Application of MANOVA and Hotelling's T square on Academic Performance of University Students Based on Mode of Entry

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Abstract

The study aimed to investigate the relationship between students' entry mode into the University of Ilorin and their academic performance. Two faculties, Education and Physical Science, were selected, and a total of seven departments were chosen: four from the Faculty of Physical Science (Zoology, Biochemistry, Statistics, and Mathematics) and three from the Faculty of Education (Guidance & Counseling, Education & Management, and Agricultural Education). A total of 45 students' results were randomly selected from each department, comprising 15 from Remedial/Pre-degree, 15 from Jamb/UTME, and 15 from Direct Entry. Six null hypotheses were formulated and tested using various statistical tests such as Box's M test, Shapiro Wilk test , Mardia test, MANOVA, and Hotelling T square, all at a 0.05 level of significance. The analysis revealed that there was no significant difference in the performance of students based on their mode of entry in all selected departments and between the faculties. However, the paper shows that students admitted through Direct Entry had the highest mean performance, indicating that they performed better than students admitted through Jamb/UTME and Remedial/Pre-Degree modes. The recommendation is for Nigerian universities to prioritize students entering through the Direct Entry program for admissions. This is because these students tend to exhibit more mature thinking and behavior, which would result in less stress for lecturers in the classrooms.

1. Introduction

Learning involves the acquisition of knowledge or skills through study. It is demonstrated by how students respond to environmental, social, emotional, and physical stimuli and how they understand and retain new information. Academic performance is a complex behavior influenced by various factors such as memory, prior knowledge, aptitude, and psychological elements. In today's educational institutions, researchers, educators, and trainers focus on students' academic success and aim to identify the factors that impact their performance. Academic performance is an assessment of a student's abilities across a wide range of academic subjects. Teachers and education officials often measure student achievement based on classroom performance, graduation rates, and standardized test scores.

The primary function of schools is to provide academic instruction. Schools aim to impact children's learning, socialization, and career readiness. Despite the emphasis on a broad range of educational outcomes, academic achievement remains essential. The term "academic performance" is frequently used in higher education discussions. Academic performance encompasses a learner's skills, attitudes, and behaviors that contribute to academic success in the classroom. Every educational institution has always been concerned with the academic success of its students.

There is a general agreement that schools should play a significant role in the education process, but there is a dispute on what that role should be. Some argue that schools' primary goal should be to prepare students for academic success. Others believe that schools' efforts to educate children should be integrated with those of other social organizations, such as families and communities. In reality, the administrators of educational institutions, teachers, and parents are largely responsible for students' academic achievement, and schools should organize themselves efficiently and effectively to achieve this goal.

Over the years, researchers have used a range of metrics to assess academic success, including report card grades, grade point averages, standardized test scores, teacher ratings, other cognitive test scores, grade retention, and dropout rates. Teacher evaluations, quizzes, and examinations are commonly used to measure students' academic achievement. In reality, students are more likely to experience and demonstrate academic achievement when they feel personally validated and believe that their efforts count and have the potential to affect or control their academic success. These factors motivate children to find a sense of purpose and see the educational experience as personally significant. The following are identified as basic factors that influence students' poor performance in their academic endeavors.

Teachers' approach to using instructional materials: Teachers play a crucial role in guiding students' learning using a variety of teaching resources. The effectiveness of skill and knowledge development in an educational setting depends on the applicability, sufficiency, and effective usage of available materials. It's important to consider the relevance of instructional resources to the lesson's purpose and their ease of use to improve learner performance. However, many school instructors are unaware of how to utilize instructional tools, and there is a lack of induction courses, lectures, and seminars in the teaching profession to improve understanding and enable the use of advanced instructional materials. As a result, teachers often do not make the best use of the few instructional materials at their disposal because they do not know how to use them effectively.

Teaching technique utilized: Poor teaching can manifest in various ways, such as ineffective communication, disorganization, inadequate planning, and a failure to engage students. Additionally, teachers who lack expertise in their subject area or lack enthusiasm for teaching can contribute to poor instruction. When teachers fail to meet the needs of their students, it can have a long-term impact on their academic performance. Poor teaching can result in decreased motivation, leading to the development of bad study habits and lower grades. This can cause students to lose interest in learning and develop negative perceptions of school.

