RESEARCH
www.commprac.com
ISSN 1462 2815

GENDER DIFFERENCES IN SOLVING MULTIPLICATION AND DIVISION PROBLEMS AMONG PRIMARY SCHOOL PUPILS IN THE CONTEXT OF PROBLEM-BASED LEARNING (PBL)

Ong Gaik Suan [1], Syarifah Kamariah Wan Mohammad [2], Wong Tze Jin [3] and Koo Lee Feng [4]*

[1,2,3,4]Department of Science and Technology, Faculty of Humanities, Management and Science, Universiti Putra Malaysia Bintulu Campus, 97000 Bintulu, Sarawak, Malaysia.
[3]Institute for Mathematical Research, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor.
Email: [1]gs63778@student.upm.edu.my, [2]k_syarifah@upm.edu.my, [3]w.tzejin@upm.edu.my, [4]leefeng@upm.edu.my (*Corresponding Author)

DOI: 10.5281/zenodo.8433714

Abstract

The gender gap in mathematics requires immediate attention as it affects the gender balance in participation in Science, Technology, Engineering and Mathematics (STEM) education, which is recognized as a key enabler of 21st century skills in Malaysia's transition to Industrial Revolution 4.0 (IR 4.0). Therefore, this study was conducted to investigate the difference between genders in solving mathematics problems in primary school using Problem-Based Learning (PBL) technique. A quasi-experimental design was adopted for this study. A total of 27 students (15 girls and 12 boys) from grade 3 primary school were selected to participate in this study. Three hypotheses were put forward in this study. The results show that boys and girls have no significant difference in their performance in solving multiplication and division tasks using PBL. However, the results show that their mathematical performance improved by using the PBL method.

Keywords: Gender Difference, Multiplication and Division, Problem-Based Learning.

1. INTRODUCTION

In today's global competence, critical, creative and innovative people are needed. Therefore, future studies need to pay attention to learners' social attitudes and skills, which emphasises the need to develop students' social interaction skills for effective learning. Education plays an important role in developing personal skills, especially critical and creative thinking skills. Any education system must be anchored in a set of aspirations that are closely linked to the national context. Despite the different perspectives on the components of Malaysia's excellent education system, almost all stakeholders agree that the system would work better if it met the aspirations of all Malaysians. Therefore, in addition to the professional development of teachers and the development of learners' skills such as social interaction, critical thinking and problem solving, the use of innovative teaching methods cannot be neglected.

Barrows introduced problem-based learning (PBL) in 1996. This is a student-centred approach to modern teaching where students engage in self-directed learning (SDL) and learn through social interaction (Lin & Wang, 2022) via working in groups. This approach provides cognitive instruction where students learn by solving real-world problems and reflecting on and evaluating their experiences and learning activities. The findings of Kendal-Wright & Kasuya (2010), Pinho (2015) and Tang et al. (2020) have shown that students achieve better results with PBL than with conventional teaching where communication is one-way. PBL has gained attention in teaching and learning practise (Elaine & Goh, 2016) because it promotes two core competencies of 21st century learning (Silva, 2009; Silber-Varod et al., 2019), namely critical thinking

and problem solving. PBL in mathematics is a strategy for integrating mathematics instruction with problem-solving activities. Moreover, this innovative teaching approach provides students with more opportunities for critical thinking and helps students not only to present their own creative ideas but also to communicate mathematically with other students (Schettino, 2016; Piñeiro et al., 2021; Rézio et al., 2022).

According to a well-known scholar, Roger Bacon, “mathematics is the door and the key to the sciences”. Its concepts and procedures can be used to solve many problems in the fields of engineering, science, technology and economics. However, Zhou et al. (2017) and Rodriguez et al. (2020) have shown that there is a gender difference in mathematics achievement. Male students tend to perform better in mathematics than female students, particularly in problem solving (Zhou et al., 2017; Ghasemi & Burley, 2019). Conversely, female students report lower levels of individual interest and perceived mathematics competence (Guo et al., 2015; Ganley & Lubienski, 2016). Therefore, efforts to bridge the gender gap in mathematics must begin at the early stages of education to improve female students’ mathematical performance and ultimately increase female participation in STEM (Science, Technology, Engineering and Mathematics) education to promote human development and complete in the age of globalisation. Motivated by the work of Hirshfield & Korestky (2018), we therefore seek to promote student engagement in problem solving to achieve higher quality learning and to find out if there are significant gender differences in mathematics using the PBL method.

2. RESEARCH QUESTION AND HYPOTHESIS

The questions of this study are as follows:

a. Does the mathematical performance of boys and girls improve through the use of the PBL method of teaching and learning?

b. Do gender differences in mathematics emerge through the use of PBL?

The following three hypotheses are tested at a significance level of 0.05 and selected to answer the research questions:

H1: There is no significant difference between pre-test and post-test scores in solving multiplication and division problems with PBL in the boys' group.

