THE ROLE OF ACTIVE LEARNING STRATEGIES IN IMPROVING PHYSICS EDUCATION AT THE UNDERGRADUATE LEVEL

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Abstract

This paper explores the involvement of the use of active learning strategies in enhancing the teaching of physics at the undergraduate level. A mixed-methods design was used to select 100 students who were split into a control group (tradition teaching) and an experimental group (active learning). The data were obtained after conducting pre- and post-tests, surveys, classroom observations, and records of academic performance. Findings suggest that, students who were subjected to active learning displayed a much better conceptual mastery, interest, and academic learning than students taught using conventional methods. The results indicate the usefulness of student centered methodologies in developing critical thinking, team work and motivation thus active learning is a useful tool in developing physics education at the undergraduate level.

Keywords: *Active Learning, Physics Education, Undergraduate Students, Academic Performance, Student Engagement.*

1. INTRODUCTION

Physics being a fundamental subject of science is essential in developing the analytical and problem-solving of the students. However, the nature of undergraduate physics education has been challenged by passive learning, lack of engagement and conceptual understanding when learner is instructed in the traditional methods of lecturing. Physics is often viewed as abstract, challenging by many students, hence making them less interested and less performing well. Active learning strategies are being adopted by educators across the globe in order to overcome such problems and this approach focuses on participation, involvement, and cooperation by students. Active learning changes the teacher-centered approach towards teaching to the student-centered learning that encourages learners to discuss, solve problems, teach each other, and conduct hands-on experiences. It has been illustrated that these strategies do not only improve academic performance but they also stimulate critical thinking, creativity and motivation. In this regard, it will be important to analyze how active learning could contribute to the enhancement of undergraduate physics learning because it may offer meaningful information on how effective teaching practices should be structured and meaningful learning experiences facilitated.

1.1. Objectives of the Study

- To assess how well students' conceptual understanding of physics is improved through the use of active learning methodologies.

- To determine how active learning affects physics course participation and engagement among undergraduates.
- To determine the effect of active learning strategies on physics students' comprehension and ability to solve problems.

2. LITERATURE REVIEW

Fazio (2020) describes some of the most common active learning techniques in physics instruction and briefly describes some of the psychological and pedagogical concepts that support active learning. The role of the active learning in promoting conceptual knowledge and critical thinking skills of students is then explored. The expediency of an investigation-based learning approach in aiding students to achieve mechanisms of functioning and explanatory models, besides in discerning similarities among what appear to be unrelated events, is concisely reviewed in a study example.

Fazio et al., (2021) products of a symposium which comprised numerous contributions to the active learning research field. To show how active learning involves thoughts and then a response and feedback, we shall start with a system analysis of the mental processes in learning physics. Then, we describe a new approach to active learning in which students will participate in theatrical activities of physics nature. The evidence of application of active engagement methods in physics teacher training courses is then provided. Finally, but not the least, an investigation of inquiry-based learning strategy among the pre-service physics educators is provided within the context of socioscientific issues.

Apkarian et al., (2021) Survey data from 3769 instructors is used to examine introductory STEM courses. Three beliefs concentrate on contextual elements, such as class size, classroom design, and teacher evaluations; three beliefs concentrate on individual elements, such as job stability, research endeavors, and previous exposure. According to the data, teachers can and do use active learning in their classes regardless of the circumstances. Nonetheless, trends in the data support assumptions about how these factors affect the use of active learning, with the exception of job stability. We talk about how these findings may affect departmental and institutional policies that support the use of active learning.

Dou et al., (2018) Examining three undergraduate MI courses (N = 221) revealed a decline in students' interest in general science, physics, and physics self-efficacy. We found a negative correlation between self-efficacy and scientific interest and a positive correlation between self-efficacy and interest in physics. Applying structural equation modeling, we confirmed that student interactions have a favorable effect on self-efficacy. This study provides nuanced insights into the role of interest and self-efficacy as learning constructs in undergraduate active-learning science classes, and it situates classroom interactions within broader frameworks of career theory.

3. RESEARCH METHODOLOGY.

3.1. Research Approach

This mixed-methods study uses both quantitative and qualitative techniques to investigate active learning strategies in undergraduate physics instruction. This approach offers a comprehensive view of student views and learning outcomes.

3.2. Research Design

An experimental design will be employed, where one group of students is taught using traditional lecture-based methods (control group) and another group using active learning

strategies (experimental group). Comparative analysis will highlight the impact of the strategies.

3.3. Population and Sample

The sample of study will be undergraduate physics students. The purposive sampling tool will be employed to sample two sections in the same course which have 50 students each so that the academic backgrounds remain similar. Therefore, the sample will comprise 100 students.

3.4. Data Collection Methods

- Pre-test and Post-test: This will be used to assess the conceptual knowledge and learning among the students prior to and after instruction.
- Questionnaires/Surveys: To gather the Perceptions, level of engagement and feedback of the students on their methods of learning.
- Classroom observations: To evaluate the student participation, collaboration and interaction.
- Academic Performance Records: To assess the improvement in solving problems and performance in exams.

3.5. Data Analysis

- Quantitative Data: The statistical analysis will be performed with the help of statistical tools (e.g., paired t-test, ANOVA) to identify significant differences between groups in the following data: Pre-test and post-test scores, exam results, and surveys ratings.
- Qualitative Data: Open-ended survey responses and classroom observation notes will be analyzed through thematic analysis to identify common patterns and insights.

