Comparative Analysis of Academic Performance and Student Satisfaction: A Statistical Study of Online Versus Traditional Learning Modes

Chinonso Job[1]; Onwe, Festus Chijioke[2]

[1]Department of Data Analytics and Technology
University of Bolton, United Kingdom

[2]University of Port Harcourt,
Rivers State, Nigeria.

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Abstract: The rapid expansion of online education necessitates rigorous empirical investigation into its effectiveness compared to traditional classroom instruction. This study presents a comprehensive statistical analysis examining the relationship between learning modality and academic outcomes, utilizing data from 500 student records obtained from the UCI Machine Learning Repository. Employing multiple linear regression and binary logistic regression methodologies, we evaluated how learning mode, attendance rates, study duration, and demographic variables influence academic performance and student satisfaction. Results indicated that students in traditional learning environments achieved significantly higher academic performance scores (M = 76) compared to online learners (M = 73), with attendance percentage emerging as a significant positive predictor (β = 0.10, 95% CI [0.05, 0.15], p < 0.001). Logistic regression analysis revealed that online students exhibited significantly lower satisfaction levels (OR = 0.65, 95% CI [0.45, 0.95], p < 0.05). The multiple regression model explained approximately 15% of variance in academic performance (R^2 = 0.15), suggesting the presence of unmeasured confounding variables. These findings carry important implications for educational policy and institutional decision-making regarding learning modality implementation. Recommendations include enhancing attendance monitoring systems for online courses, developing interactive digital learning tools, and implementing hybrid learning models that leverage the strengths of both modalities.

Keywords: Academic Performance, Student Satisfaction, Online Learning, Traditional Learning, Multiple Regression, Logistic Regression, Educational Technology.

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I. INTRODUCTION

The landscape of higher education has undergone profound transformation over the past two decades, with online learning emerging as an increasingly prevalent alternative to traditional classroom instruction (Allen & Seaman, 2017). The COVID-19 pandemic further accelerated this shift, compelling educational institutions worldwide to rapidly adopt remote learning modalities (Hodges et al., 2020). This unprecedented expansion of online education has intensified scholarly debate regarding the comparative effectiveness of different learning environments and their impact on student outcomes.

Academic performance and student satisfaction represent two critical metrics for evaluating educational effectiveness. Academic performance, typically measured through assessment scores and grades, reflects the degree to which students have acquired intended learning outcomes (Richardson et al., 2012). Student satisfaction, conversely, captures the affective dimension of the learning experience, encompassing perceptions of instructional quality, engagement, and overall educational value (Elliott & Shin, 2002). Both constructs have been linked to student retention, graduation rates, and long-term career success, underscoring their importance to educational stakeholders.

Despite extensive research comparing online and traditional learning environments, empirical findings remain inconsistent. Meta-analytic studies have reported effect sizes ranging from negligible to moderate, with considerable heterogeneity across contexts, subject domains, and student populations (Means et al., 2013; Zhao et al., 2005). This variability suggests the presence of moderating factors that warrant systematic investigation. Moreover, much existing research relies on convenience sampling and lacks rigorous statistical controls for confounding variables such as attendance patterns and study behaviors.

This study addresses the following research objectives: (1) To compare academic performance outcomes between online and traditional learning modalities while controlling for attendance and study duration; (2) To examine the relationship between learning mode and student satisfaction; (3) To identify significant predictors of academic performance and high achievement; and (4) To provide evidence-based recommendations for educational policy and practice.

II. RELATED LITERATURE

The Community of Inquiry (CoI) framework provides a theoretical foundation for understanding learning effectiveness in different modalities (Garrison et al., 2000). This framework posits that meaningful educational experiences emerge from the intersection of three interdependent elements: social presence, cognitive presence, and teaching presence. Traditional classroom environments may facilitate stronger social presence through face-to-face interaction, while online environments require deliberate pedagogical design to achieve comparable levels of engagement.

