Gender Gap in Mathematics Achievement: Empowering Women's Awareness in Mathematics

Alberta Parinters Makur[1], Bedilius Gunur[2] and Apolonia Henrice Ramda[3]
{alberta_makur@unikastpaulus.ac.id[1], gbedilius@gmail.com[2], apoloniahendrice@gmail.com[3]}

[1,2,3]Universitas Katolik Indonesia Santu Paulus Ruteng, Indonesia

Abstract. This study assessed gender differences in learning mathematics using generative learning. This research was a quasi-experimental research with a posttest-only control group design. Fifty-seven pre-service mathematics teachers were involved in this study. Nineteen male pre-service mathematics teachers and thirty-eight female teachers were taught real analysis using generative learning. The data were collected through an essay test. Using a t-test at 0.05 level of significance, the data analysis and interpretation of this study indicated that male and female pre-service mathematics teachers who took real analysis courses using generative learning did not differ significantly in achievement, revealing that male and female pre-service mathematics teachers were able to compete and collaborate in mathematics. The findings suggest that a generative learning strategy can improve the critical thinking skills of males and females who took real analysis courses.

Keywords: generative learning, gender, mathematics achievement, real analysis

1 Introduction

Researchers have noticed and explored the relationship between gender and mathematics achievement [1–5]. Several studies [6–10] report that men perform better and have a positive attitude towards mathematics than women. Women who fail math exams tend to blame their lack of ability, while men in similar situations claim they have put extra work into it. Differences in perspectives between women and men related to mathematical abilities are fascinating to study, considering the essential ability of mathematics is important for everyone regardless of sex. Gender differences significantly affect patterns of behaviour, attitudes, and participation. Concerning education, a thorough understanding is needed to identify the factors that result in differences in achievement and achievement, especially in mathematics.

Nevertheless, nowadays, the gender gap in science and mathematics achievement at the end of secondary school has not been significant in recent decades. Qualitatively, this gender gap has begun to narrow significantly [5]. The authors point out that reasons for the narrowing of the gender gap may include family background, parents' beliefs and attitudes toward mathematics, teaching styles, attitudes and beliefs of teachers, environment and student achievement, and experiments that make girls feel less inferior even though other research revealed that teacher expectation bias does not contribute significantly to the gender gap in reading or mathematics [11]. Currently, every child, both girls and boys, often play games related to mathematics or who often does activities related to mathematics. In particular, girls often play shopping activities that also involve math. This idea, of course, develops familiarity

ICEHHA 2022, October 21-22, Ruteng, Indonesia

DOI 10.4108/eai.21-10-2022.2329587

and skills related to mathematics and results in a feeling of confidence in their abilities. The type and frequency of activities may vary, but still, parents tend to engage their children to develop numerical and literacy skills.

Moreover, the current influence of the internet tends to accommodate learning activities for girls and boys to improve their numeracy skills. Even though women's achievements in mathematics are pretty good, some fields of work related to mathematics are still dominated by men. This idea is, of course, interesting for further research. The gender differences associated with self-confidence were more substantial than those for performance in mathematics.

This narrowing gender gap can also be seen from the almost balanced interest of student-teacher candidates who choose to become math teachers. In the Mathematics Education Study Program at the Indonesian Catholic University of Santu Paulus Ruteng, 73% of students are female. Mathematics, which men originally dominated, is now also in demand by women. Furthermore, academically, the average GPA of a female pre-service teacher is 3.20, and male pre-service teacher is 3.23, which is similar. This is in line with Toney's research in [12], who said that women are the majority group in college mathematics education but are a minority group in almost all mathematics departments in the United States. This is due to a cultural conflict between the values, goals, and objectives of someone who wants a college mathematics education and those in many university mathematics departments.

This study aims to fill this gap by analysing the gender gap in mathematics achievement. This study wants explicitly to analyse differences in mathematical abilities concerning the ability to think logically, systematically, and critically which are claimed to be abilities that men naturally possess. For this reason, the courses chosen to measure this are accurate analyses. In addition, the generative learning model was chosen during the learning process because this model is considered to accommodate the needs of both women and men in learning mathematics. The following research questions will be examined Is there a gender gap in the mathematics achievement of pre-service mathematics teachers taught objective analysis using generative learning?

