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Learning basic physics in Pharmacy Study Program with systems thinking skills needed by pharmacy students

Meiry Akmara Dhina[a,b]*, Ida Kaniawati[a], Yusi Riksa Yustiana[a]

[a]Universitas Pendidikan Indonesia, Dr. Setiabudi St., No. 229, Bandung, West Java, 40154, Indonesia
[b]Universitas Al-Ghifari, Cisaraten Kulon St., No 140, Bandung, West Java, 40293, Indonesia
e-mail: meiryakmara@upi.edu
* Corresponding Author.

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Abstract: This research is a preliminary study aimed at analyzing the methods of teaching basic physics applied in the pharmacy program, as well as its implications for the relevance of physics concepts in pharmacy courses and the development of students' system thinking skills. A cross-sectional survey method was used, employing a structured questionnaire based on the Likert scale, involving physics course instructors from private and public universities. The research findings indicate that, although basic physics has significant potential in contributing to the development of the system thinking skills required by pharmacy graduates, challenges in integrating physics concepts with pharmacy courses still exist. The pharmacy curriculum's focus on pharmaceutical and health aspects may overlook students' understanding of basic physics. Therefore, the importance of developing teaching methods and physics laboratory practices that are appropriate for the pharmacy context becomes clearer. This research concluded that there is a need for the development of more suitable learning methods for basic physics courses in the pharmacy program, with an emphasis on developing system thinking skills crucial in the field of health, and the integration of pharmacy laboratories as a learning support. This is expected to enhance the understanding of physics concepts in the pharmacy context and build relevant system thinking skills for graduates of the pharmacy program.
Keywords: basic physics; pharmacy; system thinking; basic health physics

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Introduction

In the dynamic and ever-changing field of science and technology, the field of pharmacy education plays a central role in preparing students with the knowledge and skills necessary to actively participate in an increasingly complex healthcare system. In addition to comprehensively understanding drugs and their roles in human health, pharmacy education requires recognition of various fields of science, including the fundamental principles of physics.

The field of physics, as a branch of fundamental science, primarily aims to uncover the fundamental principles that govern the observed behavior in the universe (Coccia, 2020; Kale & Babrekar, 2019; Laszlo, 2020). Physics education aims to disseminate current pedagogical approaches for teaching its fundamental concepts (Bao & Koenig, 2019; Farmonov, 2020). Historically, the discipline of physics has been taught through educational institutions ranging from secondary schools to universities. Pedagogical approaches in the classroom often involve traditional teaching methods, frequently complemented by practical laboratory activities to confirm the principles taught during lectures. Topics introduced in the classroom are further reinforced through the use of demonstrations, direct experiments, and research-based investigations. Engaging in active learning methodologies, such as conducting experiments, provides students with the opportunity to investigate and understand subjects through direct exploration. Through engaging in experimental activities, students acquire the skills to transform their perspectives and overcome their biases about physical phenomena, thus revealing the underlying principles (Bao & Koenig, 2019; Farmonov, 2020)..

The discipline of physics holds a prominent position in the academic programs of various pharmacy institutions and colleges. Pre-pharmacy curricula generally include a range of courses, such as biology, anatomy, physiology, general chemistry, organic chemistry, calculus, and physics (Vinall et al., 2019). According to the American Association of Colleges of Pharmacy (AACP) report, pharmacy education encompasses examinations in physics and biology (Allen et al., 2020). Furthermore, it should be noted that the American Council on Pharmaceutical Education (ACPE) has established specific prerequisites for admission to pre-professional programs. These prerequisites include essential science disciplines such as general chemistry, organic chemistry, biology (with an emphasis on human processes and diseases), mathematics, information technology, and communication, as well as physics (Engle, 2020; Maerten-Rivera et al., 2020).

Various developments in pharmacy education and practice have resulted in competency frameworks on a global scale. These frameworks generally serve as guiding principles for formulating, enhancing, and modifying pharmacy curricula. Pharmacy students are required to develop a range of skills and knowledge that enable them to understand the healthcare needs of patients and the broader community throughout their educational and training journey (Nunes-da-Cunha & Fernandez-Llimos, 2019). Some colleges have integrated basic physics courses into their academic programs, considering it a necessary prerequisite for advanced courses and a foundational skill for anyone pursuing a career in pharmacy. However, it is not uncommon for students to have a limited understanding of the correlation between the field of physics and other academic disciplines, especially those closely related to pharmacy studies. Inadequate competency in physics is also deemed unsatisfactory within pharmacy curricula, as demonstrated by poor performance in scientific reasoning in pharmacy-related courses (Marušić & Dragojević, 2020).