Self-determination theory (SDT) offers complementary insights into student motivation and satisfaction across learning contexts (Ryan & Deci, 2000). According to SDT, intrinsic motivation flourishes when learners experience autonomy, competence, and relatedness. Online learning environments may offer enhanced autonomy through flexible scheduling, while potentially compromising relatedness due to reduced interpersonal contact. These theoretical perspectives inform our analysis of how learning modality influences academic outcomes and satisfaction.

➢ *Empirical Evidence on Learning Modality Effects*
A substantial body of research has examined the comparative effectiveness of online and traditional instruction. Bernard et al. (2004) conducted a comprehensive meta-analysis of 232 studies, finding a small but significant advantage for classroom instruction (d = 0.10) in achievement outcomes, while satisfaction favored traditional settings (d = 0.22). More recent meta-analyses have yielded mixed results, with some studies reporting no significant differences (Means et al., 2013) and others finding advantages for blended learning approaches (Vo et al., 2017).

Research on predictors of academic performance has consistently identified attendance as a significant factor (Credé et al., 2010). The relationship between attendance and achievement appears robust across educational levels and subject domains, with meta-analytic estimates suggesting correlations ranging from 0.40 to 0.60. However, the operationalization of attendance in online environments presents methodological challenges, as engagement metrics may not directly correspond to physical presence measures used in traditional classrooms.

➢ *Student Satisfaction in Different Learning Environments*
Student satisfaction represents a multidimensional construct encompassing evaluations of instructional quality, course content, instructor responsiveness, and peer interaction (Kuo et al., 2014). Studies examining satisfaction in online environments have highlighted the importance of instructor presence, course organization, and technology functionality (Alqurashi, 2019). Research suggests that while online learners often appreciate flexibility and convenience, they may experience reduced satisfaction related to social isolation and limited immediate feedback (Muilenburg & Berge, 2005).

III. METHODOLOGY

➢ *Data Source and Sample*
This study utilized data from the UCI Machine Learning Repository, specifically the "student_performance_satisfaction.csv" dataset. The original dataset comprised 500 student records containing academic performance ratings, satisfaction scores, and associated demographic and behavioral variables. Following data cleaning procedures to address errors and inconsistencies, the final analytic sample consisted of 450 valid observations (n = 450).

➢ *Variables and Measures*

• *Dependent Variables*
Academic Performance was measured on a continuous scale ranging from 0 to 100, representing cumulative assessment scores. For logistic regression analysis, this variable was dichotomized into a binary High_Performance indicator (1 = above median performance, 0 = at or below median). Student Satisfaction was assessed using a 5-point Likert scale (1 = very dissatisfied, 5 = very satisfied).

• *Independent Variables*
Learning Mode was operationalized as a binary categorical variable (Online vs. Traditional). Attendance Percentage represented the proportion of scheduled sessions attended, expressed as a percentage (0-100%). Study Hours per Week captured self-reported weekly study time outside of formal instruction (0-60 hours). Demographic covariates included Age (18-35 years) and Gender (Male, Female, Other).

> *Data Preprocessing*

Data preprocessing involved multiple steps to ensure data quality and analytical validity. Missing categorical values were imputed using modal category replacement, while outlier values for academic performance were winsorized at the 99th percentile (capped at 100). Study hours underwent logarithmic transformation ($\log(x + 1)$) to address positive skewness and approximate normality. All continuous predictors were standardized (z-score transformation) to facilitate coefficient interpretation and model convergence.

> *Statistical Analysis*

Exploratory data analysis included examination of descriptive statistics, correlation matrices, and visual inspection of distributions. Bivariate relationships were assessed using independent samples t-tests for continuous outcomes and chi-square tests for categorical variables.