The influence of peer groups: The influence of peers can have a significant impact on students' academic achievement. When students spend a lot of time on extracurricular activities, their academic priorities may be overlooked, leading to lower academic performance. Academic achievement is not only about proficiency in academic subjects but also encompasses students' abilities, performance, and overall development. It is believed that there is a connection between peer groups and academic achievement. Peer influence can be either positive or negative. While negative peer influence can adversely affect a student's academic performance, stronger students can positively influence their peers and help improve overall academic achievement.

After carefully considering the points above, it can be inferred that students' success and excellent academic results contribute to the production of high-quality graduates capable of becoming future leaders and providing an efficient workforce for the country (Ali et al., 2009). Academic achievement is a crucial aspect of education (Oppong-Sekyere et al., 2013; Rono, 2013) around which the entire education system revolves. According to Narad and Abdullah (2016), a student's academic performance determines the level of success or failure experienced by an academic institution and is a significant priority for both instructors and institutions (Farooq et al., 2011; Jayanthi et al., 2014; Wu et al., 2014; Fajar et al., 2019). However, there are several factors that influence students' academic achievement.

Many people are confused about which type of admission process leads to the best academic outcomes. They are still unsure about how to determine which admission style will produce the greatest results. Nigeria's educational institutions have not been fulfilling their responsibilities for many years. According to Okpitike (2001), Frazen (2003), and Ihebuzor (2007), the intellectual achievements and skills of graduates from universities and other educational institutions are not meeting expectations. Ironically, the phrase "falling level of education" has become common in discussions about higher education in Nigeria. According to Bulus and Garara (2007), an international organization rated the intellectual level of Nigerian students and found that for a decade, most Nigerian colleges were producing graduates below world standards. The National Universities Executive Secretary stated that the post-JAMB examination is an innovative way to ensure that only qualified candidates are admitted to universities, addressing concerns about JAMB exam scores (Okoye, 2009).

2. MODE OF ENTRY INTO NIGERIA UNIVERSITY

The performance of different modes of entry in Nigerian universities can vary depending on various factors such as the academic preparedness of the students, the quality of the institutions offering the different modes of entry, and the specific requirements of the university programs. Here's a breakdown of each mode:

1. **Direct Entry**: This mode allows students to gain admission into the university directly without sitting for the Unified Tertiary Matriculation Examination (UTME) conducted by the Joint Admissions and Matriculation Board (JAMB). Instead, students typically apply with an Advanced Level (A-level) certificate, National Diploma (ND), or Higher National Diploma (HND) from recognized institutions. Direct entry candidates often enter into the second year of their chosen degree program.
2. **Remedial Programs**: Remedial programs are designed to prepare students who do not meet the standard academic requirements for direct entry into university programs. These programs offer courses aimed at enhancing students' academic skills and knowledge in subjects like Mathematics, English, and Sciences. After successfully completing a remedial program and passing the university's entrance examination, students can progress to regular undergraduate studies.
3. **JAMB (UTME)**: The UTME, conducted by JAMB, is the most common mode of entry into Nigerian universities. Students who have completed their secondary education take this standardized examination, which covers subjects such as English, Mathematics, and other relevant subjects. Depending on their scores, students can apply for admission into universities.

Each mode of entry has its advantages and challenges:

- **Direct Entry**: Students entering through this mode often have a more focused academic background and may excel in their chosen field from the start. However, competition for direct entry slots can be fierce, and students need to meet specific eligibility criteria.
- **Remedial Programs**: These programs provide an opportunity for students who may not have performed well in their secondary education to improve their academic skills and gain admission to university. However, success in these programs depends on the student's commitment and ability to overcome academic challenges.
- **JAMB (UTME)**: This mode of entry is the most common and provides a standardized assessment for university admission. However, it can be highly competitive, and students may need to prepare extensively to perform well in the examination and secure admission to their desired university and program.

In terms of performance, it's challenging to generalize which mode of entry performs better overall, as success depends on individual circumstances and the specific requirements of each university program. Some students may thrive in direct entry programs, while others may benefit from remedial programs to improve their academic standing. Ultimately, students should consider their academic strengths, career goals, and the requirements of their desired university programs when choosing the mode of entry that is best for them.

There is a conception that the University Matriculation Examination (UME) candidates perform better than the Direct Entry, and Pre-degree candidates in their University Examination (Irtwange and Agbe, 2010). Yet others believe that pre-degree candidates perform better than the UME and Direct Entry candidates in their university examination. Yet another group believes that Direct Entry candidates are superior to both the pre-degree and UME candidates (Sawyer, 2000). The people who hold this view argued that the pre-degree and direct entry candidates cannot pass the UME conducted by JAMB, hence they opted for the pre-degree programme or institutions that enable them to get the direct entry requirement (Adekoya, 2006).