4. RESULTS AND DISCUSSIONS

Table 1: Control and Experimental Group Pre- and Post-test Scores

Group	N	Mean Pre-test Score	Mean Post-test Score	Mean Gain	t-value	p-value
Control (Traditional)	50	42.3	56.8	+14.5	2.15	0.036
Experimental (Active Learning)	50	41.7	72.5	+30.8	5.92	0.001

The experimental group high in exposure to active learning strategies had a significantly greater mean gain of the group (+30.8) than the control group (+14.5). This contrast is statistically significant ($p < 0.05$), which proves that conceptual learning is better promoted in physics through active learning than through traditional teaching.

Table 2: Student Engagement Levels

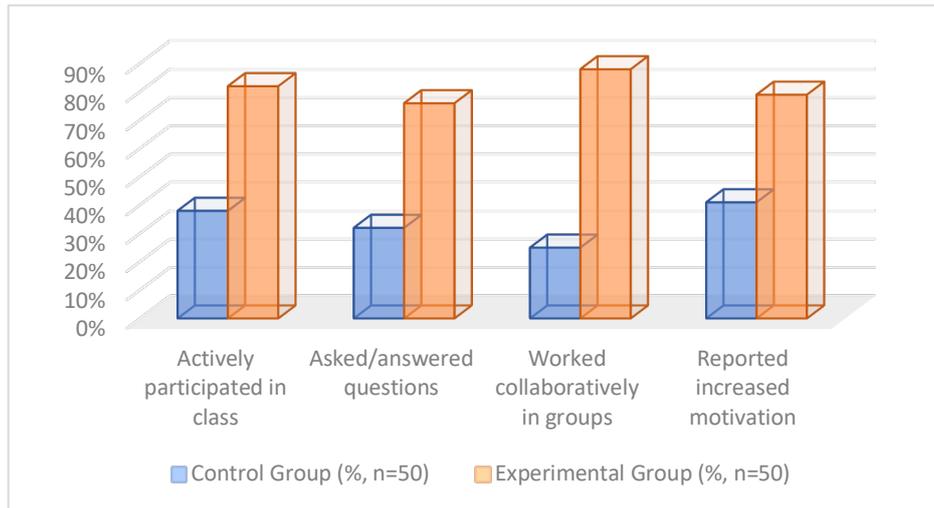| Engagement Indicator	Control Group (%, n=50)	Experimental Group (%, n=50)
Actively participated in class	38%	82%
Asked/answered questions	32%	76%
Worked collaboratively in groups	25%	88%
Reported increased motivation	41%	79%

Figure 1: Graphical representation on Student Engagement Levels

All the indicators of higher engagement were reported among the students in the experimental group, so active learning does not only improve performance but also motivates, helps to collaborate with peers and participate.

Table 3: Academic Performance

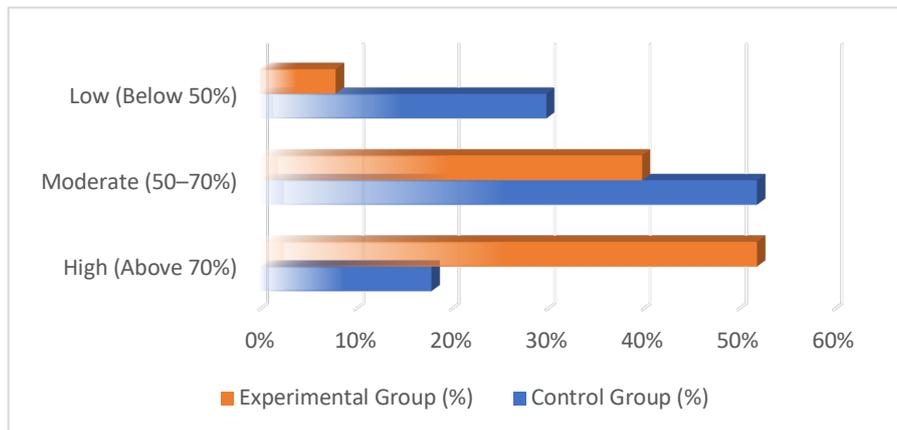| Performance Category	Control Group (%)	Experimental Group (%)
High (Above 70%)	18%	52%
Moderate (50–70%)	52%	40%
Low (Below 50%)	30%	8%

Figure 2: Graphical representation of Academic Performance

The distribution indicates that active learning led to the decreasing number of low-achieving students and more students were shifted to the high-achievement group, which indicates that active learning has a positive impact on academic performance.

5. CONCLUSION

The study found that active learning plans improve undergraduate physics instruction. Active learning students had better conceptual knowledge, involvement, and problem-solving skills than lecture-based students, according to pre-test, post-test, student engagement survey, and academic performance records. Collaboration, critical thinking and motivation were also enhanced through active learning and hence low achieving students were minimized and more learning was enhanced. These findings indicate that the transition of teacher to student based

instruction does not only improve academic performance but also develop student skills that are necessary in lifelong learning. Thus, the active learning strategies in undergraduate physics classrooms can be discussed as an efficient and the sustainable educational practice to support science education.

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