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GENDER AND STUDENTS' MATHEMATICAL LITERACY ABILITIES

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Abstract

Gender is one of the most commonly considered factors in educational research since many years, to explain differences in mathematics achievement. Despite the stereotype that boys are better than girls in mathematics, the most recent results of the Programme for International Student assessment, PISA, showed that in a significant number of countries there was a reduction or even elimination of the gap between boys and girls in terms of their performance in mathematical literacy. More specific for Greece in 2003, according to PISA's data and results, the difference in students' mathematical literacy performance between the boys and girls measured 19 points, with boys outperforming girls, while fifteen years later in PISA 2018, this difference has been reduced to zero points. This current study aims to investigate the abilities of boys and girls in mathematical literacy upon completing their compulsory education, which in more words means to evaluate in terms of the functional use of their mathematical knowledge when solving real-life math problems. Moreover, it aims to answer to the research question, if there is a statistically significant difference in mathematical literacy performance between boys and girls? The research was carried out in 650 students from all over Greece who were completing 9th grade or were at the beginning of the 10th grade and their schools were selected based on the degree of urbanization of the area where the respective school was located (large urban center, small urban center, rural area). The findings of the research showed that there are no significant differences in the average performance in mathematical literacy between boys and girls.

Keywords: *Gender, Greece, mathematical literacy, compulsory education.*

1. Introduction

Gender should not determine one's abilities. When provided with equal opportunities, both boys and girls stand an equal chance of realizing their potential, as highlighted by the OECD (OECD, 2015). Despite this principle, the underrepresentation of women in STEM fields persists, both in higher education and the professional realm. This enduring discrepancy has spurred increased research interest in comprehending gender differences in math performance (Breda & Napp, 2019; Else-Quest et al., 2010; Ghasemi & Burley, 2019; Régner et al., 2014). Recognizing that gender can significantly impact a country's economic development and social inclusion, it becomes imperative to study and consider gender differences in education when formulating strategies and policies to enhance educational outcomes (EACEA, Eurydice, 2010). Additionally, investigating students with high proficiency in mathematics is crucial, as it directly influences their choices in higher education. This exploration may provide insights into the lower percentage of women opting for studies related to mathematics and science (Lubinski & Benbow, 2006, cited in Eriksson et al., 2020).

In addition to the mentioned points, it is worth noting that recent years have witnessed a transformation in the characteristics expected of individuals, influenced by the digitization of various aspects of our lives. The skills deemed essential for active and thoughtful participation in 21st-century advancements as a creative and analytical citizen have been redefined, particularly in relation to mathematics (OECD, 2018). These revised attributes collectively constitute a mathematically literate individual. Therefore, it is crucial to delve into a more targeted investigation of the mathematical literacy skills of both genders, boys and girls, rather than focusing solely on general mathematical proficiency.

The OECD's Programme for International Student Assessment (PISA) from 2000 till today measures every three years the achievement of 15-years old students on mathematical literacy. In the 2022 PISA survey, statistical analysis revealed that boys outperformed girls in mathematical literacy in 40 out of 81 participating countries, while girls demonstrated a statistically significant advantage over boys in 17 out of 81 countries (OECD, 2023). Over the decade from 2009 to 2018, 43 out of 64 countries partaking in the

PISA survey showed no statistically significant change in the performance difference between boys and girls in mathematical literacy. Throughout this period, boys consistently outscored girls. The OECD recommends looking to countries that have successfully reduced or eliminated achievement gaps between boys and girls as examples, emphasizing that gender-related achievement gaps are neither inherent nor inevitable (OECD, 2019a). The ultimate objective is to establish conditions conducive to enabling both boys and girls to maximize their potential to the fullest extent possible. More specifically concerning Greece, data from the PISA survey reveals that in 2003, there was a 19-point difference in mathematical literacy performance between boys and girls, with boys surpassing girls. According to the OECD, this gap translates to a difference of half a school year[1] between the two genders. However, over the course of fifteen years, by 2018, this disparity has been completely eradicated (Nolka & Sofianopoulou, 2022). It's worth noting, as indicated by the OECD, that Greece falls into the category of countries where the reduction and elimination of this difference are attributed to a decline in the performance of boys rather than an improvement in the performance of girls (OECD, 2019b). In the most recent PISA 2022 survey, this margin expanded to a 6-point advantage in favor of boys but without a statistically significant difference (OECD, 2023).

