Investigation of gender influence to enhance the indicator of mathematical competency of college students in integral calculus learning

Y Ramdani1, *, O Rohaeni1 and L Wachidah2

1Study Program of Mathematics, Universitas Islam Bandung, Jl. Ranggamalela No. 1, Bandung 40116, Indonesia
2Study Program of Statistics, Universitas Islam Bandung, Jl. Ranggamalela No. 1, Bandung 40116, Indonesia

*yaniramdani66@gmail.com

Abstract. This research investigates the difference in indicator of college students' mathematical competence in Integral calculus learning based on gender. The research design was quasi-experiment involving 200 college students. The research instrument was a test of mathematical competency. Value category refers to the Standard Reference. Data were analyzed by the Mann-Whitney U test. The results showed that in the scientific debate strategy for men and women the average value of each indicator in a row were: (1) Concepts understanding were C and B categories; (2) Procedures fluency were A and A; (3) Strategic competencies were B and B; (4) Adaptive reasoning were B and B; (5) Productive disposition were B and B. Gender differences in the scientific debate strategy do not have a significant effect on enhancement of indicator of mathematical competence. In the conventional learning shows: (1) Concepts understanding were C and B; (2) Procedures fluency were C and B; (3) Strategic competencies were D and C; (4) Adaptive reasoning were C and B; (5) Productive disposition were C and B. Gender differences in conventional learning do not have a significant effect on enhancement of concept understanding, strategic competence, and adaptive reasoning. These have a significant influence on the enhancement of procedural fluency and productive disposition.

1. Introduction

Men and women were often placed in different spaces in the teaching and learning process. This difference was often termed gender difference. Friedman et al. found that men looked better than women in quantitative ability and space understand abilities [1]. A tendency towards differences of accuracy in the information conveying about the formula used in solving problems between male and female students. The academic ability based gender show that male student has a Grade Point Average (GPA) were 3.05 and female student have a GPA was 3.04 which means they have the same relatively abilities. The mathematical performance of male students was more confident than female students [2]. Opinions that develop in the community say that male students' mathematics is better than female students. This opinion creates a gender gap in mathematical abilities. This opinion refers to explicit theories, namely the views or beliefs that people have about their various personality traits, such as intelligence or mathematical abilities [3,4]. In countries with high levels of gender equality, gender differences in mathematical abilities and the read values in 75 countries examined by a new study [5]. Female students
consistently score higher in reading, while male students get higher math scores, but this gap is related and varies with the social and economic conditions of the community as a whole.

These conditions indicate that male students have a higher mathematical value than female students, but the gap varies and is related to the social and economic aspects of the country. In relation to gender disparity in mathematics Jacob [2] argues that one of the causes of the gender gap in mathematics is that mothers have a perception that their boys' mathematics is better than their daughter's mathematics. This is what causes male students to be more confident when he communicates the mathematics orally. The verbal mathematical communication ability of male students who have high math ability are more accurate than female students who have high mathematical abilities.

This gender difference was examined based on several research results that reveal differences in the results achieved. The learning strategy used in this study is Scientific Debate and conventional. The Scientific Debate application can enhance the ability of communication and connections mathematical are better than conventional [6]. Scientific Debate Strategy is able to develop students' creative thinking skills better than conventional [7]. The application of scientific debate strategy in Integral Calculus learning can improve communication ability and mathematical connections and the college students' mathematical creative thinking skills are better than conventional [8,9].

The implementation of the learning strategy is the Integral Calculus class. Integral is an important concept in mathematics. Student mastery in integral concepts contributes to the development of engineering, science, and industry [9]. When viewed from the aspect of gender, the number of women is still lacking in the career of science, technology, mathematics, and engineering (STEM) although there are focused efforts to increase the number of women in such fields [10]. The importance of this integral concept is not yet in line with the learning outcomes. Some studies show that the ability of students in the concept of integration is still low. The college students' understanding of integral concept has not reached the limit of mastery learning in the group with an average value of 59.20 [8]. Many college students in a conventional classroom have a shallow understanding and incomplete about the basic calculus concepts [11]. Based on the above conditions, this study investigates gender influences on enhancing the college student' mathematical competency indicators in Integral Calculus learning.