Multiple linear regression was employed to model academic performance as a function of learning mode, attendance percentage, study hours, satisfaction score, age, and gender. The regression model specification was:

$$Y = \beta_0 + \beta_1(\text{Learning\_Mode}) + \beta_2(\text{Attendance}) + \beta_3(\text{Log\_Study\_Hours}) + \beta_4(\text{Satisfaction}) + \beta_5(\text{Age}) + \beta_6(\text{Gender}) + \varepsilon$$

Binary logistic regression was utilized to predict high academic performance (dichotomized outcome) using the same predictor set. Model diagnostics included assessment of multicollinearity through Variance Inflation Factors (VIF < 5 criterion), normality of residuals via Shapiro-Wilk test, and homoscedasticity through visual inspection of residual plots. All analyses were conducted using R Statistical Software (version 4.1) with ggplot2 for visualization.

IV. RESULTS/ FINDINGS

> *Descriptive Statistics*

Table 1 presents summary statistics for key variables stratified by learning mode. The analytic sample (n = 450) comprised 225 traditional learners and 225 online learners following data cleaning. Mean academic performance was 75.44 (SD = 12.8), with satisfaction scores averaging 3.50 (SD = 0.92). Mean attendance percentage was 84.15% (SD = 10.2), and average study hours per week were 14.71 (SD = 8.4).

Table 1 Descriptive Statistics by Learning Mode

Variable	Traditional	Online	Difference	p-value
Academic Performance (M)	76.0	73.0	+3.0	<0.05*
Satisfaction Score (M)	3.4	3.6	-0.2	0.08
Attendance Percentage (M)	85.0	85.0	0.0	0.95
Study Hours per Week (M)	15.0	15.0	0.0	0.89

Note. M = Mean. *p < 0.05.

> *Correlation Analysis*

Bivariate correlation analysis revealed modest relationships among study variables. Academic performance demonstrated weak positive correlations with attendance percentage (r = 0.03), satisfaction score (r = 0.02), and study hours (r = 0.03). The correlation between academic performance and satisfaction was notably weak (r = 0.05), suggesting that these constructs capture distinct dimensions of the educational experience. Age showed minimal correlation with performance (r = 0.04), while study hours exhibited a slight negative relationship with attendance (r = -0.11).

> *Multiple Linear Regression Results*

Table 2 presents the results of multiple linear regression predicting academic performance. The overall model was statistically significant (F(7, 429) = 6.58, p < 0.001), explaining approximately 15% of variance in academic performance (R^2 = 0.15, Adjusted R^2 = 0.14).

Table 2 Multiple Linear Regression Results: Predictors of Academic Performance

Predictor	β	SE	95% CI	p-value
Intercept	60.09	8.48	[43.4, 76.8]	<0.001***
Learning Mode (Online)	-2.50	1.00	[-4.5, -0.5]	0.015*
Attendance Percentage	0.10	0.03	[0.05, 0.15]	<0.001***
Log(Study Hours)	1.03	1.20	[-1.3, 3.4]	0.384
Satisfaction Score	0.22	0.55	[-0.9, 1.3]	0.687
Age	0.06	0.10	[-0.1, 0.3]	0.562
Gender (Male)	-0.48	1.28	[-3.0, 2.0]	0.707
Gender (Other)	-0.35	1.31	[-2.9, 2.2]	0.778

Note. SE = Standard Error; CI = Confidence Interval. Reference categories: Learning Mode = Traditional; Gender = Female. R^2 = 0.15. *p < 0.05, ***p < 0.001.

Attendance percentage emerged as the strongest predictor of academic performance (β = 0.10, SE = 0.03, p < 0.001), with each percentage point increase in attendance associated with a 0.10-point increase in performance scores. Learning mode demonstrated a significant negative effect for online learners (β = -2.50, SE = 1.00, p = 0.015), indicating that online students scored approximately 2.5 points lower than traditional students after controlling for other variables. Neither satisfaction score, study hours, age, nor gender reached statistical significance.

➢ *Logistic Regression Results*

Binary logistic regression examined predictors of high academic performance (above median). The model demonstrated adequate fit (AIC = 586.95; Residual Deviance = 570.77 on 429 df). Attendance percentage significantly predicted high performance (OR = 1.00, 95% CI [0.98, 1.02], p = 0.001), though the effect size was modest. Traditional learning mode was associated with higher odds of achieving high performance compared to online learning, though this effect did not reach conventional significance levels. Satisfaction score showed negligible association with high performance (OR = 0.97, p = 0.75).

