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Report

Pedagogical Strategies for Enhancing Physics Education for Pre-Physical Therapy Students

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Abstract

This study explores instructional strategies designed to improve engagement and learning outcomes in introductory physics courses for non-science majors, focusing on pre-physical therapy (pre-PT) students. Given that many of these students lack a robust mathematical background, the teaching approach aims to bridge this gap through structured problem-solving frameworks, hands-on activities, and contextual applications that link physics principles to health sciences. To address this, a teaching approach was developed over three years in two courses at Widener University in Pennsylvania: College Physics I (Mechanics and Heat) and College Physics II (Electricity and Magnetism). This approach combines structured problem-solving frameworks, real-world applications, hands-on activities, and active learning techniques. By emphasizing the relevance of physics concepts to health sciences, such as using examples from biomechanics and neuroelectric signaling, students are encouraged to connect theory with practical applications in their future careers. The structured problem-solving framework simplifies complex physics problems into manageable steps, fostering both computational and conceptual understanding. Interactive assignments and discussion threads further enhance engagement, while activities focused on scientific communication help students articulate complex ideas clearly. These methods helped students to approach physics as an interconnected field relevant to their future careers rather than isolated quantitative challenges. Assessments, including course evaluations and student feedback, indicate that this approach not only enhances conceptual understanding but also fosters scientific communication skills critical for healthcare professions. The findings contribute to a growing body of research suggesting that tailored physics curricula can significantly improve engagement and success among non-science majors pursuing professional healthcare pathways.

Keywords

Physics Education, Pre-physical Therapy, Pedagogical Strategies, Interdisciplinary Teaching, Student Engagement

1. Introduction

Introductory physics courses play a foundational role across a wide range of academic disciplines, including health sciences, engineering, and general science programs [1, 2]. Despite this, students outside of the physical sciences, particularly those pursuing careers in healthcare, often encounter significant challenges when engaging in physics. Many of these students, including those interested in fields like physical therapy (PT), have limited prior experience with mathematics and quantitative reasoning. For them, physics can seem daunting—more a barrier than a bridge to their professional goals [3, 4]. However, these students bring their own strengths to the classroom: they are often highly motivated, ca-

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reer-focused, and eager to understand the practical applications of physics in their chosen fields.

This paper examines a three-year teaching experience in two introductory algebra-based physics courses—College Physics I (Mechanics and Heat) and College Physics II (Electricity and Magnetism)—designed specifically for non-science majors. The primary focus was on students intending to enter health-related careers, such as Physical Therapy, where understanding physics concepts could directly impact their ability to succeed professionally. Recognizing the unique challenges these students face, the course was tailored to support their limited experience in math-intensive subjects while emphasizing the relevance of physics to healthcare. This approach aimed not only to reduce student apprehension but also to cultivate a sense of relevance and curiosity about the role of physics in real-world applications related to health and wellness [5].

To enhance the accessibility of physics content, several strategies were implemented: structured, interactive lectures that combined visual aids with group activities, problem-solving frameworks designed to simplify complex problems [6, 7], and innovative assignments that connected course material to future career contexts [8-10]. Recognizing the importance of fostering scientific literacy in health professions, the course also incorporated hands-on activities, including practical experiments and projects that illustrate theoretical concepts through experiential learning [11-14]. Additionally, the course integrated assignments focused on developing communication skills, a critical component of healthcare professions [15, 16]. These assignments encouraged students to articulate physics concepts using clear, precise language, both verbally and in writing, laying a foundation for scientific literacy that they could carry forward in their careers.

Over three academic years, this study explored how these methods influenced student engagement, motivation, and conceptual understanding in physics. The effectiveness of the teaching approach was assessed through course evaluations, direct observations, and qualitative feedback from students. Initial observations indicated that by making physics concepts more relevant to their career goals and providing a supportive, structured learning environment, students were better able to overcome their initial hesitation towards the subject. For instance, applications of mechanics and electromagnetism to human anatomy and physiological processes gave students a new perspective on how physics principles operate within the human body, deepening their understanding of the importance of these concepts in their future healthcare roles.

This paper aims to contribute to a growing body of literature on contextualized learning and STEM education for non-science majors. By examining the impact of teaching strategies tailored to pre-PT students, it highlights the potential for physics courses to be more inclusive and supportive of diverse academic backgrounds. The findings suggest that, when students can relate physics concepts to personal or professional interests, their engagement and retention improve, transforming physics from an abstract subject into a practical tool with clear connections to their future careers.