Competency-based curricula involve the integration of desired competencies with various aspects of education, such as teaching and learning methodologies, educational practices, diverse learning contexts and settings, assessment methods, and research activities (Kraus, S. F., & Krause, 2020; Liu et al., 2021; Nguyen et al., 2022; Nunes-da-Cunha & Fernandez-Llimos, 2019; Pettersen, 2019). In order for pharmacists to effectively address societal challenges, it is crucial for them to have a comprehensive understanding of physics education in the context of pharmacy. Therefore, the development of basic physics learning within pharmacy curricula, aligned with the competencies required by pharmacy professionals, is necessary. The integration of physics into pharmacy education is essential because it is a scientific field included in the healthcare sector. This requires the creation of physics education specifically designed for pharmacy curricula while also aligning with the competencies required by pharmacy practitioners. Achieving this development can be facilitated through engagement in educational procedures and direct experiences that cultivate the system thinking skills required among individuals who have completed a pharmacy program.

The importance of understanding how teaching methods and laboratory protocols in basic physics courses are integrated into pharmacy curricula is evident. Thus, in-depth preliminary research is needed to comprehensively evaluate how the principles of basic physics are integrated into pharmacy curricula, ensuring alignment with the skills and knowledge required in modern pharmacy practice. The objectives of this study are to investigate pedagogical approaches in teaching basic physics principles, the significance of physics concepts in fostering pharmacy competencies, the integration of physics laboratory exercises, the cognitive abilities required for pharmacy graduates, and educators' aspirations regarding the advancement of physics education in the field of pharmacy. The following research questions (RQ) have been formulated:

1. How are basic physics teaching methods implemented in pharmacy programs?
2. How is the implementation of basic physics laboratories carried out in pharmacy programs?
3. What are the physics concept requirements in pharmacy program courses?

4. How does basic physics contribute to the development of the thinking skills needed for pharmacy graduates?
5. What is the relevance of basic physics principles in the context of pharmacy studies?

Method

Research Design

This research employed a cross-sectional survey design to examine the pedagogical approach used in teaching basic physics concepts (Algahtani et al., 2021; Thapa et al., 2021; Wang & Cheng, 2020). This approach is used to answer the extent to which physics topics contribute to the development of pharmacy competencies, the integration of physics laboratory practices, the cognitive skills required by pharmacy graduates, and the views of academics on the progress of basic physics education in the field of pharmacy. Participants in this study were instructors responsible for teaching basic physics principles in pharmacy programs at one private and one public university in Indonesia. These instructors were responsible for teaching basic physics principles to students and providing guidance during laboratory sessions. The research involved voluntary participation with a guarantee of participant identity confidentiality.

Data Collection

The data collection was facilitated through the use of a carefully designed structured questionnaire to effectively address research questions and objectives. This survey instrument consisted of closed-ended questions and used a Likert scale. The survey was divided into multiple sections that align with the research questions. Each section was tailored to encourage participants to provide participants relevant to specific research questions. The structured questionnaire consisted of the following sections:

1. **Part 1: Teaching Methods of Basic Physics**. This section inquired about the methods used to teach basic physics in pharmacy programs. The participants were asked to rate the frequency and effectiveness of various teaching strategies using a Likert scale.
2. **Part 2: Implementation of Basic Physics Laboratory Exercises.** In this part, the participants were asked about the practical aspects of laboratory exercises in basic physics. Likert scale questions would measure the extent to which laboratory components enhance the understanding of physics concepts.
3. **Part 3: Physics Concept Needs in Pharmacy Courses**. This part would explore the relevance and need for physics concepts in pharmacy courses. The participants would be asked to assess the importance of physics concepts in various pharmacy courses.
4. **Part 4: Contribution of Basic Physics to Developing Thinking Skills**. The participants would assess the impact of basic physics on the development of thinking skills required by graduates of pharmacy programs. A Likert scale would gauge the influence of physics education on thinking skills.
5. **Part 5: Relevance of Basic Physics Principles in Pharmacy Studies**. This final section examined the broader relevance of basic physics principles in the context of pharmacy studies. The participants were asked to express their opinions on the importance of integrating physics education into the pharmacy curriculum.