2 Generative Learning

Generative learning was developed based on constructivism learning theory Wittrock [13] stated that generative learning focuses on how students process information, in which they are engagedly involved in learning activities. Generative learning processes were based on the nature of constructivism. Students were encouraged to study actively based on their initial knowledge and then intertwined connections between initial knowledge and new concepts to construct new knowledge. Students become the centre of learning and build their understanding with guidance from a facilitator such as a teacher or a lecturer, so the new concepts become their findings. Such learning is believed to be more meaningful. In essence, generative learning is learning about how a student builds knowledge in his mind, such as building an idea about a phenomenon/building the meaning of a term and a strategy to explain how and why questions. The essence of generative learning is that the brain does not receive information passively but actively constructs that information and then draws conclusions.

According to [14], The stages in generative learning are intended to motivate students to actively understand any information learned during the learning process by selecting relevant information, organising, and integrating it with previously learned knowledge. According to Osborne and Wittrock [15], to improve mathematical abilities, students are encouraged to express their ideas or ideas with various variations, such as drawing, writing, or making mathematical models according to the concepts they have. Students are also allowed to express ideas or ideas accompanied by supporting reasons for the problems that have been given. Students are expected to better understand the concepts they built themselves so that the learning process becomes more leverage. Thus, indirectly students will be motivated to take the learning process seriously and actively.

Generative learning consists of several procedures: (1) Orientation Stage, where students are allowed to relate the material to everyday experiences, which aims to build an impression of the concept being studied with everyday life. This is done to foster students' motivation when learning the concept; (2) The stage of expressing ideas, where students can express their ideas about certain concepts being studied. Differences of opinion can occur in this stage so that students will realise that there are other points of view in studying certain concepts; (3) The challenge and restructuring stage, where the teacher prepares an atmosphere where students can discuss and exchange ideas about the opinions of each student in the class while expressing the advantages of each student's opinion about the concept being studied. Then, the teacher guides the demonstration to test the correctness of the student's opinions. At this stage, it is expected that students have begun to change the structure of their understanding (conceptual change); (4) The implementation stage, which is an activity where students are allowed to test alternative ideas that they build to solve various problems. Through this stage, the teacher can ask students to solve simple and complex problems; (5) The review stage, where students are allowed to evaluate the weaknesses of the old concepts that have been made. Students are also encouraged to be able to recall the material and concepts they learned during the lesson [13].

3 Method

Research procedures while conducting the research :

a. Formulating research objectives and research questions or developing hypotheses;

During the lecture, researchers saw that female students had relatively the same mathematical abilities as male students and sometimes even surpassed male students. This is different from the general assumption that mathematics is a male-dominated subject. For this reason, researchers are interested in researching the gender gap in mathematics achievement. The results of this observation lead to the hypothesis that the abilities of men and women in mathematics are relatively the same.

b. Conducting literature review;
   To support the research process, researchers conducted a literature study on the abilities of men and women in mathematics. This research study is more directed at differences in male and female mathematical abilities. The factors that trigger the emergence of self-concept related to mathematics are observed to support the research results.
c. Using convenience samples;
   The researcher chose a convenience sample where all 57 student pre-service teachers who took real analysis courses were involved in the study.
d. Carrying out the learning process for the Real Analysis course with the topic: Sequence using generative learning;
   During the research process, researchers used a generative learning strategy. After conducting a literature study, this strategy is considered to accommodate the needs of male and female pre-service teachers. The lecture material chosen during this research was Real Number Sequences.
e. Providing math achievement tests;
   After the lecture process was completed for six meetings, the researcher gave a final test to see their learning outcomes. This test measures all course participants' logical and systematic thinking skills.
f. Carrying out and analysing the data using SPSS;
   After the test was completed, the researcher checked the answers of all research subjects and assessed and analysed the test results.
g. Interpreting the data.
   The results of the analysis of the data obtained, reviewed, and then associated with the results of research that has been done before.

The post-test-only quasi-experimental design was adopted for the research. Second-grade pre-service teachers who took the Real Analysis course at Mathematic Education Department, Universitas Katolik Indonesia Santu Paulus Ruteng, were chosen as the population. The study used a convenience sample consisting of 19 male and 38 female pre-service mathematics teachers; all the students participated as subjects in the study. They all took the Real Analysis Course for one semester and were taught using generative learning during the course. This study was designed to find whether there is a gender gap in mathematics achievement between male and female pre-service mathematics teachers taught real analysis using generative learning.