2. Materials and Methods

The study involves non-science major students enrolled in an algebra-based introductory physics course at Widener University in Pennsylvania comprising a total of 62 participants who are pursuing pre-professional healthcare pathways. Instructional strategies included:

1. Well-structured teaching methods: Combining PowerPoint lectures, whiteboard notes, group work, and innovative quizzes.
2. Problem-solving strategies: Breaking down complex problems and providing step-by-step explanations.
3. Real-world applications: Relating physics concepts to students' future careers in health sciences through specific examples and assignments.
4. Hands-on activities: Incorporating practical experiments and projects to enhance learning and connect theoretical concepts to real-world scenarios.
5. Fostering scientific communication skills: Guiding students in articulating physics concepts using precise terminology and encouraging peer instruction.
6. Building personal connections: Creating a positive and supportive learning environment through activities such as "write & share" sessions and guest lectures.

3. Results

3.1. Structured Problem-Solving

Recognizing that many pre-physical therapy students are less experienced in the quantitative skills traditionally expected in physics courses, the instructor developed a structured problem-solving methodology designed to scaffold their learning process. This framework breaks down complex physics problems into four distinct steps:

1. Identification of Known and Unknown Variables: Students are first guided to list all relevant information provided in the problem and to explicitly state the unknowns they need to solve for.
2. Application of Physics Principles: Next, students are encouraged to connect the problem at hand with the appropriate physical laws or concepts, such as Newton's laws, conservation principles, or electrical laws, depending on the context of the problem.
3. Symbolic Representation: Prior to numerical substitution, students are required to write the relevant equations symbolically, fostering an understanding of the relationship between physical quantities beyond mere computation.
4. Algebraic Manipulation and Solution: Only after un-

derstanding the symbolic form do students proceed with the algebraic manipulation necessary to solve the problem numerically.

This structured approach not only facilitates problem-solving but also promotes a conceptual understanding of the physical laws underpinning the calculations. It encourages students to view physics not as a set of disjointed numerical exercises but as a coherent framework for understanding the natural world. This method aligns with cognitive load theory [7], which suggests that breaking down complex tasks into manageable steps can enhance learning, particularly for students with weaker backgrounds in the subject matter.

3.2. Discipline-Specific Applications

To make physics more relevant to students in health sciences, the instructor deliberately integrates real-world examples and applications related to their future professional fields. For example, in College Physics I (Mechanics and Heat), students analyzed the kinematics of a swinging leg modeled as a simple pendulum and explored the rotational dynamics of a dancer through the conservation of angular momentum. In College Physics II (Electricity and Magnetism), electrical circuits are connected to biological processes such as nerve impulse propagation, emphasizing the electrochemical basis of neuronal communication.

Additionally, the instructor facilitates discussion threads on digital learning platforms (such as *Canvas*) focused on topics such as "How Electricity and Magnetism Work in the Human Body." In this discussion assignment, each student posts 1-3 articles or videos related to a topic of interest and formulates five questions about the materials they shared. To earn full points for this assignment, each student must also respond to at least two of their peers' posts and answer their questions. The students work in the Spring 2024 covers a wide range of topics, such as Electromyography, Electrostimulation used by Physical Therapist, 'Can Humans Sense Magnetic Fields' and Neuron Action Potentials. The students can learn at least 3 applications of electromagnetism in human bodies by the end of these discussions. Here is the example rubric of this discussion thread:

Discussion Topic: How Do Electricity and Magnetism Function in the Human Body?

Part I – Initial Post

1. Select a specific topic related to electricity or magnetism in the human body that interests you.

2. Share links to relevant articles or videos that provide insights into your chosen topic.

3. Develop at least five questions based on your shared resources for your classmates to explore while reading or watching the material.

Part II – Responding to Your Classmates

1. Choose at least two of your classmates' posts and answer their questions.

2. It's okay if you can't find the answer to a couple of their questions. However, to earn full credit, be sure to answer at least 80% of their questions.

These discussions are designed to demonstrate the applicability of physics concepts in students' chosen careers and to provide motivation for engagement with the material. This approach is consistent with the literature on contextual learning [8-10], which suggests that students are more likely to engage with and retain information when it is directly connected to their personal or professional interests.