2. Experiment method

2.1. Participant
The population in this study is students of Department of Mathematics and Statistics in Indonesia, the same level as the Department of Mathematics and Statistics of Universitas Islam Bandung (UNISBA). The subjects of the study were three-semester students (N = 200).

2.2. Hypothesis test
Mathematical competency indicators that are measured include: (1) $X_1$ is an understanding of concepts namely understanding concepts, operations, and relations. (2) $X_2$ is the procedure fluency that is the ability to implement procedures in a flexible, accurate, efficient and appropriate manner. (3) $X_3$ is a strategic competence, namely the ability to formulate, present, and solve mathematical problems. (4) $X_4$ is an adaptive reasoning that is the capacity to think logically, reflective, explain, and propose justification. (5) $X_5$ is a productive disposition that is the ability to always see mathematics positively, useful and meaningful way. The hypothesis tested is as follows:

Hypothesis-1: Gender differences do not have a significant influence on the enhancement of the understanding of integral concepts

Hypothesis-2: Gender differences do not have a significant influence on the enhancement of the procedures fluency in the integral concept

Hypothesis-3: Gender differences do not have a significant influence on the enhancement of strategic competence in an integral concept

Hypothesis-4: Gender differences do not have a significant influence on the enhancement of adaptive reasoning in an integral concept
Hypothesis-5: Gender differences do not have a significant influence on the enhancement of productive dispositions in integral concepts

2.3. Data analysis
Value category refers to the Standard Reference Benchmark (SRB). The value interval $80 \leq N < 100$ was category A (Very Good), $70 \leq N < 79$ was category B (Good), $60 \leq N < 69$ was category C (Enough), $50 \leq N < 59$ was category D (Less) and $N < 50$ was category E (Failed). The examining of gender influence to the enhancement of indicators of college students' mathematics competency in learning of integral calculus with Scientific Debate and conventional learning were used Mann-Whitney U with $p$-value = 0.05.

3. Results and discussion
Mathematical competency indicator data on the Scientific Debate strategy based on gender were described in table 1 below:

| Mathematical Competence | Gender | N   | Mean  | Std. Deviation | Std. Error Mean | Category |
|-------------------------|--------|-----|-------|----------------|-----------------|----------|
| X1                      | Male   | 40  | 69.00 | 17.40          | 3.89            | C        |
|                         | Female | 62  | 77.43 | 18.10          | 1.99            | B        |
| X2                      | Male   | 40  | 85.90 | 16.39          | 3.67            | A        |
|                         | Female | 62  | 89.85 | 15.73          | 1.74            | A        |
| X3                      | Male   | 40  | 70.10 | 19.05          | 4.26            | B        |
|                         | Female | 62  | 71.62 | 14.56          | 1.61            | B        |
| X4                      | Male   | 40  | 74.55 | 18.22          | 4.08            | B        |
|                         | Female | 62  | 71.19 | 16.20          | 1.79            | B        |
| X5                      | Male   | 40  | 75.19 | 13.91          | 3.11            | B        |
|                         | Female | 62  | 76.70 | 11.77          | 1.30            | B        |

Before reviewing the influence of gender on the improvement of college students' mathematical competency indicators in the integral concept so is examined data normality. From the results of the normality test, it is known that the data is not normally distributed. The statistical test used is the Mann-Whitney U test. Data processing results are presented in table 2 below:

|                  | X1     | X2     | X3     | X4     | X5     |
|------------------|--------|--------|--------|--------|--------|
| Mann-Whitney U   | 602.00 | 662.00 | 770.50 | 724.00 | 768.50 |
| Wilcoxon W       | 812.00 | 872.00 | 4173.50| 4127.00| 978.50 |
| Z                | -1.86  | -1.43  | -0.42  | -0.81  | -0.43  |
| Asymp. Sig. (2-tailed) | 0.06 | 0.15   | 0.68   | 0.42   | 0.66   |

