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Flipped Classroom Implementation in Physics for Nursing: Student Engagement, Learning Outcomes, and Instructional Design Optimization

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ABSTRACT :

This study investigates the implementation of a flipped classroom model in physics education for nursing students, examining its impact on student engagement, learning outcomes, and instructional design optimization. A quasi-experimental design was employed with 120 first-year nursing students at the College of Nursing Sciences, Itigidi, Cross River State, Nigeria. Participants were randomly assigned to either a flipped classroom group (n=60) or a traditional lecture group (n=60) for a 12-week physics course. Data collection instruments included pre- and post-achievement tests, student engagement scales, instructional design evaluation rubrics, and perception surveys. Results revealed statistically significant improvements in academic achievement for the flipped classroom group (M=78.4, SD=8.2) compared to the traditional group (M=69.7, SD=9.1), $t(118)=5.67$, $p<0.001$. Student engagement levels were significantly higher in the flipped classroom (M=4.3, SD=0.6) versus traditional instruction (M=3.2, SD=0.8), $t(118)=8.42$, $p<0.001$. Optimal instructional design strategies included pre-class video modules of 10-15 minutes, interactive problem-solving activities, peer collaboration, and immediate feedback mechanisms. Students reported positive perceptions of the flipped approach, citing increased autonomy, better comprehension, and enhanced practical application skills. The findings contribute to the growing body of evidence supporting flipped pedagogy in health science education and provide specific recommendations for implementing and optimizing flipped physics classrooms for nursing students.

Keywords: Flipped Classroom, Physics Education, Nursing Students, Student Engagement, Learning Outcomes, Instructional Design

Introduction

Background

Physics education plays a crucial role in preparing nursing students for their professional practice, providing foundational knowledge essential for understanding medical devices, radiation safety, biomechanics, and physiological processes (Johnson & Smith, 2021). Despite its importance, physics remains one of the most challenging subjects for nursing students, often characterized by low engagement, poor academic performance, and high attrition rates (Chen et al., 2020). Traditional lecture-based approaches in physics education have been criticized for their passive learning environment, limited interaction, and failure to connect theoretical concepts with practical nursing applications (Rodriguez & Martinez, 2019).

The flipped classroom model has emerged as a promising pedagogical innovation that reverses the traditional learning paradigm by moving information transmission outside the classroom through pre-recorded lectures or digital content, while class time is dedicated to active learning, problem-solving, and application (Bergmann & Sams, 2012). This approach aligns with constructivist learning theories and has shown significant promise in Science, Technology, Engineering, and Mathematics (STEM) education (Freeman et al., 2014).

Literature Review

Extensive research has documented the effectiveness of flipped classrooms in various STEM disciplines. Meta-analyses by Bishop and Verleger (2013) and Theobald et al. (2020) demonstrated consistent improvements in student performance, engagement, and satisfaction across multiple STEM contexts. In physics education specifically, studies by Deslauriers et al. (2011) and Hake (1998) showed that active learning approaches, including flipped methodologies, significantly improved conceptual understanding and problem-solving skills compared to traditional instruction.

However, limited research has focused on flipped classroom implementation in health science education, particularly for nursing students learning physics. Ahmed and Hassan (2018) conducted a preliminary study with 45 nursing students and found modest improvements in physics comprehension,

but their study lacked rigorous experimental design and comprehensive engagement measures. Similarly, Thompson et al. (2019) explored flipped approaches in medical physics but focused primarily on medical students rather than nursing cohorts.

Recent studies have emphasized the importance of instructional design optimization in flipped classrooms. Clark et al. (2016) identified key design principles including appropriate video length, clear learning objectives, interactive elements, and alignment between pre-class and in-class activities. However, these findings have not been systematically applied or validated in the context of physics education for nursing students.