3.3. Active Learning and Engagement

In conjunction with structured problem-solving and contextualized applications, the instructor employs active learning techniques to engage students and reinforce their understanding of key concepts. For instance, in College Physics I, students participate in hands-on experiments measuring human reaction times using simple apparatuses, which provides a practical application of free-fall motion. Similarly, in College Physics II, students construct creative electric circuits using LEDs and sensors, allowing them to visualize and manipulate the principles of electricity and magnetism in an interactive format.

These activities are designed to shift the classroom dynamic from passive receipt of information to active engagement with material, consistent with the evidence supporting active learning as a means of improving student outcomes in STEM disciplines. By integrating these exercises into the curriculum, students are able to develop a deeper and more intuitive understanding of abstract concepts, while simultaneously fostering a sense of collaboration through group-based problem-solving.

3.4. Scientific Communication Skills

A key component of our pedagogical approach in physics education for students in pre-professional healthcare pathways is the development of students' scientific communication skills. Recognizing that many students in these courses will enter health professions where clear and precise communication of scientific concepts is essential, the instructor incorporated assignments that required students to articulate their understanding of physics both verbally and in writing.

For example, students are tasked with producing short video lectures explaining fundamental physics concepts, a format that required them to simplify and communicate complex ideas clearly, such as explaining the projectile motion, force analysis and the motion of bicycle wheels. This exercise not only enhances their comprehension but also provides them with a transferable skill set applicable in both academic and professional contexts. In addition, peer review of these video projects encourages collaborative learning, as students worked together to refine their explanations and correct misconceptions.

4. Discussion

The instructional strategies described herein have led to marked improvements in both student engagement and learning outcomes, as reflected in both qualitative and quantitative measures. Course evaluations consistently indicate that students appreciate the structured problem-solving framework and the relevance of course material to their professional goals. For instance, many students commented on how the explicit connection between physics and health sciences increased their motivation to engage with the subject matter, with some reporting that these connections helped demystify physics and make it more approachable.

Quantitatively, exam scores over the three-year period have shown a steady improvement, particularly in the areas of problem-solving and conceptual understanding. The structured approach to problem-solving, in particular, has been highly effective in reducing the number of errors due to poor mathematical manipulation or misunderstanding of fundamental principles.

The active learning exercises, especially those involving hands-on experiments and group work, were similarly well-received, with students reporting that these activities helped them apply theoretical knowledge in a practical context. These findings are consistent with the broader literature on the effectiveness of active learning in improving student outcomes in STEM disciplines [11-14].

5. Conclusion

The challenges of teaching algebra-based physics to non-science majors, particularly those in health-related fields, can be addressed through integrating pedagogical strategies that bridge the gap between abstract physics concepts and their practical applications for pre-physical therapy students. By employing structured problem-solving techniques, contextualizing physics principles through real-world examples, and engaging students with active learning exercises, the instructor has significantly enhanced student motivation and performance. The application of physics in human physiology, biomechanics, and electromagnetism has made the subject more relevant and accessible to students pursuing health science careers. These methods have improved both conceptual understanding and problem-solving abilities, as evidenced by increased engagement, higher exam scores, and positive course evaluations. The success of this approach underscores the value of interdisciplinary teaching and the need for continued innovation in physics education for pre-professional healthcare students.

Abbreviations

Pre-PT	Preliminary Physical Therapy Program
STEM	Science, Technology, Engineering, and Math
LED	Light-Emitting Diode

Author Contributions

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Conflicts of Interest

The author declares no conflicts of interest.

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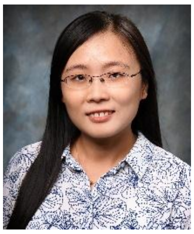
Biography



Xin Du is currently an Assistant Professor of Physics at Widener University, a position held since 2021. Before that, she served as an Assistant Professor at Aquinas College, where she chaired the Department of Physics from 2018 to 2021. She completed her PhD in Physics from Emory University in 2016, and B.S in physics from Nanjing University (China) in 2010. In addition to teaching, her research interests focus on the areas of soft matter physics and the dynamics of complex systems. She has also secured external funding from the U.S. Department of Energy, receiving competitive grants in both 2023 and 2024 to study the dynamics of spin glasses and the interplay of entropy and energy in glassy systems during their tenure as a Visiting Faculty at Brookhaven National Laboratory. She currently serves on the board of AAPT SEPS (American Association of Physics Teachers Southeastern Philadelphia Section).

Research Field

Xin Du: Soft Matter Physics, Jamming Transition, Glass Transition, Physics Education