The structured questionnaire was designed to ensure clarity, cohesion, and alignment with research objectives. This instrument would undergo initial validation through a small number of participants to refine the questions. Subsequently, the final questionnaire was distributed to instructors responsible for teaching physics-related courses in the pharmacy curriculum. The data, collected from the survey, was analyzed quantitatively using statistical methods to interpret Likert scale responses and qualitatively through thematic analysis of open-ended responses. The results of this comprehensive data collection process would contribute to a deep understanding of the integration of basic physics into pharmacy education.

Data Analysis

The quantitative data analysis obtained from Likert scale questions is conducted using descriptive statistical analysis, which includes frequency, percentage, and mean. The qualitative responses were analyzed for content to reveal relevant themes and recurring patterns for each research question. These findings would provide an overview of the basic physics teaching methods, the relevance of physics topics to pharmaceutical competence, the implementation of physics laboratory practices, the critical thinking skills required for pharmacy graduates, and the academic perspective on the development of physics education in the pharmacy program.

Results and Discussion

Identification of Teaching Methods Used in the Pharmacy Program

This study aims to identify the teaching methods employed in the Pharmacy Program. Respondents, consisting of pharmacy faculty members, completed the survey by providing insights into the teaching methods currently used in their courses. The gathered data revealed the use of conventional lecture methodologies and discussion-based approaches as common, where educators deliver course material and engage students through the use of PowerPoint presentations. Although efforts have been made to shift the emphasis from faculty-led education to student-centered learning, there is still a lack of diverse alternative pedagogical approaches suitable for higher education.

The data presented in Figure 1 depict the extent to which efforts have been made to promote diversity in the learning environment. It reveals that among faculty members, discussion-based methods contribute to 37.8% of the teaching approaches, question-and-answer sessions make up 16.2%, experiments constitute 10.8%, and presentations contribute 35.1%.

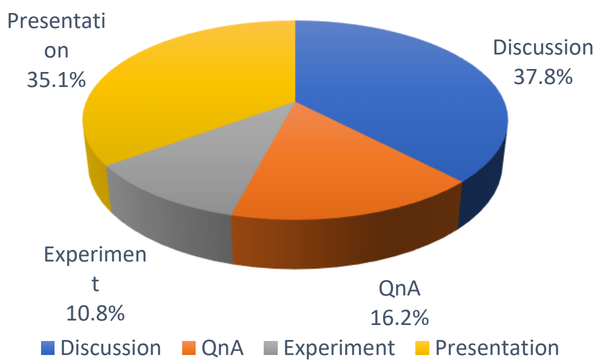

Figure 1. Diagram of Teaching Method Variations in the Pharmacy Program

The collected data emphasize the need to create appropriate learning approaches specifically designed for pharmacy education to promote the essential cognitive skills expected from individuals working in the field of pharmacy. Based on this research, it can be concluded that there is still a lack of comprehensive understanding of emerging pedagogical approaches among pharmacy faculty. Consequently, there is potential for students to experience a dull learning experience when using traditional teaching approaches, which may not be adequate in facilitating their cognitive development (Gorbunova et al., 2018; Khodabandelou et al., 2019; Zhong, 2022).

Increasing emphasis on holistic patient care and evidence-based decision-making in pharmacy practice requires a better educational approach (Marewski & Gigerenzer, 2022). Comprehensive pharmacy education should provide students with various learning opportunities that enable them to efficiently address complex health problems. Educators can enhance student engagement and develop essential skills needed for contemporary pharmacy practice by incorporating innovative teaching approaches, including problem-based learning, case studies, simulations, and hands-on experiments (Flynn et al., 2019; Kholikova, 2021).

The shortcomings revealed in the teaching approaches not only highlight the need for pedagogical advancements but also underscore the importance of ongoing professional growth for pharmacy faculty. Development initiatives within the pharmacy program that aim to incorporate new teaching methodologies, encourage active learning, and enhance instructional design have the potential to improve the overall quality of pharmacy education.

In short, it is evident that the teaching techniques within the pharmacy curriculum are generally dominated by lectures and discussions. However, there is an urgent need to investigate and adopt new pedagogical strategies more suited to the requirements of contemporary pharmacy practice. The formation and implementation of efficient pedagogical approaches to develop indispensable thinking skills required by pharmacy professionals necessitate inevitable collaboration among academicians, practitioners, and education researchers.