At the end of the semester, data were collected using an essay test. The research instrument, the essay test, was designed to measure mathematical critical thinking skills. Each question requires students to prove a mathematical statement if the statement is true or provide a counter-example if the statement is false. The data were analysed using a parametric test and t-test at a significance level of 0.05. Before the data were analysed, the assumption of normality and homogeneity were already checked. Data analysis was carried out by using IBM SPSS Statistics 21.

3 Results and Discussion

The hypothesis male and female pre-service mathematics teachers taught real analysis using generative learning do not differ significantly in their mean achievement scores was tested using a t-test at 0.05 level of significance. Data was carried out and analysed using SPSS 21.0.

		Kolmogorov-Smirnov[a]		
	GENDER	Statistic	df	Sig.
NILAI	L	.159	19	.200*
	P	.111	38	.200*

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Figure 1. Test of Normality

The normality test of the data used the Kolmogorov-Smirnov test at a 0.05 level of significance. The analysis results, seen in Figure 1, showed that all research samples came from a normally distributed population. The sig value is greater for both male and female are 0.200, which are greater than 0.05.

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
NILAI	Equal variances assumed	.053	.819	-1.077	55	.286	-1.736578947	1.611793419
	Equal variances not assumed			-1.053	34.035	.300	-1.736578947	1.648542188

Figure 2. Independent Samples Test

The homogeneity of variance test was conducted on groups of students based on gender, namely male and female, using Levene's Test of Equality of Error Variances. Based on the results of the analysis, as shown in the table above, shows the value of $F = 0.053$ and a significant value of 0.819. At 0.05 level of significance, the significant value obtained is more excellent, namely $0.819 > 0.05$, meaning that all sample data groups are homogeneous.

The gender factor is not significant. This is evident from the previous table, $sig = 0.286$. The implication is that there is no significant difference between the achievement mean scores of male and female mathematics pre-service teachers who taught real analysis using a generative learning strategy. Thus, the hypothesis of no significant difference is accepted.

This is in line with research results which show that women have moved forward, taking steps to narrow the gap in educational attainment and achievement between men and women. Currently, women have actively participated in being the driving force in certain fields that are important for domestic and international competitiveness and were previously dominated by men. [13]. But, having said so, there are many challenges that females currently face outside the classroom concerning mathematics, especially in developing areas such as Indonesia, where parents and societal views of mathematics hold such stereotypical views. Men compared to women [2, 7]. These deeply rooted views and stereotypes of society, in general,

will be challenging to change and will require a long process to change significantly; however, changes can start now from within the class. As a starting point, changes in the practice of learning mathematics need to occur to provide women with a more meaningful experience in mathematics [7]. In particular, in the Mathematics Education major, prospective teachers need to be equipped with a learning process that accommodates the tendencies of each student to learn and also a more comprehensive way of thinking about mathematics so that mathematics is not only regarded as an activity of thinking but rather the ability to think logically, critically and systematically.

In educating prospective teachers, it is necessary to make more concerted efforts to equip teachers with a mathematics teaching approach to avoid harming certain groups of girls or boys. The process of learning and teaching mathematics and the evaluation strategies carried out at the end of each lesson must be free of gender bias. The hope is that every male and female student will see themselves as equals able to compete and collaborate in-class activities. Boys and girls teachers must collaborate with boys and girls and adapt more socially just and inclusive approaches to create equal opportunities for all students regardless of gender [2].

Teachers and prospective teachers, apart from parents, have an important role in shaping children's perceptions of mathematics. It is time for the stereotype that boys are more successful at math than girls to stop. This assumption is largely unsupported by empirical evidence, but if left unchecked, it will be accepted as truth and allow for gender gaps in attitudes, perceptions, and interests in mathematics. This is dangerous because it can lead to subjects unrelated to mathematics. Ultimately, careers in quantitative fields, such as science, technology, engineering, and mathematics, are dominated by boys. Teachers need to create a learning environment for all children, girls and boys, which can foster a positive attitude toward mathematics from an early age.

The importance of a learning environment that accommodates the needs of students based on gender needs to be well realised by pre-service mathematics teachers. Differences in learning objectives, achieving understanding for female students, and learning speed for male students need to be well recognised in the learning design. The learning model is applied while taking into account the needs of each gender. This must be done early so that no more differences occur because of cultural definitions, this job is for men, and this job is for women.