This belief of people over which mode of entry is better in terms of university performance is different from one group to another, hence this study was undertaken to examine which mode of entry performs better than others in Nigerian universities.

The academic performance of students admitted into the universities in Nigeria has been an issue of great concern to lecturers and all those who are interested in the education industry. There are minimum entry requirement that candidates must possess before they can be admitted into degree programme in the universities. University of Ilorin is not an exception. The requirements are met by both pre-degree/remedial, UME, and direct entry candidates. That is, candidates

are needed to hold NECO/WAEC SSCE or its equivalents with credits in five (5) subjects relevant to their course(s), including English and mathematics, in no more than one sitting.

3. METHODOLOGY

This study utilized multivariate analysis of variance and Hoteling's T-square to compare academic performance among students across different departments (Guidance and Counseling, Education and Management, Agriculture Education, Zoology, Biochemistry, Statistics, and Mathematics) and faculty (Education and Physical Science) based on the mode of entry. The students' cumulative grade point averages (CGPAs) were used for the analysis. A simple random sampling approach was employed to collect CGPAs from just 15 students in each mode of entrance and department, regardless of gender, during the same academic session.

4. MULTIVARIATE ANALYSIS OF VARIANCE

Multivariate analysis of variance (MANOVA) expands the analysis of variance to include circumstances when more than one dependent variable must be investigated concurrently. Or Multivariate analysis of variance (MANOVA) is a statistical approach for comparing differences between two or more groups when there are numerous dependent variables.
Hypothesis
H_0: There is no significant difference in the performance of students across all selected departments and their respective modes of entry.
H_1: There is significant difference in the performance of students across all selected departments and their respective modes of entry.
Test Statistic
The test statistic is define as

1. Wilks lambda
   The determinant of the error sums of squares and cross-products matrix E is divided by the determinant of the total sum of squares and cross-products matrix T = H + E. If H is large relative to E, then |H + E| will be large relative to |E|. Therefore, we will reject the null hypothesis if Wilks' lambda is small (close to zero).
   $$\Lambda^* = \frac{|E|}{|H + E|}$$

2. Hotelling – Lawley Trace
   We multiply matrix H by the inverse of matrix E, and then we obtain the trace of the resulting matrix. If H is larger than E, the Hotelling-Lawley trace will be significant. Therefore, we will reject the null hypothesis if this test statistic is significant.
   $$T_0^2 = trace(HE^{-1})$$

3. Pillai Trace
   When we multiply the matrix H by the inverse of the total sum of squares and cross products matrix T = H + E, the Pillai trace will yield a large value if H is significantly larger than E. Therefore, we will reject the null hypothesis if this test statistic is large.
   $$V = trace(H(H + E)^{-!})$$

4. Roy's Maximum Root: Largest eigenvalue of HE^{-1}
   We multiply H by the inverse of E and then find the biggest eigenvalue of the resultant matrix. If H is larger than E, Roy's root will be enormous. Therefore, we will reject the null hypothesis if this test statistic is high.

5. Hotelling's T square

Hypothesis
H0: There is no significant difference in the academic performance of students between the Faculty of Education and the Faculty of Physical Science, depending on their respective modes of entry.
H1: There is a significant difference in the academic performance of students between the Faculty of Education and the Faculty of Physical Science, depending on their respective modes of entry.
Test Statistic
$$T^2 \geq \frac{(n_1 + n_2 - 2)p}{n_1 + n_2 - p - 1} F_{p, n_1 + n_2 - p - 1\,(\alpha)}$$

Where p = number of random variable (Remedial, Jamb and Direct entry) and $F_{p, n_1 + n_2 - p - 1\ (\alpha)}$ represents F – distribution with $p,\ n_1 + n_2 - p - 1$ degree of freedom.

6. Data Analysis

The R package will be utilized for data analysis, and we need to perform tests to confirm that the key assumptions of MANOVA are met before calculating the MANOVA test statistic.

Testing for Homogeneity of covariance Matrices

Box's M-test for Homogeneity of Covariance Matrices is used to test for homogeneity of covariance matrices across the groups.