But apart from the score of boys and girls separately and the differences between them it should be noted that Greece's mean performance in mathematical literacy in general all the years from 2000 till 2022, has been consistently below the OECD average with a statistically significant difference. The observed stability and lower status could be partially attributed to the insufficient alignment among Greek mathematics curricula, junior high school mathematics textbooks, and the PISA mathematics framework. Furthermore, the emphasis on content rather than the intended framework might contribute to this situation. (IEP, 2019; Nolka & Sofianopoulou, 2022; OECD, 2018). To a certain extent, this current study tackles the concern by aligning the specific issues within its research tool with the junior high school mathematics curriculum, contrasting them with both the PISA survey and Greek results.

2. Research

This study involved 650 students from across Greece, either in the final stages of 9th grade or at the outset of 10th grade, who were either completing or had recently completed compulsory education. The schools included in the sample were chosen based on the level of urbanization in their respective regions. 60% of the students enrolled in schools situated in large urban centers, while 25% attended schools in small urban centers. Additionally, 16% of the sample attended schools located in rural areas of Greece. Among the 650 survey respondents, 303 (46.6%) were boys, and 347 (53.4%) were girls.

The research utilized a mathematical test consisting of five authentic, real-world math problems, each comprising individual sub-questions or items. In total, students were required to address and respond to eleven items. These problems were presented in the form of word problems grounded in real-life contexts, always initiated by an introductory text or stimulus. The subject matter ranged from everyday experiences to broader interests and the world of the students, showcasing mathematical abilities relevant to literate individuals. The initial tool comprised eleven items designed to align with the four overarching categories of mathematical content: a) change and relationships, b) quantity, c) space and shape, and d) uncertainty and data, as defined in the PISA international assessment program. Each item was carefully crafted to meet these criteria. Within each of the four categories, questions of varying difficulty levels—specifically, three degrees of difficulty—were incorporated to cater to the diverse needs of both male and female participants in the study. Beyond encompassing mathematical content, these eleven items were intentionally developed to align with one of the three core mathematical processes: formulation, application, and interpretation. Additionally, they were designed to address the process of mathematical reasoning, which students were required or expected to employ during problem-solving activities. Moreover, the mathematical concepts and knowledge that were surfacing within both the overall set of problems and individual items, which students were tasked with recalling and applying, aligned with the curriculum of compulsory education in Greece, encompassing junior high school mathematics. The dependent variable for mathematical literacy achievement was the performance or score on the mathematical test. The score was determined through the coding of students' responses, their categorization into acceptable, partially acceptable, non-acceptable, or no answer, and the calculation of weighting coefficients for each item based on the graded difficulty of the problems.

This study intended to answer to the research question, if there is a statistically significant difference in mathematical literacy performance between boys and girls?

[1] According to the OECD, approximately 38 or 40 units correspond to one school year.

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3. Results

To investigate potential statistically significant differences in mathematical literacy performance between boys and girls in the sample, an independent samples t-test was employed. The analysis revealed no statistically significant distinctions in the average performance in mathematical literacy between boys and girls within the sample ($t(648) = .234$, p-value = .815 > .05). Boys displayed a slightly higher average performance (M = 16.48) compared to girls (M = 16.29). The scoring scale spans from 0 to 42 points. Among the sampled students as a whole, the mean score for mathematical literacy was 16.38 units, with a standard deviation of 10.02.

Table 1. Mean performance in mathematical literacy categorized by gender.

Gender	M	SD	SE	N	t	df
Boys	16.48	10.53	.61	303	.234	648
Girls	16.29	9.57	.51	347		

To facilitate broader application of the current research findings, we categorized them based on students' proficiency in mathematical literacy. This categorization involves three distinct score levels, determined by the students' performance in mathematical literacy, specifically gauged through successful responses to a set of problems in the administered math test. Concretely, students accumulating up to 14 units fall into the low-level category, those amassing 15 to 30 units are classified as medium-level, and students accumulating more than 30 units are placed in the high-level category of mathematical literacy.

The Chi-square test examining the relationship between gender (two categories) and mathematical literacy levels (three categories: low, medium, high) revealed no significant deviation from independence [$x2(2) = 3.08$, p-value = .214>.05]. Both boys and girls demonstrated frequencies across mathematical literacy levels that closely aligned with the expected values (Table 2). Less than half of the girls in the sample and over half of the boys were categorized as having low mathematical literacy skills. Conversely, close to one-tenth of the boys and girls in the sample individually demonstrated a high level of mathematical literacy.

Table 2. Gender and mathematical literacy score level.