4 Conclusion

This research has been conducted to assess gender differences in learning mathematics using generative learning. The results of this study indicated that male and female pre-service mathematics teachers who took real analysis courses using generative learning did not differ significantly in achievement. So, male and female pre-service mathematics teachers could compete and collaborate in mathematics.

Further research needs to be done to examine the emerging trends in this study in more depth. A better approach is to examine situational factors that might influence the gender gap, for example, family background, social culture, teacher's belief, parents' attitude toward mathematics, and other factors that might affect how someone perceives her/himself ability toward mathematics. In addition, why the women's advantage in education only sometimes guarantees women's opportunities in the labour market.

Acknowledgements. The authors would like to thank the fellow lecturers and students at the Mathematics Department Universitas Katolik Indonesia Santu Paulus Ruteng, who have provided support during the research and completion of this paper.

References

[1] M. Menon, "The Family-School Connection : Parental Influences in Academic Achievement and the Underlying Gender Differences," *World Sci. News*, vol. 67, no. 2, pp. 173–188, 2017.

[2] J. T. Ajai and B. I. Imoko, "Gender Differences in Mathematics Achievement and Retention Scores: A Case of Problem-Based Learning Method," *Int. J. Res. Educ. Sci.*, vol. 1, no. 1, p. 45, 2016, doi: 10.21890/ijres.76785.

[3] F. Siddiq and R. Scherer, "Is there a gender gap? A meta-analysis of the gender differences in students' ICT literacy," *Educ. Res. Rev.*, vol. 27, no. March, pp. 205–217, 2019, doi: 10.1016/j.edurev.2019.03.007.

[4] A. M. Penner and R. Willer, "Men's Overpersistence and the Gender Gap in Science and Mathematics," *Socius*, vol. 5, 2019, doi: 10.1177/2378023118821836.

[5] G. Ellison and A. Swanson, "Dynamics of the Gender Gap in High Math Achievement," *J. Hum. Resour.*, p. 0620–10972R1, 2021, doi: 10.3368/jhr.58.5.0620-10972r1.

[6] A. M. Steegh, T. N. Höffler, M. M. Keller, and I. Parchmann, "Gender differences in mathematics and science competitions: A systematic review," *J. Res. Sci. Teach.*, vol. 56, no. 10, pp. 1431–1460, 2019, doi: 10.1002/tea.21580.

[7] J. Hall, "Gender Issues in Mathematics: An Ontario Perspective," *J. Teach. Learn.*, vol. 8, no. 1, 2012, doi: 10.22329/jtl.v8i1.3004.

[8] A. Adamu, "(PDF) Gender Differences in Secondary School Students' Attitudes towards Learning Mathematics and the Resulting Implications on their Performance," *J. Educ. Res.*, vol. 6, no. 1, pp. 179–192, 2018.

[9] A. M. Mejía-Rodríguez, H. Luyten, and M. R. M. Meelissen, "Gender Differences in Mathematics Self-concept Across the World: an Exploration of Student and Parent Data of TIMSS 2015," *Int. J. Sci. Math. Educ.*, vol. 19, no. 6, pp. 1229–1250, 2021, doi: 10.1007/s10763-020-10100-x.

[10] K. Lee and J. Anderson, "Gender Differences in Mathematics Attitudes in Coeducational and Single Sex Secondary Education," in *Annual Meeting of the Mathematics Education Research Group of Australasia*, 2015, pp. 357–364.

[11] S. Gentrup and C. Rjosk, "Pygmalion and the gender gap: do teacher expectations contribute to differences in achievement between boys and girls at the beginning of schooling?," *Educ. Res. Eval.*, vol. 24, no. 3–5, pp. 295–323, 2018, doi: 10.1080/13803611.2018.1550840.

[12] A. F. Toney, "Alternate Trajectories: Women Moving into Mathematics Education," *Investig. Math. Learn.*, vol. 6, no. 3, pp. 29–50, 2014, doi: 10.1080/24727466.2014.11790334.

[13] Y. Bae and T. M. Smith, "Women in mathematics and science: findings from the condition of education 1997," 1997.

[14] T. Nurianna, T. and P. Hutapea, Familiarization Studies: Critical Components in Conducting Successful Fieldwork, *Advanced Science Letters*, vol. 21, no. 4, pp. 667-671, 2015.

[15] L.Fiorella and R. E.Mayer, *Learning as a generative activity: Eight learning strategies that promote understanding.* Cambridge University Press, 2015, doi: https://doi.org/10.1017/CBO9781107707085