Jurnal Ilmiah Profesi Pendidikan
Volume 8, Nomor 3, Agustus 2023
ISSN (Print): 2502-7069; ISSN (*Online*): 2620-8326

Deconstructing Gender Gaps in Basic Physics Education: A Multivariate Analysis of Practical Work Performance, Semester Outcomes and Literacy among Undergraduate Biology Education Students

Muhammad Taufik[1]* & Sutrio[1]
[1]Program Studi Pendidikan Fisika Jurusan PMIPA FKIP Universitas Mataram, Indonesia
*Corresponding Author: taufik@unram.ac.id

Article History
Received: July 17th, 2023
Revised: August 16st, 2023
Accepted: August 23th, 2023

Abstract: Basic physics plays a crucial role in the education of undergraduate biology students. Proficiency in physics literacy, learning outcomes, and practical work is essential for their success. This study investigates the influence of gender on these aspects among undergraduate biology education students. A quantitative approach was employed, utilizing questionnaires, tests, and observations. The sample comprised 17 students from biology education program PMIPA FKIP Mataram University. The results do not provide evidence to suggest that there are significant differences between genders in terms of practical work performance, semester outcomes, or literacy scores.

Keywords: Basic Physics Semester Outcomes, Gender, Physics Literacy, Practical Work Performance, Undergraduate Biology Education Students.

INTRODUCTION

Despite their distinct physical and natural differences within the family structure, as determined by God, men and women should not be differentiated by these features in the pursuit of academic achievement, particularly among university students. In countries that adopt the concept of egalitarianism, there is no difference or special treatment between male and female students. However, there are also countries that still practice this difference in treatment, as Friedman argues. 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 (Friedman,1995).

Decades of psychological research have documented sex differences in cognitive abilities, yet methodological and theoretical perspectives within this field have undergone significant transformations. While males and females display no substantial discrepancy in overall intelligence, extensive literature reveals sex-specific variations in performance on certain cognitive tasks Notably, males tend to demonstrate superior performance on tasks demanding visual-spatial skills, potentially contributing to subsequent gender disparities in quantitative domains such as mathematics and science, and ultimately influencing the underrepresentation of women in STEM fields. Conversely, females typically exhibit greater proficiency in tasks involving verbal and language abilities, potentially explaining observed differences in reading and writing skills, as well as the lower proportion of men pursuing higher education (Reilly,2019). Other studies have found similar results between men and women in mathematics and science courses (Hyde, 2006). Thus, there seems to be a difference in results, with some studies suggesting gender bias and others suggesting no gender bias.

For this reason, researchers are interested in investigating whether gender bias persists in basic physics classes, even though teachers strive for equality and do not discriminate based on gender. The researchers used three data sources to support their findings: basic physics laboratory grades, semester grades, and physics literacy skills.

Basic physics occupies a central position in the curriculum of undergraduate biology education programs. The study of this foundational discipline equips students with the crucial understanding of physical principles relevant to diverse biological phenomena. Physics relevant to biology and medicine is comprehensively discussed by Davidovits (2019).

Basic physics typically refers to the fundamental principles and concepts that form the foundation of the field of physics. Physics is a natural science that deals with matter and energy and interactions of matter with one another. It also deals with all physical processes and phenomena of a particular system (Serway, 2018). These concepts are often covered in introductory physics courses and serve as the building blocks for more advanced studies in the discipline. Some key topics in basic physics include: Classical Mechanics. Electromagnetism: Thermodynamics, Optics, Modern Physics, Fluid Mechanics, Wave Mechanics and Nuclear Physics.

Competence in physics literacy, semester outcomes, and practical work performance is paramount for future biology educators. Physics literacy fosters the comprehension of complex concepts, while semester learning outcomes assess the depth of understanding attained through coursework. Practical work performance provides essential hands-on experience in applying theoretical knowledge to concrete situations.

METHOD

This quasi-experimental study delves into the potential influence of gender on academic performance within a specific group of 17 first-year Biology education students (Class B). As their Basic Physics instructor, I am uniquely positioned to investigate this topic from within the larger S1 Biology education student population. This research, while lacking random assignment due to practical constraints, utilizes three crucial data points: basic physics lab grades, semester final grades, and physics literacy scores. By examining these metrics through both ANOVA and MANOVA, the study aims to uncover any statistically significant differences in male and female student achievement.