*a* Grouping Variable: Gender

From table 2, it is known that gender factors in the Scientific Debate class do not have a significant effect on improving mathematical competency indicators. This means that the Scientific Debate strategy can enhance college students' mathematical competency evenly. The Scientific Debate strategy has the characteristics of interactivity, bring up collaborative learning and encourages active students to express opinions, ask questions, comment on teachers or friends, debate, discuss, encourage independent learning and collaborate [9]. Knowledge construction in the application of Scientific Debate strategies is based on several habits that can be created by learning such as creating settlement uncertainty [9]. In
mathematical knowledge, uncertainty is expressed in the form of conjectures. Different results are developed and validated. Such conditions can develop indicators of mathematical competence equally.

Mathematical competency indicator data based gender in the class conventional was described in table 3 below:

| The Indicator of Mathematical Competence | Gender | N  | Mean | Std. Deviation | Std. Error Mean | Category |
|-----------------------------------------|--------|----|------|----------------|-----------------|----------|
| X1                                      | Male   | 45 | 69.44| 17.99          | 3.60            | C        |
|                                         | Female | 52 | 71.17| 16.05          | 1.89            | B        |
| X2                                      | Male   | 45 | 68.65| 19.83          | 3.97            | C        |
|                                         | Female | 52 | 78.45| 12.08          | 1.42            | B        |
| X3                                      | Male   | 45 | 59.58| 14.24          | 2.85            | D        |
|                                         | Female | 52 | 62.29| 11.40          | 1.34            | C        |
| X4                                      | Male   | 45 | 63.82| 20.32          | 4.06            | C        |
|                                         | Female | 52 | 71.72| 11.55          | 1.36            | B        |
| X5                                      | Male   | 45 | 63.77| 15.56          | 3.11            | C        |
|                                         | Female | 52 | 70.73| 9.73           | 1.15            | B        |

Before reviewing the influence of gender on the improvement of college students' mathematical competency indicators in the integral concept so is examined data normality. From the results of the normality test, it is known that the data is not normally distributed. The statistical test used is the Mann-Whitney U test. Data processing results are presented in table 4 below:

| The Indicator of Mathematical Competence | X1       | X2       | X3       | X4       | X5       |
|-----------------------------------------|----------|----------|----------|----------|----------|
| Mann-Whitney U                          | 859.00   | 577.00   | 861.00   | 728.50   | 654.50   |
| Wilcoxon W                              | 1184.00  | 902.00   | 1186.00  | 1053.50  | 979.50   |
| Z                                       | -0.34    | -2.67    | -0.32    | -1.42    | -2.03    |
| Asymp. Sig. (2-tailed)                   | 0.73     | 0.01     | 0.75     | 0.16     | 0.04     |

a Grouping Variable: Gender

From table 4 it is known that gender factors in conventional classes do not have a significant effect on the enhancement of the indicators of mathematical competence, namely: (1) Understanding of concepts (X1). (2) Strategic competence (X2). And (3) Adaptive reasoning (X4). Gender factors in conventional classes have a significant influence on enhancement: procedural fluency (X3) and productive disposition (X5).

Based on the calculation results show that conventional learning has not increased every indicator of college students' mathematical competency evenly. In general, the calculus learning process in conventional classrooms is still presented in the form of problem-solving exercises, explanation of concepts and techniques through examples [8].

In general, the average enhancement of male mathematical competency indicators was lower than that of women. The difference in results achieved based on gender is in accordance with the results of research that has been done by previous researchers. Researchers have found differences in mathematical abilities based on gender, male students show higher mathematical abilities since the first level [12]. However, recent research shows that the mean value math difference between female students and male students has drastically changed [13-15]. Gaps in achieving mathematical abilities based on
gender persist among them, especially high-level mathematical abilities male students tend to outperform female students in the 95th and 99th percentiles.