Table 1

Test Statistic	Degree of Freedom	P-value
Chi-sq (Approx.) = 30	36	0.7488

We will use Box's M test to assess the homogeneity of the variance-covariance matrices. The null hypothesis is that the variance-covariance matrices are consistent across the dataset. Therefore as the *p-v*alue is significant ($p > 0.05$) for Box's M test, we fail to reject the null hypothesis and conclude that variance-covariance matrices are equal in all the department.

Testing for Normality

Another important assumption of MANOVA is normality. We will use the Shapiro-Wilk test to check for normality.

Table 2

	Remedial	Jamb	Direct
Test Statistic	0.9686	0.9803	0.9875
P-value	0.0134	0.12	0.4339

Based on the table 2, it's clear that the p-value for all three entry modes is greater than 0.01. Therefore, we cannot reject the null hypothesis. There is enough evidence from the data to support the null hypothesis, indicating that the data support normality.

Mardia Test

The Mardia Test is utilized to assess whether a set of variables conforms to a multivariate normal distribution.

Table 3

	Beta-hat	Kappa	P-value
Skewness	0.5541	9.6969	0.4675
Kurtosis	13.0142	-1.8575	0.0632

The table above shows the results of testing for multivariate normality in both the skewness and kurtosis of the dataset. Since both p-values are greater than 0.05, we do not have enough evidence to reject the null hypothesis of the test. Therefore, we cannot conclude that the three variables in our dataset do not follow a multivariate normal distribution.

The MANOVA results are below

Table 4

Department	Mean vector			Variance		
	(Rem	Jamb	Direct)	(Rem	Jamb	Direct)
Guidance & counselling	(2.013	2.152	**2.480**)	(0.624	0.328	1.073)
Education & Management	(2.248	2.346	**2.898**)	(0.512	0.356	0.691)
Agricultural Education	(2.082	2.327	**2.640**)	(0.497	0.748	0.550)
Zology	(2.319	2.435	**2.906**)	(0.527	0.802	0.987)
Biochemistry	(2.015	2.190	**2.427**)	(0.723	0.444	0.813)
Statistics	(1.731	2.025	**2.704**)	(0.385	0.519	0.637)
Mathematics	(1.870	2.073	**2.606**)	(0.372	0.672	0.449)

General Linear Model: Test, Performance versus Mode of Entry
Table 5

Test Statistic	Df	Test stat	Approx F	Num Df	Den Df	Pr (>F)
Pillai	6	0.1229	0.6975	18	294.0	0.8133
Wilks	6	0.8802	0.6974	18	272.0	0.8130
Hotelling-Lawley	6	0.1326	0.6976	18	284.0	0.8130
Roy	6	0.0981	1.6019	6	98.00	0.1547

The output above indicates that the four multivariate lead to the same conclusion and three variables (pre-degree/remedial, UTME/JAMB and Direct Entry) do not exhibit statistically significant differences among departments. Since the P-values is practically greater than 0.05, which means we can safely reject the alternative hypothesis in the favor of null hypothesis that is no group mean vector differs from the rest. This implies that the performance of students' base on their mode of entry (Direct Entry, UTME, and Pre-Degree/Remedial program) are equal across departments. We can conclude that there is no difference between the performances of the students base on their mode of entry.

7. Hotelling's T Square

Hotelling's T-square test is a multivariate statistical test used to compare the means of multiple variables simultaneously. It is an extension of the univariate t-test to multiple dimensions. This test is particularly useful in multivariate hypothesis testing when comparing the mean vectors of two groups or assessing whether a mean vector significantly deviates from a known vector.

Two - sample Hotelling's T square Test:

This test compares the mean vectors of two independent samples.

$$T^2 = \frac{n_1 n_2}{n_1 + n_2}(\bar{x}_1 - \bar{x}_2)'S_p^{-1}(\bar{x}_1 - \bar{x}_2) \sim T^2(p, n_1 + n_2 - 2)$$

It can be related to F - distribution by

$$\frac{n_1 + n_2 - p - 1}{(n_1 + n_2 - 2)p}T^2 \sim F(p, n_1 + n_2 - 1 - p)$$

Where:

- n_1 and n_2 are the sample sizes of the two groups.
- $\bar{x}_1$ and $\bar{x}_2$ are the sample mean vectors of the two groups.
- S_p is the pooled sample covariance matrix.