ANOVA is a statistical test used to compare the means of two or more groups. It does this by examining the variance between groups and within groups. (Binus,2023). ANOVA is a parametric statistical test that is used to compare the means of two or more groups. ANOVA works by comparing the variance between groups to the variance within groups. If the variance between groups is significantly greater than the variance within groups, then it is likely that there is a difference between the means of the groups. ANOVA can be used to test a variety of hypotheses, including:

H0: $\mu1 = \mu2 = \mu3$ (all means are equal)
H0: $\mu1 \neq \mu2$ (the means of the two groups are not equal)
H0: $\mu1 < \mu2$ (the mean of the first group is less than the mean of the second group)
H0: $\mu1 > \mu2$ (the mean of the first group is greater than the mean of the second group).

ANOVA will initially analyze each variable individually, offering insights into potential gender gaps in specific areas like lab work, overall semester performance, and physics comprehension. Subsequently, MANOVA is a multivariate statistical test that is used to compare the means of two or more groups for multiple dependent variables. MANOVA works by comparing the variance between groups for each dependent variable to the variance within groups for each dependent variable. If the variance between groups is significantly greater than the variance within groups for any of the dependent variables, then it is likely that there is a difference between the means of the groups for that dependent variable. MANOVA can be used to test a variety of hypotheses, including:

H0: $\mu1 = \mu2 = \mu3$ (all means are equal for all dependent variables)
H0: $\mu1 \neq \mu2$ (the means of the two groups are not equal for any of the dependent variables)
H0: $\mu1 < \mu2$ (the mean of the first group is less than the mean of the second group for any of the dependent variables)
H0: $\mu1 > \mu2$ (the mean of the first group is greater than the mean of the second group for any of the dependent variables)

FINDINGS AND DISCUSSION

FINDINGS

The research results are presented in Figures 1 and Tables 1-11.

DOI: https://doi.org/10.29303/jipp.v8i3.1117

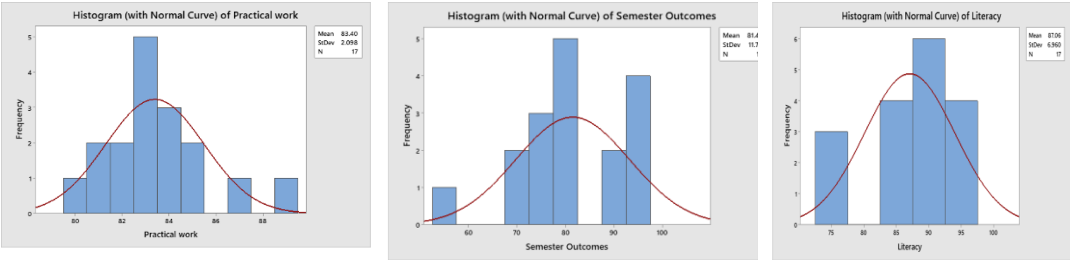

Figure 1. Histogram of physics laboratory, semester and literacy grades with a superimposed normal curve

Descriptive statistics for practical work, semester outcomes, and literary, including mean, standard deviation, variance, coefficient of variance, minimum and maximum values, are presented in Table 1.

Table 1. Descriptive Statistics: Practical work, Semester Outcomes, Literacy

Variable	**Mean**	**StDev**	**Variance**	**CoefVar**	**Minimum**	**Maximum**
Practical work	83.401	2.098	4.403	2.52	80.360	88.580
Semester Outcomes	81.47	11.73	137.51	14.39	54.00	96.00
Literacy	87.06	6.96	48.45	8.00	73.33	96.67

Table 2 presents the results of the analysis of variance (ANOVA) for practical work values using the adjusted sum of squares (SS) method.

Table 2. Analysis of Variance for Practical work, using Adjusted SS for Tests

Source	**DF**	**Seq SS**	**Adj SS**	**Adj MS**	**F**	**P**
Gender	1	2.261	2.261	2.261	0.50	0.491
Error	15	68.193	68.193	4.546		
Total	16	70.454				

Table 3 presents the analysis of variance for Practical Work with criteria Wilks, Lawley-Hotelling, Pillais dan Roys which is analyzed using MANOVA statistics.