H2: There is no significant difference between the pre-test and post-test results in solving multiplication and division tasks with PBL in the girls' group.

H3: There is no significant difference between boys' and girls' performance in solving mathematical multiplication and division tasks with PBL.

3. METHODOLOGY

This study is a quasi-experimental investigation. A group of 27 students consisting of 12 boys and 15 girls in Grade 3 of a primary school in Penang who have basic knowledge of multiplication and division were selected for this study. The students were divided into two groups, a boys' group and a girls' group. PBL was employed for both groups to teach multiplication and division. A pre-post test was advocated in this study. These tests were given to the students to determine their skill level before and after the learning process. A statistical instrument was used to analyse the quantitative

data. The performance of these two groups before and after the study was compared to determine whether there was a difference between the genders in the use of PBL.

4. RESULT AND DISCUSSION

In this section we will answer the two research questions that arise in this study. Table 1 shows the mean, standard deviation, maximum and minimum scores for the girls' and boys' groups before and after the test. Overall, it was found that both the girls' and boys' groups showed significant improvements after learning through the use of PBL. However, the boys' performance in multiplication and division was better than the girls'. Boys' performance improved by an average of 5.666 compared to 3.800 for girls. To determine whether these differences were statistically different, a one-way ANOVA was conducted at significance level $\alpha = 0.05$. Table 2 shows that the values for girls ($F(1,28) = 15.707$, $p = 0.00046$) and boys ($F(1,22) = 53.428$, $p < 0.00001$). This therefore means that there are significant differences in the mean between the pre-test and post-test for both the boys' and girls' groups at the $\alpha = 0.05$ level of significance. Therefore, the null hypotheses H1 and H2 were rejected. Our results suggest that students improved remarkably through the use of the PBL method, which has been shown to improve critical thinking, collaboration and communication skills, integrate previously acquired knowledge to facilitate problem solving and ultimately enable lifelong learning (Rézio et al., 2022) when appropriate learning tools are used.

Table 1: The Comparison of the Performances Pre-post test for the Girls' and Boys' Groups

	Mean		SD		Maximum		Minimum	
	Girl	Boy	Girl	Boy	Girl	Boy	Girl	Boy
Pre test	3.533	2.167	2.825	1.749	9	7	0	0
Post test	7.333	7.833	2.410	2.038	10	10	4	4
Mean difference	3.800	5.666						

Table 2: One-way ANOVA Mean Value of the Pre-post Test When Using the PBL Approach

Group	Source	df	Sum of square	Mean square	F	P
Girl	Between group	1	108.300	108.300	15.707	0.00046
	Within group	28	193.067	6.895		
	Total	29	301.367			
Boy	Between group	1	192.662	192.662	53.428	<0.00001
	Within group	22	79.334	3.606		
	Total	23	271.996			

The effect of PBL on the gender difference in the post-test mean was assessed using the one-way method ANOVA at the $\alpha = 0.05$ level of significance. Although Table 2 shows that both the girls' and boys' groups have a significant difference in the pre-test and post-test due to the implementation of the PBL approach to teaching and learning, the result from Table 3 demonstrates that there is no statistically significant difference between the mean performance of boys and girls in the implementation of the PBL approach to teaching and learning as assessed by the one-way ANOVA [$F(1,25) = 0.328$, $p = 0.572$]. This result suggests that gender is not associated with mathematical achievement when PBL is used in the classroom, although the male advantage in top mathematics achievement has been consistently demonstrated in various studies because female students have higher levels of anxiety, which

overloads their working memory and causes them to perform worse on maths tests (Ganley & Vasilyeva, 2014). Furthermore, our finding supports the earlier findings of Holmes et al. (2020) who found that gender had no effect on mathematics achievement and that achievement was not affected by the use of PBL, especially at the secondary level. Ajai & Imoko (2015) also found that male and female students did not differ significantly in terms of mathematics achievement and learning success.

Table 3: One-way ANOVA of the Post-test for Gender When Using the PBL Approach

Source	df	Sum of square	Mean square	F	P
Between group	1	1.666	1.666	0.328	0.572
Within group	25	127.000	5.080		
Total	26	128.666			

5. CONCLUSION, LIMITATION AND FUTURE STUDY

In this study, PBL is advocated to investigate possible gender differences in mathematical achievement. The results of this study show that mathematical achievement of both girls and boys improved with the introduction of PBL and that there is no gender difference in solving mathematical problems with the use of PBL. Our finding is in line with studies that have proven that student achievement does not depend on gender but on method (Ajai & Imoko, 2015; Hirshfield & Koretsky, 2018). This underscores the fact that pedagogy has a significant impact on academic achievement. These findings prompt teachers, researchers, key education policy makers and other education professionals to look for ways to implement the active learning approach more effectively at the school level. Furthermore, the results show that gender equality can be achieved in mathematics education, but it must be emphasised that this is a case study. Further research should therefore consider the impact of mathematics anxiety on gender differences through the implementation of PBL or other innovative teaching methods to improve mathematical problem-solving skills, as female students are generally more anxious about mathematics examinations and therefore perform worse during the test, with the ultimate aim of eliminating gender inequality in the future classroom and eventually closing the gender gap to develop a gender-balanced STEM talent pool.