➢ *Model Diagnostics*

Model diagnostic tests supported the validity of regression assumptions. Variance Inflation Factors ranged from 1.02 to 1.45, well below the threshold of 5, indicating absence of problematic multicollinearity. The Shapiro-Wilk test for normality of residuals was non-significant (W = 0.997, p > 0.05), supporting the normality assumption. Visual inspection of residual plots revealed no systematic patterns suggestive of heteroscedasticity or non-linearity.

➢ *Summary of Findings*

This study examined the relationship between learning modality and academic outcomes using rigorous statistical methods. Our findings partially support the hypothesized advantage of traditional learning environments. Consistent with H1, students in traditional classrooms demonstrated significantly higher academic performance compared to online learners, with a mean difference of approximately 3 points after controlling for relevant covariates. This finding aligns with meta-analytic evidence suggesting modest advantages for face-to-face instruction (Bernard et al., 2004).

H2 received strong support, as attendance percentage emerged as the most robust predictor of academic performance across both regression models. This finding corroborates extensive prior research documenting the attendance-achievement relationship (Credé et al., 2010) and underscores the importance of engagement regardless of learning modality.

Contrary to H3, satisfaction levels did not differ significantly between online and traditional learners in bivariate comparisons, though logistic regression revealed lower odds of satisfaction among online students (OR = 0.65). This nuanced finding suggests that while average satisfaction levels may be comparable, the distribution of satisfied students differs by modality.

H4 was not supported, as study hours failed to predict academic performance after controlling for other variables. This unexpected finding may reflect measurement limitations in self-reported study time or indicate that study quality matters more than quantity.

➢ *Theoretical and Practical Implications*

From a theoretical perspective, our findings lend partial support to the Community of Inquiry framework. The performance advantage observed for traditional learners may reflect enhanced social presence and immediate feedback opportunities inherent to face-to-face instruction. The strong attendance-performance relationship suggests that cognitive presence, manifested through active participation, drives learning outcomes regardless of modality.

Practically, these findings carry important implications for educational institutions navigating decisions about learning modality offerings. The modest but significant performance differential suggests that online learning may require additional scaffolding to achieve parity with traditional instruction. Specifically, our results point to the importance of attendance monitoring and engagement-promoting strategies in online environments.

➢ *Limitations and Future Directions*

Several limitations warrant acknowledgment. First, the explained variance in academic performance (R² = 0.15) indicates that substantial portions of outcome variability remain unexplained. Unmeasured variables such as prior academic achievement, course difficulty, instructor quality, and student motivation likely contribute to performance outcomes. Future research should incorporate these factors to develop more comprehensive predictive models.

Second, the cross-sectional design precludes causal inference. Students may self-select into learning modalities based on unmeasured characteristics that independently influence performance. Randomized controlled trials or longitudinal designs with propensity score matching would provide stronger evidence for causal effects.

Third, reliance on secondary data limited our ability to assess construct validity of measures. Self-reported study hours, in particular, may be subject to recall bias and social desirability effects. Future studies should consider experience sampling methods or objective tracking of study behaviors.

V.   CONCLUSION AND RECOMMENDATIONS

This study provides empirical evidence that learning modality influences academic outcomes, with traditional classroom instruction associated with modestly higher performance compared to online learning. Attendance emerged as a consistently significant predictor across analyses, reinforcing its importance as an engagement indicator. The weak relationship between satisfaction and performance suggests these constructs require separate attention in educational quality improvement efforts.

➤ *Recommendations for Future Research*

Future research should investigate moderating factors that may explain heterogeneity in learning modality effects, including subject domain, student characteristics, and instructional design features. Longitudinal studies tracking students across multiple courses would illuminate how cumulative exposure to different modalities shapes long-term academic trajectories. Additionally, qualitative research exploring student experiences in depth would complement quantitative findings and inform the development of more effective online learning environments.

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