Table 3. MANOVA Tests Practical work for Gender

Criterion	**Test Statistic**	**DF**			
		F	**Num**	**Denom**	**P**
Wilks'	0.96791	0.497	1	15	0.491
Lawley-Hotelling	0.03316	0.497	1	15	0.491
Pillai's	0.03209	0.497	1	15	0.491
Roy's	0.03316				

s = 1 m = -0.5 n = 6.5

Table 4 presents the results of the analysis of variance (ANOVA) for Semester Outcomes values using the adjusted sum of squares (SS) method.

Table 4 Analysis of Variance for Semester Outcomes, using Adjusted SS for Tests

Source	**DF**	**Seq SS**	**Adj SS**	**Adj MS**	**F**	**P**
Gender	1	2.71	2.71	2.711	0.02	0.894
Error	15	2197.52	2197.52	146.502		
Total	16	2200.24				

Table 5 presents the analysis of variance for Semester Outcomes with criteria Wilks, Lawley-Hotelling, Pillais dan Roys which is analyzed using MANOVA statistics.

Table 5. MANOVA Tests Semester Outcomes for Gender

Criterion	Test Statistic	F	DF		P
			Num	Denom	
Wilks'	0.99877	0.019	1	15	0.894
Lawley-Hotelling	0.00123	0.019	1	15	0.894
Pillai's	0.00123	0.019	1	15	0.894
Roy's	0.00123				

s = 1 m = -0.5 n = 6.5

Table 6 presents the results of the analysis of variance (ANOVA) for Literacy values using the adjusted sum of squares (SS) method.

Table 6. Analysis of Variance for Literacy, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Gender	1	0.560	0.560	0.5602	0.01	0.918
Error	15	774.603	774.603	51.6402		
Total	16	775.163				

Table 7 presents the analysis of variance for Semester Outcomes with criteria Wilks, Lawley-Hotelling, Pillais dan Roys which is analyzed using MANOVA statistics.

Table 7. MANOVA Tests Literacy, for Gender

Criterion	Test Statistic	F	DF		P
			Num	Denom	
Wilks'	0.99928	0.011	1	15	0.918
Lawley-Hotelling	0.00072	0.011	1	15	0.918
Pillai's	0.00072	0.011	1	15	0.918
Roy's	0.00072				

s = 1 m = -0.5 n = 6.5

Table 8 presents the analysis of variance for Practical Work, Semester Outcomes with criteria Wilks, Lawley-Hotelling, Pillais dan Roys which is analyzed using MANOVA statistics.

Table 8. MANOVA Tests Practical Work, Semester Outcomes Versus Gender

Criterion	Test Statistic	F	DF		P
			Num	Denom	
Wilks'	0.96391	0.262	2	14	0.773
Lawley-Hotelling	0.03744	0.262	2	14	0.773
Pillai's	0.03609	0.262	2	14	0.773
Roy's	0.03744				

s = 1 m = 0 n = 6

Table 9 presents the analysis of variance for Practical work, Literacy with criteria Wilks, Lawley-Hotelling, Pillais dan Roys which is analyzed using MANOVA statistics.

Table 9. MANOVA Tests Practical work, Literacy versus Gender

Criterion	Test Statistic	F	DF		P
			Num	Denom	
Wilks'	0.96524	0.252	2	14	0.781
Lawley-Hotelling	0.03601	0.252	2	14	0.781
Pillai's	0.03476	0.252	2	14	0.781
Roy's	0.03601				

s = 1 m = 0 n = 6

Table 10 presents the analysis of variance for Semester Outcomes, Literacy with criteria Wilks, Lawley-Hotelling, Pillais dan Roys which is analyzed using MANOVA statistics.

Table 10. MANOVA Tests Semester Outcomes, Literacy versus Gender

Criterion	Test Statistic	DF			
		F	Num	Denom	P
Wilks'	0.99793	0.015	2	14	0.986
Lawley-Hotelling	0.00208	0.015	2	14	0.986
Pillai's	0.00207	0.015	2	14	0.986
Roy's	0.00208				

s = 1   m = 0   n = 6

Table 11 presents the analysis of variance for Practical work, Semester Outcomes, Literacy with criteria Wilks, Lawley-Hotelling, Pillais dan Roys which is analyzed using MANOVA statistics.