Based on the above conditions, the questions that arise are What factors might contribute from gender differences in mathematical interest, achievement, the choice of the career in science, technology, mathematics, and engineering (STEM). Researchers are currently exploring the idea that women’s implicitly held beliefs about their intelligence play a role in the gender gap in math achievement and the underrepresentation of women in science, technology, math, and engineering (STEM) careers [16,17].

Recent studies related to gender influences on mathematical interest find that male students show higher interest in mathematics than female students [18-22]. Gender influence on mathematical abilities has been seen since grade 4 [23]. In adolescence, boys have a higher interest in mathematics [23]. The greater male variability in mathematics is not universal and greater male variability correlates with several measures of gender inequality [24].

Gender disparities between them at the ability of high levels have declined in the United States and did not occur in several countries, such as Denmark and the Netherlands [24,25]. Over a span of thirty years, the ratio of boys to girls at the highest levels (i.e., 95th percentile) of math ability as measured by the SAT math exam has declined from about 13:1 to 4:1 [25]. Recent research shows the difference in average scores math achievement between girls and boys has been drastically decreasing [13-15] and achievement distribution scores the end is now basically the same between the two sexes [24]. This condition is in accordance with the results of the study, namely: (1) Gender differences in the scientific debate class do not have a significant influence on enhancement of concept understanding, procedural fluency, strategic competence, adaptive reasoning, and productive dispositions in integral concepts; and (2) Gender differences in conventional learning do not have a significant influence on increasing concept understanding, strategic competence, and adaptive reasoning. Gender differences in conventional learning have a significant effect on improving procedural smoothness and productive disposition.

However, this also supported that no consistent argument has been agreed upon regarding any potential gender differences in competitive attitudes, because some studies also have reported that females are more competitive than males are [26]; others have indicated that no significant gender differences exist for competitive attitudes, which is consistent with the findings of this study [27].

4. Conclusion
Based on the results of the above research, it can be concluded that the value category for male and female in the scientific debate class is: (1) The concepts understanding were categories C and B; (2) Procedures fluency were categories A and A; (3) Strategic competence were B and B; (4) Adaptive reasoning were category B and B; (5) Productive dispositions were categories B and B. Gender differences did not have a significant influence on increasing concept understanding, procedural fluency, strategic competence, adaptive reasoning, and productive dispositions in integral concepts. In conventional learning the value categories for men and women show: (1) The concepts understanding was the category C and B; (2) Procedures fluency were categories C and B; (3) Strategic competencies were categories D and C; (4) Adaptive reasoning was a category C and B; (5) Productive dispositions were categories C and B. Gender differences in conventional learning do not have a significant effect on improving concept understanding, strategic competence, and adaptive reasoning. Gender differences in conventional learning have a significant effect on improving procedural fluency and productive disposition.