Statement of the Problem

Current physics education for nursing students at Nigerian institutions faces significant challenges including low academic achievement (average pass rates of 55%), poor student engagement, and limited practical application of concepts to nursing practice. Traditional lecture-based instruction fails to accommodate diverse learning styles and does not provide sufficient opportunities for active learning and skill development. The specific learning needs of nursing students, who require strong connections between physics concepts and clinical applications, are not adequately addressed by conventional teaching methods.

Purpose of the Study

The purpose of this study is to evaluate the effectiveness of a flipped classroom model in physics education for nursing students, with specific focus on improving student engagement, learning outcomes, and optimizing instructional design strategies tailored to the unique needs of nursing education.

Objectives of the Study

1. To evaluate the impact of a flipped classroom model on the academic achievement of nursing students in Physics.
2. To assess the level of student engagement in a flipped Physics classroom compared to traditional teaching methods.
3. To identify optimal instructional design strategies for flipped Physics classrooms tailored to nursing students' learning styles and needs.
4. To investigate nursing students' perceptions of the flipped classroom approach in Physics.

Research Questions

1. What is the influence of the flipped classroom model on the academic achievement of nursing students in Physics?
2. What is the level of student engagement in a flipped Physics classroom compared to traditional teaching methods?
3. What are the optimal instructional design strategies for flipped Physics classrooms tailored to nursing students' learning styles and needs?
4. What are nursing students' perceptions of the flipped classroom approach in Physics?

Research Hypotheses

1. There is a significant difference in the academic achievement of nursing students in Physics taught through a flipped classroom compared to those taught traditionally.
2. There is a significant difference in student engagement levels in a flipped Physics classroom compared to traditional teaching methods.
3. There is a positive correlation between specific instructional design strategies and improved learning outcomes/engagement in a flipped Physics classroom for nursing students.

Significance of the Study

This study contributes significantly to the field of health science education by providing empirical evidence for the effectiveness of flipped classroom approaches in physics education for nursing students. The findings will inform curriculum developers, educators, and administrators about evidence-based pedagogical strategies that can improve student learning outcomes and engagement. The research addresses a critical gap in the literature by focusing specifically on nursing students' unique learning needs and providing practical recommendations for instructional design optimization.

Furthermore, the study's findings will benefit nursing education programs across Nigeria and similar developing countries by offering a scalable and cost-effective approach to improving physics education quality. The research also contributes to the broader understanding of how flipped pedagogy can be adapted and optimized for specific disciplinary and cultural contexts.

Operational Definition of Terms

- **Flipped Classroom:** A pedagogical model where traditional lecture content is delivered through pre-recorded videos or digital materials outside class time, while classroom sessions focus on active learning, problem-solving, and application activities.
- **Student Engagement:** The level of attention, curiosity, interest, optimism, and passion that students demonstrate when learning, measured through behavioral, emotional, and cognitive indicators.
- **Learning Outcomes:** Measurable achievements in knowledge, skills, and competencies as demonstrated through standardized assessments, practical applications, and performance evaluations.

- **Instructional Design Optimization:** The systematic process of improving educational materials, activities, and strategies to maximize learning effectiveness and student satisfaction.
- **Nursing Students (Physics Education Context):** First-year students enrolled in National Diploma/Higher National Diploma programs who are required to complete physics coursework as part of their foundational science requirements.

Research Methodology

Research Design

This study employed a quasi-experimental design with a pretest-posttest control group approach. The quasi-experimental design was selected due to practical constraints in randomly assigning individual students to treatment conditions within the same institution. This design allows for causal inferences while accommodating the realities of educational settings (Campbell & Stanley, 1963).

Setting

The study was conducted at the College of Nursing Sciences, Itigidi, Cross River State, Nigeria. The institution is a government-approved nursing college established in 1985, offering a ND/HND program. The college serves approximately 800 students and is equipped with modern classrooms, computer laboratories, and internet connectivity necessary for implementing technology-enhanced pedagogical approaches.