Gender/Levels	Low-level	Medium-level	High-level	x^2	df
Boys	162 (53.5%) (156.60)	102 (33.7%) (111.90)	39(12.9%) (34.50)	3.08	2
Girls	174 (50.1%) (179.40)	138 (39.8%) (128.10)	35 (10.1%) (39.50)		
Total	336 (51.7%)	240 (36.9%)	74 (11.4%)		

Expected frequencies are shown in parentheses below the corresponding frequencies

4. Conclusion

This current study examined the abilities of 650 boys and girls in mathematical literacy and examined the gender differences in mathematical literacy performance upon completing the compulsory education in Greece. Analyzing the results from the research tool, it becomes evident that both male and female students, taken as a whole, lack satisfactory levels of mathematical literacy skills. More specifically, concerning the research question posed in this study, it is found that the gender factor does not influence students' performance in mathematical literacy.

When comparing the findings of the current research with existing literature, it is first observed that the gender factor has been found to be statistically insignificant regarding the performance of male and female students in Greece in mathematical literacy. This pattern aligns with the findings from the PISA 2018 survey, which indicated no significant difference and specifically a zero difference in scores between boys and girls. It is also consistent with the results of the most recent PISA 2022 survey, where the gap widened to 6 points in favor of boys, although this difference was not statistically significant.

The current study's significance lies to our discovery that the trend observed in the international PISA study aligns with the national data from Greece upon comparison. These discoveries are crucial for promoting Greek students' gender equality in mathematical literacy. Hence, the poor performance of students in Greece in mathematical literacy does not depend on gender. Therefore, other causes should be sought and suitable conditions should be created to develop the abilities of all Greek students as a whole in mathematical literacy.

References

Breda, T., & Napp, C. (2019). Girls' comparative advantage in reading can largely explain the gender gap in math-related fields. *Proceedings of the National Academy of Sciences of the United States of America, 116(31),* 15435-15440. https://doi.org/10.1073/pnas.1905779116

EACEA, Eurydice. (2010). *Gender differences in educational outcomes: study on the measures taken and the current situation in Europe*. Publications Office. https://data.europa.eu/doi/10.2797/3598

Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). Cross-National Patterns of Gender Differences in Mathematics: A Meta-Analysis. *Psychological Bulletin*, *136*(1), 103-127. https://doi.org/10.1037/a0018053

Eriksson, K., Björnstjerna, M., & Vartanova, I. (2020). The Relation Between Gender Egalitarian Values and Gender Differences in Academic Achievement. *Frontiers in Psychology*, *11*(February), 1-14. https://doi.org/10.3389/fpsyg.2020.00236

Ghasemi, E., & Burley, H. (2019). Gender, affect, and math: a cross-national meta-analysis of Trends in International Mathematics and Science Study 2015 outcomes. *Large-Scale Assessments in Education*, *7*(1), 1-25. https://doi.org/10.1186/s40536-019-0078-1

IEP. (2019). *Greek Mathematics Education and PISA assessment,* Athens: Institute of Educational Policy.

Nolka E., & Sofianopoulou C. (2022). Mathematics in Southern Europe: Mathematics Education and Performance, Through the Prism of PISA, in Greece, Italy, Portugal and Spain. ISSN: 2188-1162. *The European Conference on Education 2022*: *Official Conference Proceedings*. https://doi.org/10.22492/issn.2188-1162.2022.24

OECD. (2015). *The ABC of Gender Equality in Education: Aptitude, Behaviour, Confidence*. PISA, OECD Publishing. http://dx.doi.org/10.1787/9789264229945-en

OECD. (2018). *Pisa 2021 Mathematics Framework (First Draft)*. https://www.upc.smm.lt/naujienos/smm/penkiolikmeciu-matematinis-rastingumas/GB-2018-4-PISA-2021-Mathematics-Framework-First-Draft.pdf

OECD. (2019a). *PISA 2018 Results (Volume I): What Students Know and Can Do*. PISA, OECD Publishing, Paris. https://doi.org/10.1787/5f07c754-en

OECD. (2019b). PISA 2018 Results (Volume III): What School Life Means for Students' Lives. Paris: OECD. https://doi.org/10.1787/acd78851-en

OECD (2023), *PISA 2022 Results (Volume I): The State of Learning and Equity in Education*, PISA, OECD Publishing, Paris, https://doi.org/10.1787/53f23881-en.

Régner, I., Steele, J. R., Ambady, N., Thinus-Blanc, C., & Huguet, P. (2014). Our future scientists: A review of stereotype threat in girls from early elementary school to middle school. *Revue Internationale de Psychologie Sociale* (Vol. 27, Issues 3–4).