Acknowledgments
This study was supported by the Ministry of Research and Technology Directorate of Higher Education (KEMENRISTEKDIKTI). We are grateful to anonymous reviewers for reviewing earlier versions of this manuscript. We also appreciate the help from Rector and Research Institutions and Community Service; the final version would not have been possible without their constructive comment.
References
[1] Friedman L 1995 The space factor in mathematics: Gender differences Review of Educational Research 65(1) 22-50
[2] Niederle M and Vesterlund L 2010 Explaining the gender gap in math test scores The role of competition The Journal of Economic Perspectives 24 129-144
[3] Burkley M, Parker J, Stermer S P and Burkley E 2010 Trait beliefs that make women vulnerable to math disengagement Personality and Individual Differences 48(2) 234–238
[4] Dweck C S and Leggett E L 1988 A social-cognitive approach to motivation and personality Psychological Review 95(2) 256–273
[5] Wall J, Brown A and Selmer S 2014 Elementary prospective teachers’ mathematical justifications through online mentoring modules. In M. Searson & M. Ochoa (Eds.) Proceedings of Society for Information Technology & Teacher Education International Conference 2014 (pp. 490-493). Chesapeake, VA: Association for the Advancement of Computing in Education
[6] Ramdani Y 2011 Scientific Debate Instructional to Enhance Students Mathematical Communication, Reasoning, and Connection (Bandung: Indonesian Education University)
[7] Ramdani Y 2014 Scientific Debate Instructional for The Enhancement Creative Thinking Ability of Student MIMBAR Social and Development Journal 30(1)
[8] Ramdani Y 2013 Scientific Debate Instructional to Enhance Students Mathematical Communication, Reasoning, and Connection Ability in the Concept of Integral Proceeding, International Conference on Mathematical and Computer Sciences
[9] Ramdani Y, Rohaeni O and Dianita 2018 Increasing Indicators Of Mathematics Competency In Integral Concept Through Debate Scientific Strategy International Journal Of Innovation And Research In Educational Sciences pp 8-15
[10] Hill C, Corbett C and St. Rose A 2010 Why so few Women in science, technology, engineering, and mathematics (Washington DC: AAUW)
[11] Sabella M S and Redish E F 2007 Knowledge organization and activation in physics problem-solving Phys. Educ. Res., Am. J. Phys. Suppl. 75 1017
[12] Penner A M and Paret M 2008 Gender differences in mathematics achievement: Exploring the early grades and extremes Social Science Research 37(1) 239–253
[13] Hyde J S 2005 The gender similarities hypothesis American Psychologist 60(6) 581-592
[14] Hyde J S, Lindberg S M, Linn M C, Ellis A B and Williams C C 2008 Gender similarities characterize math performance Science 321 494–495
[15] Hyde J S and Linn M C 2006 Gender similarities in mathematics and science Science 314 599–600
[16] Burkley M, Parker J, Stermer S P and Burkley E 2010 Trait beliefs that make women vulnerable to math disengagement Personality and Individual Differences 48(2) 234–238
[17] Dweck C S 2006 Is math a gift? Beliefs that put females at risk In S. J. Ceci & W. Williams (Eds.), Why aren’t more women in science? Top researchers debate the evidence pp 47–55 (Washington DC: American Psychological Association)
[18] Evans E M, Schweingruber H and Stevenson H W 2002 Gender differences in interest and knowledge acquisition: The United States, Taiwan, and Japan Sex Roles 47(3) 153–167
[19] Köllner O, Baumert J and Schnabel K 2001 Does interest matter? The relationship between academic interest and achievement in mathematics Journal for Research in Mathematics Education 32(5) 448–470
[20] Linver M R and Davis-Kean P E 2005 The slippery slope: What predicts math grades in middle and high school? New Directions for Child and Adolescent Development 2005(110) 49–64
[21] OECD 2004 Learning for Tomorrow’s World: First Results from PISA 2003 PISA, OECD Publishing
[22] Preckel F, Göetz T, Pekrun R and Kleine M 2008 Gender differences in gifted and average-ability students: Comparing girls’ and boys’ achievement, self-concept, interest, and motivation in mathematics Gifted Child Quarterly 52(2) 146–159
[23] Frenzel A C, Goetz T, Pekrun R and Watt H M G 2010 Development of mathematics interest in adolescence: Influences of gender, family, and school context *Journal of Research on Adolescence* 20(2) 507–537

[24] Hyde J S and Mertz J E 2009 Gender, culture, and mathematics performance *Proceedings of the National Academy of Sciences* 106(22) 8801–8807

[25] Wai J, Cacchion M, Putallaz M and Makel M C 2010 Sex differences in the right tail of cognitive abilities: A 30-year examination *Intelligence* 38(4) 412–423

[26] Harris P B and Houston J M 2010 A reliability analysis of the revised competitiveness index *Psychological Reports* 106(3) 870-874

[27] Yeoh J and Yeoh P A 2015 Competitiveness between Ethnic Malays and Ethnic Chinese in Malaysia *GSTF Journal of Psychology* 2(1) 16-21