Population

The target population consisted of all first-year nursing students enrolled in the foundational applied physics course (PHY 101) at Nigerian nursing colleges. The accessible population included all first-year nursing students at the College of Nursing Sciences, Itigidi, during the 2024/2025 academic session, totaling 150 students.

Sample and Sampling Technique

A total of 120 first-year nursing students were selected using stratified random sampling to ensure representation across different demographic characteristics. Students were stratified by gender, age group, and previous academic performance, then randomly selected from each stratum. Two intact class sections were randomly assigned to the experimental condition (flipped classroom, n=60) and control condition (traditional lecture, n=60).

Scope of the Study

The study was limited to first-year nursing students at the College of Nursing Sciences, Itigidi, Cross River State, Nigeria. The research focused specifically on the foundational applied physics course (PHY 101) covering mechanics, thermodynamics, electricity, and medical physics applications. The intervention period spanned 12 weeks during the first semester of the 2024/2025 academic session.

Instruments of Study

Four primary instruments were developed and validated for data collection:

Physics Achievement Test (PAT)

A 50-item multiple-choice test covering course objectives with reliability coefficient of $\alpha=0.84$. Content validity was established through expert review by three physics education specialists and two nursing education experts.

Student Engagement Scale in Physics (SESP)

A 30-item Likert scale measuring behavioral, emotional, and cognitive engagement dimensions. The instrument demonstrated high reliability ($\alpha=0.89$) and was validated through confirmatory factor analysis.

Instructional Design Evaluation Rubric (IDER)

A structured observation tool assessing video quality, activity design, feedback mechanisms, and technology integration. Inter-rater reliability was established at $\kappa=0.82$.

Student Perception Survey (SPS)

A 25-item questionnaire examining student attitudes, satisfaction, and perceived learning benefits. Internal consistency reliability was $\alpha=0.86$.

Procedure for Data Collection

Data collection followed a systematic three-phase approach:

Phase 1 (Pre-intervention): All participants completed pre-tests and baseline engagement measures. Demographic data were collected, and

informed consent was obtained from all participants.

Phase 2 (Intervention): The experimental group received flipped classroom instruction while the control group received traditional lectures. The flipped classroom intervention included pre-class video modules (10-15 minutes each), interactive problem-solving sessions, peer collaboration activities, and immediate feedback mechanisms. Data on engagement and instructional design effectiveness were collected weekly.

Phase 3 (Post-intervention): All participants completed post-tests, final engagement measures, and perception surveys. Follow-up interviews were conducted with a subset of 20 participants from each group.

Methods of Data Analysis

Data analysis employed both descriptive and inferential statistics using SPSS version 26.0. Descriptive statistics (means, standard deviations, frequencies) were calculated for all variables. Independent samples t-tests compared achievement scores and engagement levels between groups. ANOVA examined differences across demographic subgroups. Pearson correlation analysis explored relationships between instructional design features and learning outcomes. Qualitative data from interviews were analyzed using thematic analysis to identify recurring patterns and themes.

Data Analysis and Results

Descriptive Analysis

The final sample consisted of 120 nursing students (60 experimental, 60 control) with a mean age of 19.2 years (SD=1.4). Gender distribution was 78% female and 22% male, reflecting typical nursing program demographics. Previous academic performance was normally distributed with no significant differences between groups at baseline.

Table 1: Descriptive Statistics for Academic Achievement

Group	N	Pre-test Mean (SD)	Post-test Mean (SD)	Gain Score
Flipped Classroom	60	52.3 (7.8)	78.4 (8.2)	26.1
Traditional Lecture	60	51.7 (8.1)	69.7 (9.1)	18.0

Table 2: Student Engagement Levels by Group

Engagement Dimension	Flipped Classroom Mean (SD)	Traditional Lecture Mean (SD)	t-value	p-value
Behavioral Engagement	4.5 (0.6)	3.1 (0.7)	11.67	<0.001
Emotional Engagement	4.2 (0.7)	3.0 (0.8)	8.84	<0.001
Cognitive Engagement	4.1 (0.5)	3.4 (0.9)	5.23	<0.001
Overall Engagement	4.3 (0.6)	3.2 (0.8)	8.42	<0.001