Table 11. MANOVA Tests: Practical work, Semester Outcomes, Literacy versus Gender

Criterion	Test Statistic	DF			
		F	Num	Denom	P
Wilks'	0.96066	0.177	3	13	0.910
Lawley-Hotelling	0.04095	0.177	3	13	0.910
Pillai's	0.03934	0.177	3	13	0.910
Roy's	0.04095				

s = 1   m = 0.5   n = 5.5

DISCUSSION

The ANOVA test for Practical Work vs. Gender yields a p-value of 0.491, which is greater than the typical significance level of 0.05. This suggests that there is no statistically significant difference in practical work performance between the two genders in this sample. MANOVA Results Consistent with ANOVA: The MANOVA tests (Wilks', Lawley-Hotelling, Pillai's, and Roy's) also yield non-significant p-values, supporting the conclusion that there is no overall multivariate effect of gender on the dependent variable. The ANOVA test for Semester Outcomes vs. Gender yields a p-value of 0.894, which is much higher than the typical significance level of 0.05. This strongly suggests that there is no statistically significant difference in semester outcomes between the two genders in this sample. MANOVA Results Align with ANOVA. The MANOVA tests (Wilks', Lawley-Hotelling, Pillai's, and Roy's) all yield non-significant p-values, further supporting the conclusion that there is no overall multivariate effect of gender on the dependent variable. The ANOVA test for Literacy vs. Gender yields a p-value of 0.918, which is much greater than the typical significance level of 0.05. This strongly suggests that there is no statistically significant difference in literacy scores between the two genders in this sample. MANOVA Results Consistent with ANOVA. The MANOVA tests (Wilks', Lawley-Hotelling, Pillai's, and Roy's) all yield non-significant p-values, further supporting the conclusion that there is no overall multivariate effect of gender on the dependent variable.

CONCLUSION

The criteria for rejecting the null hypothesis are that the p-value is less than or equal to the pre-established significance level. The significance level is a value that determines how much risk one is willing to take in rejecting a true null hypothesis. A p-value that is less than or equal to the significance level indicates that there is sufficient evidence to reject the null hypothesis. For the data on basic physics laboratory performance, semester outcomes, and literacy, the null hypothesis is that there is no difference between females and males in basic physics laboratory performance, semester outcomes, and literacy. The commonly used significance level is 0.05. Based on the given statistical results, the p-value for basic physics laboratory performance is 0.491, the p-value for semester outcomes is 0.894, and the p-value for literacy is 0.918. Because all p-values are greater than 0.05, the null hypothesis cannot be rejected. In conclusion, based on the given data, there is not enough evidence to suggest that there is a difference between females and males in basic physics laboratory performance, semester outcomes, and literacy.

ACKNOWLEDGMENT

We are grateful to the Head of the Biology Education S1 Study Program, PMIPA, FKIP, Universitas Mataram, for the opportunity to teach the Basic Physics course in the Biology Education S1 Study Program. We also thank the students for their enthusiastic, serious, and dedicated participation in the Basic Physics lectures and laboratory.

REFERENCES

Binus (2023). Introduction to ANOVA and MANOVA. Accesed on July 7 2023, https://sis.binus.ac.id/2023/03/31/mengenal-anova-dan-manova

Davidovits, Paul (2019). Physics in Biology and Medicine, Fifth Edition. Academic Press of Elsevier, London.

Friedman L (1995). The space factor in mathematics: Gender differences Review of Educational Research 65(1) 22-50

Hyde J S & Linn M C (2006). Gender similarities in mathematics and science Science 314 599– 600

Reilly, David Hugh (2019). Sex Differences in Cognitive Abilities and Educational Outcomes: Examining the Contribution of Sex-Role Identification. Doctor of Philosophy in Applied Psychology, Griffith University, Gold Coast.

Serway, Raymond A & Jewett, John W. (2019). PHYSICS for Scientists and Engineers with Modern Physics, California State Polytechnic University, Pomona.