International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Action Research on Addressing Persistent Misconceptions in Physics through a Multimodal Classroom Approach

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Abstract

Misconceptions in physics classrooms often arise when students rely on intuitive reasoning developed from everyday experiences rather than scientific principles. At the secondary level, such misconceptions frequently persist because classroom instruction tends to emphasize procedural problem solving over conceptual understanding. This action research study examines a classroom-based instructional intervention designed to systematically confront and restructure students' alternative conceptions in physics.

The intervention employed a multimodal teaching approach combining guided questioning, interactive simulations, hands-on experimentation, virtual laboratory activities, and short conceptual videos. The study was conducted with approximately 150 students of Grades XI and XII over a four-week instructional cycle covering selected concepts from mechanics, electricity, and optics. Conceptual diagnostic assessments and structured classroom observations were used to evaluate learning outcomes.

Post-intervention analysis revealed a substantial shift in students' reasoning patterns, with learners demonstrating improved conceptual clarity, increased engagement, and greater confidence in explaining physical phenomena using scientific language. The findings suggest that embedding multimodal strategies within routine classroom practice can effectively support conceptual restructuring and provide physics teachers with a sustainable method for addressing persistent misconceptions.

Keywords: Physics misconceptions; action research; conceptual understanding; multimodal pedagogy; secondary education

1. Introduction

Physics education plays a crucial role in developing scientific literacy, analytical thinking, and problem-solving abilities essential for participation in a technology-driven society. Despite its importance, physics is often perceived by students as abstract and difficult. One major reason for this challenge is the presence of misconceptions—alternative conceptions formed through everyday experiences, informal observations, and intuitive reasoning [3].

Students frequently believe that a continuous force is required to maintain motion, that electric current is consumed by devices, or that images can only be formed on screens. Although these ideas appear logical from a daily-life perspective, they contradict established scientific principles. Research indicates that such misconceptions often persist even after formal instruction [1].

Traditional lecture-based pedagogy, which emphasizes formula derivation and numerical problem solving, often fails to challenge these deeply rooted beliefs. Action research enables teachers to critically examine their own instructional practices and implement targeted classroom interventions. This study adopts an action research approach to explore how a multimodal instructional strategy can support conceptual change in senior secondary physics.

2. Review of Related Literature

Research in physics education has consistently shown that misconceptions are not simple factual errors but coherent cognitive structures that compete with scientific explanations [3]. Learners interpret new information through their existing mental models, making misconceptions resistant to change.

Conceptual change theory emphasizes that meaningful learning occurs when students experience dissatisfaction with their existing ideas and are guided toward scientifically acceptable explanations that are intelligible and plausible [2].

Interactive engagement methods have been found to promote conceptual change more effectively than traditional lectures. Hake's large-scale study demonstrated significantly higher learning gains in classrooms using interactive engagement strategies [1].

Digital tools such as simulations and virtual laboratories allow students to visualize abstract processes and test predictions. PhET simulations, in particular, have been shown to support inquiry-based learning when integrated with guided questioning and experimentation [4]. However, research also cautions that digital tools are most effective when combined with hands-on activities and reflective discussion.

3. Objectives of the Study

The objectives of this action research were to:

Identify prevalent misconceptions in selected topics of senior secondary physics.

Design and implement a multimodal instructional approach to address these misconceptions.

Examine changes in students' conceptual understanding following the intervention.

Observe shifts in student engagement and scientific reasoning during classroom instruction.

4. Methodology

4.1 Research Design

An action research design employing a mixed-methods approach was adopted. The study followed a plan–act–observe–reflect cycle within the regular classroom environment.

4.2 Sample

The study involved approximately 150 students from Grades XI and XII studying physics. The participants represented diverse academic abilities and learning backgrounds.

4.3 Research Tools

Diagnostic Misconception Test: Conceptual questions related to mechanics, electricity, and optics, informed by commonly reported misconceptions [3].

Observation Checklist: Used to document student participation, questioning behavior, peer interaction, and use of scientific terminology.

Instructional Resources: PhET simulations [4], low-cost laboratory materials, virtual laboratory platforms, and curated instructional videos.

4.4 Procedure

A diagnostic pre-test was administered to identify common misconceptions. The multimodal instructional intervention was implemented over four weeks during regular physics classes. A post-test and systematic classroom observations were used to assess conceptual change and learner engagement.

5. Identification of Common Misconceptions

Analysis of the diagnostic pre-test revealed several recurring misconceptions across different domains of physics, consistent with earlier research findings [3]. These misconceptions are summarized in Table 1.

Table 1: Frequently Observed Physics Misconceptions among Students

Physics Domain	Concept Area	Common Student Misconception
Mechanics	Laws of Motion	Continuous force is required to maintain motion
Mechanics	Falling Bodies	Heavier objects fall faster than lighter ones
Electricity	Electric Current	Current is consumed by electrical appliances
Electricity	Electric Circuits	Battery supplies constant current irrespective of circuit
Optics	Image Formation	Images can only be formed on a screen
Optics	Reflection	Angle of incidence depends on surface roughness

6. Multimodal Classroom Intervention

The instructional intervention was implemented in four structured stages:

6.1 Elicitation of Prior Knowledge

Students were encouraged to predict outcomes, justify reasoning, and engage in peer discussions, enabling the teacher to identify intuitive beliefs [2].

6.2 Conceptual Conflict through Simulations

PhET simulations were used to test student predictions and generate outcomes that contradicted intuitive reasoning, creating cognitive conflict [4].

6.3 Hands-on Experiments

Low-cost laboratory experiments were conducted to reinforce simulation results and connect abstract concepts with observable phenomena, supporting interactive engagement [1].

6.4 Reflection and Multimedia Integration

Instructional videos and guided discussions helped students consolidate learning and articulate scientifically accurate explanations.

7. Results and Discussion

A comparison of pre-test and post-test results indicated substantial improvement in students' conceptual

understanding across all selected domains (Table 2).

Table 2: Improvement in Conceptual Understanding after Multimodal Intervention

Topic Area	Pre-Test Understanding (%)	Post-Test Understanding (%)	Observed Learning Trend
Mechanics	42	72	High improvement
Electricity	39	68	Moderate to high improvement
Optics	45	67	Moderate improvement

The highest learning gains were observed in mechanics, where misconceptions are strongly rooted in everyday experience. Classroom observations revealed increased student participation, richer peer discussions, and greater confidence in explaining physical phenomena using scientific language. These findings align with previous research highlighting the effectiveness of interactive and inquiry-based instructional approaches [1], [2].

8. Educational Implications

The findings underscore the limitations of lecture-dominated instruction and highlight the importance of student-centered learning environments. Physics teachers should deliberately integrate simulations, experiments, and multimedia resources to explicitly address misconceptions. The proposed multimodal approach is cost-effective, flexible, and easily adaptable to diverse classroom contexts.

9. Limitations and Scope for Future Research

The study was limited to a single group of students and a short intervention period. Future research may involve control groups, extended intervention durations, and application of the framework across different grade levels and institutional settings.

10. Conclusion

This action research study demonstrates that a multimodal classroom approach effectively supports conceptual change in senior secondary physics. By systematically confronting students' intuitive beliefs through simulations, experimentation, and reflective learning, teachers can foster deeper conceptual understanding and scientific reasoning. The study offers a practical and sustainable instructional model for addressing persistent misconceptions in physics classrooms.

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