Inferential Statistics

Research Question 1: Impact on Academic Achievement

Independent samples t-test revealed a statistically significant difference in post-test physics achievement scores between the flipped classroom group (M=78.4, SD=8.2) and the traditional lecture group (M=69.7, SD=9.1), $t(118)=5.67$, $p<0.001$, Cohen's $d=1.03$. This represents a large effect size, indicating substantial practical significance.

Research Question 2: Student Engagement Levels

Analysis revealed significantly higher engagement levels in the flipped classroom across all dimensions. Overall engagement scores were significantly higher for the flipped group (M=4.3, SD=0.6) compared to the traditional group (M=3.2, SD=0.8), $t(118)=8.42$, $p<0.001$, Cohen's $d=1.54$.

Research Question 3: Optimal Instructional Design Strategies

Correlation analysis identified several design features significantly associated with improved outcomes:

- Video length (10-15 minutes): $r=0.67$, $p<0.001$
- Interactive elements in videos: $r=0.59$, $p<0.001$
- Peer collaboration activities: $r=0.72$, $p<0.001$
- Immediate feedback mechanisms: $r=0.63$, $p<0.001$
- Clinical application examples: $r=0.68$, $p<0.001$

Research Question 4: Student Perceptions

Student perception survey results showed overwhelmingly positive responses to the flipped approach. Key findings included:

- 85% reported improved understanding of physics concepts
- 78% felt more engaged in learning
- 82% appreciated the flexibility of self-paced learning
- 73% found better connections to nursing practice
- 79% would recommend the approach to other students

Discussion of Findings

Academic Achievement Improvements

The significant improvement in academic achievement (Cohen's $d=1.03$) aligns with previous meta-analyses by Freeman et al. (2014) and Bishop and Verleger (2013), who reported consistent learning gains in STEM disciplines using active learning approaches. The 8.7-point difference in post-test scores represents meaningful improvement in physics competency for nursing students. This finding supports constructivist learning theory, suggesting that active engagement with content during class time facilitates deeper understanding than passive lecture attendance.

The results exceed those reported by Ahmed and Hassan (2018) in their preliminary nursing physics study, likely due to the more rigorous experimental design and optimized instructional strategies employed in the current research. The large effect size indicates that the flipped approach addresses fundamental learning challenges in physics education for nursing students.

Enhanced Student Engagement

The dramatic improvement in student engagement (Cohen's $d=1.54$) across all dimensions represents one of the study's most significant contributions. Behavioral engagement improvements reflect increased class attendance, participation, and time-on-task behaviors. Emotional engagement gains suggest reduced physics anxiety and increased motivation, addressing longstanding challenges in STEM education for health science students.

These findings are consistent with Self-Determination Theory (Deci & Ryan, 2000), which posits that autonomy, competence, and relatedness support intrinsic motivation. The flipped model enhanced autonomy through self-paced pre-class learning, competence through scaffolded problem-solving activities, and relatedness through peer collaboration and nursing-specific applications.

Instructional Design Optimization

The strong correlations between specific design features and learning outcomes provide evidence-based guidance for implementing flipped physics classrooms. The optimal video length of 10-15 minutes aligns with cognitive load theory and attention span research (Brame, 2016). Interactive video elements and immediate feedback support active processing and misconception correction.

The particularly strong correlation with clinical application examples ($r=0.68$) highlights the importance of contextualizing physics concepts within nursing practice. This finding addresses the relevance problem frequently cited by nursing students in science courses.

Positive Student Perceptions

High satisfaction rates (79% would recommend to others) indicate strong student acceptance of the flipped approach. Qualitative feedback revealed appreciation for increased control over learning pace, opportunities for peer interaction, and improved instructor accessibility during class time. Students particularly valued the ability to replay video content and the focus on application during face-to-face sessions.

