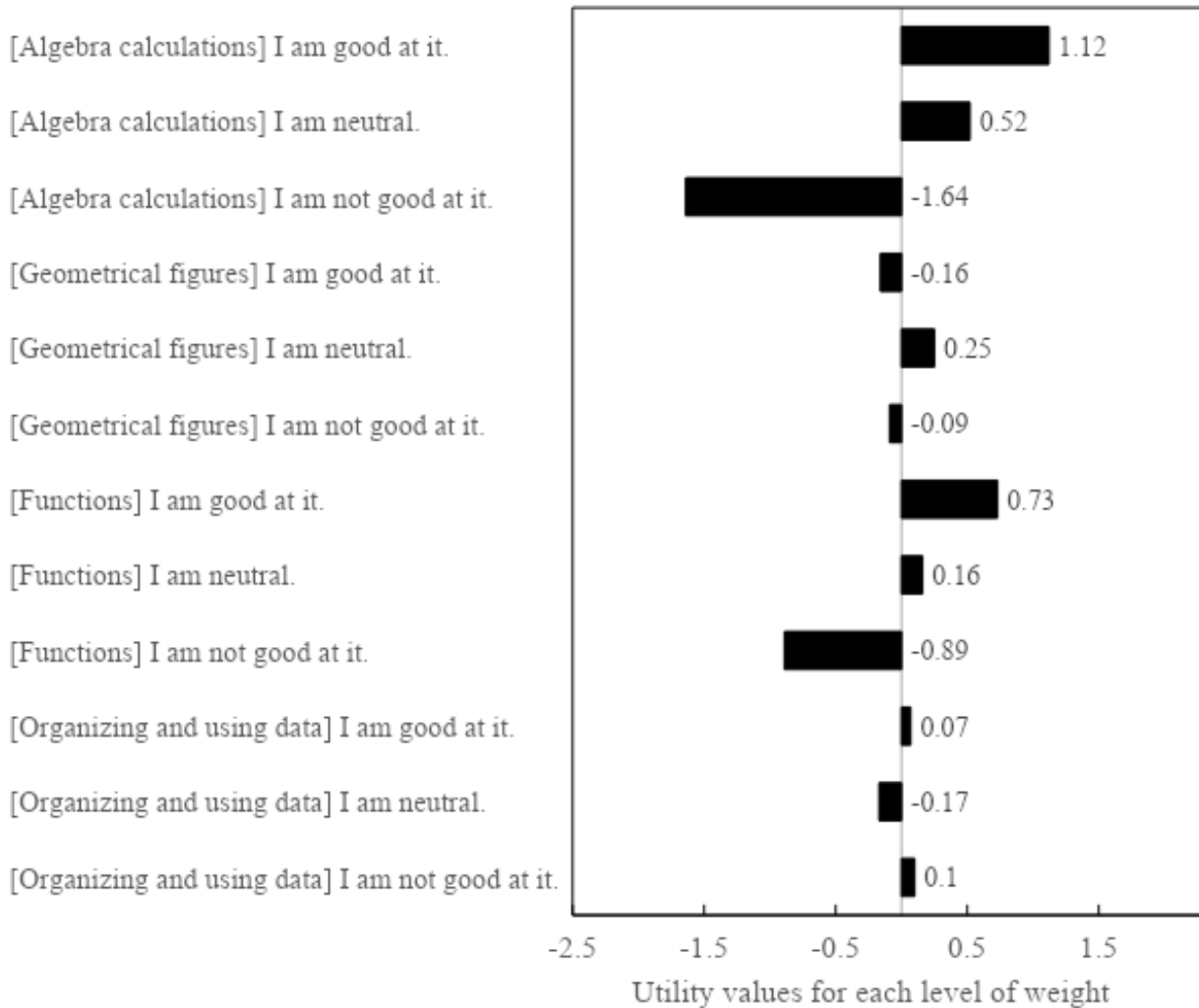
space figures' (8.0%) was ranked third. Its level 'I am neutral' showed the highest partial utility score. As with Group 1 and Group 2, the fourth attribute in Group 3 was '[Organizing and using data] What do you think about working on organizing and analyzing data and understanding data trends?' with the level, 'I am not good at it' assigned the highest partial utility.



(A) Relative Importance of Attributes

B

Group 3



(B) Utility Values for the Respective Level

Figure 3: Results of Conjoint Analysis for Group 3; $R\text{-squared} = 0.29$; $F(8, 234) = 11.7$; $p < .001$

4. Discussion

A conjoint analysis of Group 1, which had members expressing feelings of not being good at using mathematics, indicates that they felt unable to use mathematics well for three out of four areas. Of those three areas, they assign utmost importance to the ‘Functions’ area, followed by the ‘Geometrical figures’ area. The outcome indicates that young female students who felt that they were not good at mathematics to tend to be not very good at learning of the ‘Functions’ and ‘Geometrical figures’ area. Research of Japanese junior high school students’ feelings toward three

areas of mathematics learning showed that many female students who have a feeling of not being good at mathematics felt they were not good at the 'Functions' and 'Geometrical figures' area (Nishikawa & Izuta, 2017a). Particularly when specifically learning in the 'Functions' area that female students attach much value to it, a possible reason for this result is that students begin to learn functions along with related algebraic expressions, tables, and graphs from the first year of junior high school. In mathematics classes, students learn three things: the relation between the algebraic expressions of functions and tables, the relation between algebraic expressions of function and graphs, and the relation between tables and graphs of the function. If female students understood one or more of these three contexts less than well, then they might feel some weakness in using 'Functions'. The results suggest that mathematics teachers must have a good grasp of students' understanding when teaching these three contents of the 'Functions' area.

Group 2 members had feelings of being neutral toward mathematics, the analysis of survey responses showed that they tend to be good at solving calculation problems, but they tend to be bad at solving problems of plane or space figures. This tendency can also be confirmed in other findings (Nishikawa & Izuta, 2017a, 2018, 2019b). This result suggests that for students who feel neutral to mathematics to be a little good at mathematics, as a teacher teaches female students to study 'Geometrical figures', one should observe the students' understanding strictly and teach the study points carefully.

All groups showed that the area 'Organizing and using data' garnered responses of 'I am not good at it' and 'I am neutral'. In a few situations while at school, female students with a major in the humanities department at college might mathematically organize and analyze data. Organizing and analyzing data can be necessary for a social life. These results have demonstrated that a teacher of secondary education or higher education would need to educate or re-educate their students in this area.

A limitation of our study was the sample size. Our participants constitute female college students in humanities from the northeastern region in Japan. 235 respondents are not enough to make representative of Japanese female college students' feelings about mathematics learning area contents. However, from the results of those limited numbers of 235s, it is speculated that our study has a clear pattern of being good at or being not good at for each learning area contents depending on the group of female college students' feelings about mathematics.

5. Conclusion

Our research underlined the importance of providing appropriate learning content for female students in response to their feelings about mathematics. This study also presents an example of a model of a conjoint analysis-based survey for students to investigate their feelings about mathematics. These findings are expected to contribute to the planning of classes in mathematics learning in secondary education.

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