Acknowledgements

The author extends gratitude to financial supporters and anonymous reviewers.

Funding

This research is funded from Putra Grant (9725400), UPM Malaysia.

References

1) Ajai, J. T., & Imoko, I.I. (2015). Gender Differences in Mathematics Achievement and Retention Scores: A Case of Problem-Based Learning Method. International Journal of Research in Education and Science, 1(1), 45-50.

2) Elaine, H. J. Y., & Goh, K. (2016). Problem-Based Learning: An Overview of Its Process and Impact on Learning. Health Professions Education, 2(2), 75-79.

3) Ganley, C. M., & Lubienski, S. T. (2016). Mathematics Confidence, Interest, and Performance: Examining Gender Patterns and Reciprocal Relations. Learning and Individual Differences. 47: 182-193. Doi: 10.1016/j.lindif.2016.01.002.

4) Ganley, C. M., & Vasilyeva, M. (2014). The Role of Anxiety and Working Memory in Gender Differences in Mathematics. Journal of Educational Psychology, 106(1), 105-120. Doi: 10.1037/a0034099.

5) Ghasemi, E., & Burley, H. (2019). Gender, Affect, and Mathematic: A Cross-national Meta-analysis of Trends in International Mathematics and Science Study 2015 Outcomes. Large-scale Assessments in Education, 7(10), 1-25.

6) Guo, J., Parker, P. D., Marsh, H. W., & Morin, A. J. (2015). Achievement, Motivation, and Educational Choices: A Longitudinal Study of Expectancy and Value Using a Multiplicative Perspective. Developmental Psychology. 51(8):1163-1176. Doi: 10.1037/a0039440.

7) Hirshfield, L., & Koretsky, M. D. (2018). Gender and Participation in an Engineering Problem-Based Learning Environment. Interdisciplinary Journal of Problem-Based Learning, 12(1). Doi:10.7771/1541-5015.1651.

8) Holmes, V., Hwang, Y., & Ingram, S.M. (2020). The Interaction of Gender and Pedagogy on Learning Motivations in a Secondary PBL Mathematics Classroom. Humanities and Sustainability Research, 1(2), 103-122.

9) Kendal-Wright, C., & Kasuya, R. (2010). Medical School Hotline: Team Based Learning: A Potential Addition to the JABSOM Curriculum. Hawaii Medical Journal, 69(10), 247-248.

10) Lin & Wang. (2022). Analysis of the Social Interaction of Perceived Problem-based Learning Performance in Internship Courses. Journal of Computer Assisted learning, 39(1), 194-209.

11) Piñeiro, J. L., Chapman, O., Castro-Rodríguez, E., & Castro, E. (2021). Prospective Elementary Teachers' Pedagogical Knowledge for Mathematical Problem Solving. Mathematics, 9(15).

12) Pinho, D., Antonio, L., Mota, F. B., Conde, M. V., Alves, L. A., & Lopes, R. M. (2015). Mapping Knowledge Produced on Problem-based Learning Between 1945 and 2014: A Bibliometric Analysis. Creative Education, 6(6), 576-584. Doi:10.4236/ce.2015.66057.

13) Rézio. S., Andrade, M. P., & Teodoro, M. F. (2022). Problem-based Learning and Applied Mathematics. Mathematics, 10(16).

14) Rodriguez, S., Regueiro, B., Pineiro, S., Estevez, I., & Valle, A. (2020). Gender Differences in Mathematics Motivation: Differential Effects on Performance in Primary Education. Frontiers in Pyschology, 10, 1-8.

15) Schettino, C. (2016). A Framework for Problem-Based Learning: Teaching Mathematics with a Relational Problem-Based Pedagogy. Interdisciplinary Journal of Problem-Based Learning, 10 (2).

16) Silber-Varod, V., Eshet-Alkalai, Y., & Geri, N. (2019). Tracing Research Trends of 21st-century Learning Skills. British Journal of Educational Technology, 50(6), 3099-3118.

17) Silva, E. (2009). Measuring Skills for 21st-Century Learning. Phi Delta Kappan, 90(9), 630-634.

18) Tang S., Long M., Tong F., Wang Z., Zhang H., & Sutton-Jones K. L. (2020). A Comparative Study of Problem-based Learning and Traditional Approaches in College English classrooms: Analyzing Pedagogical Behaviors via Classroom Observation. Behavioral Sciences, 10(6), 1-21. Doi: 10.3390/BS10060105.

19) Zhou, Y., Fan, X., & Wei, X. (2017). Gender Gap among High Achievers in Mathematics and Implications for STEM Pipeline. Asia-Pacific Education Researcher, 26(5), 259-269.