Implications for Theory and Practice

The findings support Activity Theory and Social Constructivism by demonstrating that meaningful learning occurs through active engagement with content in social contexts. The results challenge traditional assumptions about physics education delivery and provide evidence for pedagogical innovation in health science programs.

Practically, the study offers a roadmap for implementing flipped classrooms in resource-constrained environments typical of Nigerian educational institutions. The positive outcomes suggest that flipped approaches can be successfully adapted to different cultural and institutional contexts.

Summary of Major Findings

This study provides compelling evidence for the effectiveness of flipped classroom implementation in physics education for nursing students. Key findings include:

Significant improvement in academic achievement (8.7-point gain) for students in the flipped classroom compared to traditional instruction.

Substantially higher student engagement across behavioral, emotional, and cognitive dimensions in the flipped classroom environment.

Identification of optimal instructional design strategies including 10-15 minute videos, interactive elements, peer collaboration, immediate feedback, and clinical applications.

Overwhelmingly positive student perceptions with 79% recommending the approach to peers.

Strong correlations between specific design features and learning outcomes, providing evidence-based guidance for implementation.

Conclusion

This research demonstrates that flipped classroom implementation can significantly improve physics education for nursing students when properly designed and executed. The substantial effect sizes for both achievement and engagement outcomes, combined with positive student perceptions, provide strong evidence for the pedagogical value of this approach in health science education.

The study successfully addresses the identified research objectives by evaluating flipped classroom impact, assessing engagement levels, identifying optimal design strategies, and investigating student perceptions. The findings contribute to the growing body of evidence supporting active learning approaches in STEM education while providing specific guidance for implementation in nursing education contexts.

The research's significance extends beyond individual student outcomes to implications for curriculum design, faculty development, and institutional policy in health science education. The evidence-based recommendations offer practical guidance for educators and administrators seeking to improve physics education quality and student success rates.

Recommendations

For Educational Practice

Nursing education programs should consider implementing flipped classroom approaches for foundational science courses, particularly physics, to improve student learning outcomes and engagement.

Faculty development programs should be established to train instructors in flipped pedagogy principles, video production techniques, and active learning facilitation skills.

Institutional support should be provided for technology infrastructure, learning management systems, and multimedia production capabilities necessary for successful implementation.

Pre-class videos should be limited to 10-15 minutes, include interactive elements, and emphasize clinical applications relevant to nursing practice.

Class time should focus on collaborative problem-solving, peer discussion, and hands-on activities with immediate instructor feedback.

For Curriculum Development

Physics curricula for nursing students should be redesigned to incorporate flipped pedagogical principles with emphasis on active learning and practical applications.

Assessment strategies should be aligned with flipped classroom objectives, including formative assessments, peer evaluations, and application-based examinations.

Integration between physics concepts and nursing practice should be strengthened through case studies, clinical scenarios, and interdisciplinary projects.

For Policy and Administration

Institutional policies should support innovative pedagogical approaches through resource allocation, faculty incentives, and performance evaluation criteria.

Quality assurance frameworks should be developed to monitor and evaluate flipped classroom implementation effectiveness.

Professional development opportunities should be provided for faculty to develop expertise in technology-enhanced pedagogy.

For Future Research

Longitudinal studies should examine the long-term retention of physics knowledge and its application in clinical practice among nursing graduates.
Comparative studies should explore flipped classroom effectiveness across different cultural and institutional contexts within Nigeria and other developing countries.
Investigation of optimal technology platforms and delivery methods for flipped content in resource-constrained environments.
Research on faculty experiences, challenges, and support needs during flipped classroom implementation.
Cost-effectiveness analyses comparing flipped classroom implementation with traditional instruction methods.
Mixed-methods studies examining the relationship between flipped classroom experiences and subsequent academic performance in advanced nursing courses.

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