Normality Test
Table 6

	X = Faculty of Eduction	Y = Faculty of Physical Science
Test Statistic	0.9688	0.9738
P-value	0.2622	0.2239

Test Statistics
Table 7

	X = Faculty of Eduction (Rem Jamb Direct)			Y = Faculty of Physical Science (Rem Jamb Direct)		
Mean Vector	(2.1142 2.2753 2.6727)			(1.9837 2.1807 2.6608)		
Variance co-variance	$\begin{pmatrix} 0.5294 & 0.0395 & 0.0995 \\ 0.0395 & 0.4634 & -0.1004 \\ 0.0995 & -0.1004 & 0.7668 \end{pmatrix}$			$\begin{pmatrix} 0.5246 & 0.1685 & 0.2637 \\ 0.1685 & 0.6037 & 0.0737 \\ 0.2637 & 0.0737 & 0.7150 \end{pmatrix}$		

Hotelling's two sample T2-test

Test Statistic	Degree of Freedom	P-value
0.35569	Df1 = 3, Df2 = 101	0.7851

Based on the p-value being greater than 0.05, we cannot reject the null hypothesis. Therefore, we conclude that there is no significant difference between the mean vectors (Remedial, Jamb and Direct entry) for the faculty of education and the faculty of Physical Science, suggesting that the performance of students may be influenced by the mode of entry of students.

In Table 4, the mean vector (Remedial, Jamb and Direct entry) shows that the mean for Direct Entry is higher than Remedial and Jamb in all the departments. Similarly, Table 7 indicates that the mean vector for Direct Entry in the two faculties is higher than Remedial/Pre-degree and Jamb/UMTE. This finding aligns with Sawyer (2000). Therefore, we can conclude that Direct Entry candidates performed better academically compared to other modes of entry (Remedial/Pre-degree and Jamb/UMTE).

Conclusion

After analyzing the data, it is evident that students' performance across all departments and faculties is consistent regardless of their mode of entry. Therefore, it can be inferred that students entering directly are academically stronger than those entering through Remedial/Pre-Degree or Jamb/UTME. This difference may be attributed to their age, maturity, or advanced level of education compared to students transitioning directly from secondary school or those not yet exposed to the advanced level of their course of study.

The recommendation is for Nigerian universities to prioritize students entering through the Direct Entry program for admissions. This is because these students tend to exhibit more mature thinking and behavior, which would result in less stress for lecturers in the classrooms.

Conflict of interest

The author has no conflict of interest.

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تطبيق MANOVA و Hotelling's T square على الأداء الأكاديمي لطلاب الجامعة بناء على طريقة الدخول

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الخلاصة: تهدف الدراسة إلى التحقيق في العلاقة بين طريقة دخول الطلاب إلى جامعة إيلورين وأدائهم الأكاديمي .تم اختيار كليتين ، التربية والعلوم الفيزيائية ، وتم اختيار ما مجموعه سبعة أقسام :أربعة من كلية العلوم الفيزيائية (علم الحيوان والكيمياء الحيوية والإحصاء والرياضيات) وثلاثة من كلية التربية (التوجيه والإرشاد ، التربية والإدارة ، والتعليم الزراعي .(تم اختيار ما مجموعه 45 نتائج الطلاب عشوائيا من كل قسم ، بما في ذلك 15 من العلاج/ما قبل درجة ، 15 من جامب/أوتم ، و 15 من الدخول المباشر .تمت صياغة واختبار ست فرضيات فارغة باستخدام اختبارات إحصائية مختلفة مثل اختبار بوكس إم واختبار شابيرو ويلك واختبار ماريدا ومانوفا وهوتلينج تي سكوير ، وكلها بمستوى 0.05 من الأهمية .وكشف التحليل أنه لا يوجد فرق كبير في أداء الطلاب بناء على طريقة دخولهم في جميع الأقسام المختارة وبين الكليات .ومع ذلك ، من الجدولين 4 و 7 ، من الواضح أن الطلاب المقبولين من خلال الدخول المباشر كان لديهم أعلى متوسط أداء ، مما يشير إلى أنهم أدوا أفضل من الطلاب المقبولين من خلال جامب/أوتم وطرق العلاج/ما قبل الدرجة .التوصية هي للجامعات النيجيرية إعطاء الأولوية للطلاب الذين يدخلون من خلال برنامج الدخول المباشر للقبول .وذلك لأن هؤلاء الطلاب يميلون إلى إظهار تفكير وسلوك أكثر نضجا ، مما قد يؤدي إلى تقليل الضغط على المحاضرين في الفصول الدراسية.

الكلمات المفتاحية: تجانس التباين المشترك ، مانوفا ، الدخول المباشر ، المعالجة / ما قبل الدرجة ,جامب /أوتم.