Identification of the Implementation of Basic Physics Laboratory Practices

The process of identifying the adoption of basic physics laboratory protocols was carried out by conducting a survey among faculty members affiliated with the pharmacy program. The collected data provided insights into the procedures used during laboratory sessions. It was revealed that educators provide standard laboratory modules that explain the protocols for each experiment, including the experiment's title, objectives, theoretical fundamentals, materials, and sequential methods. Furthermore, the data analysis process was conducted in accordance with predetermined equations, allowing students to essentially validate their experimental findings by referring to established criteria.

The field of pharmacy, as an academic discipline, significantly benefits from the use of laboratory procedures due to its strong connection to real-world applications. Laboratory sessions are strategically structured to enhance understanding of theoretical topics and facilitate the development of new theories, enabling students to gain a clearer understanding. Engaging in laboratory practices has the potential to promote various cognitive abilities. Therefore, it is regrettable that laboratory exercises often follow a fixed standard module structure, limiting students' experiences in comparing their findings with pre-established benchmarks set by instructors.

Identification of the Need for Physics Concepts In Pharmacy Courses

Empirical data regarding the need for physics principles were obtained through surveys distributed among members of the pharmacy academic community. The findings revealed diverse perspectives among participants. Among the pharmacy faculty members participating in the survey, it was found that 47.1% acknowledged the significance of physics concepts in the field of pharmacy studies, while 52.9% stated that the courses they taught did not require the incorporation of physics concepts. This division was supported by curriculum data, particularly the Semester Learning Plan (RPS). This plan revealed that the number of courses specifically focused on physics concepts in the curriculum was limited, as seen in Figure 2.

Figure 2. The Needs for Physics Concepts in Pharmacy Courses

Additionally, an analysis of the course distribution in private and public universities' pharmacy programs indicated that pharmaceutical physics and physical chemistry of pharmacy are the subjects most closely related to physics. This is illustrated in Figure 3. The results above indicate that a comprehensive understanding of many physics principles is required, including but not limited to Newtonian mechanics, fluid dynamics, thermodynamics, and quantum mechanics.

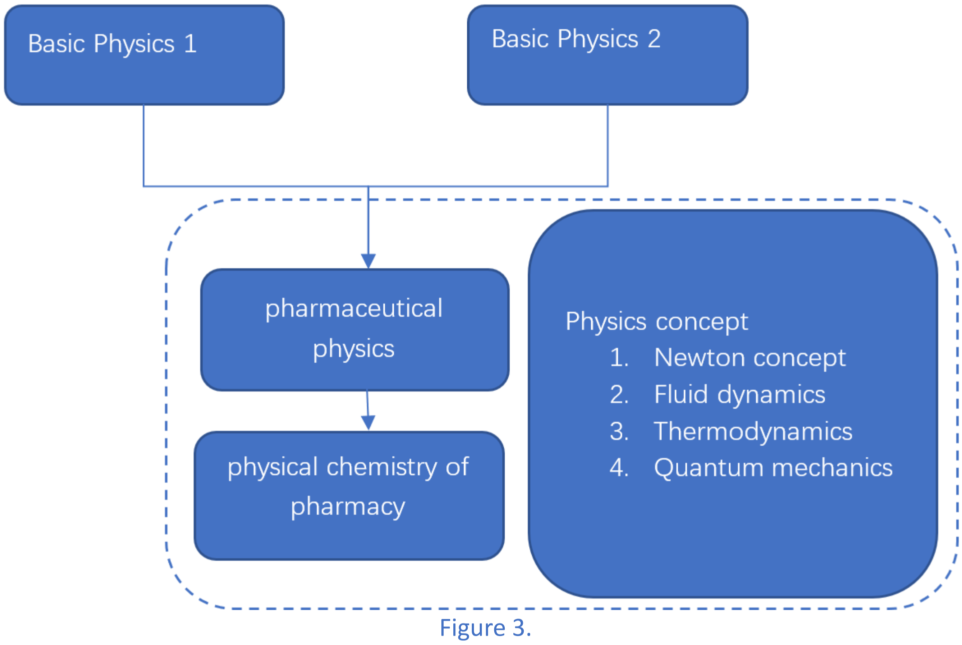

Figure 3. Courses Requiring Physics Concepts in State Universities

The complex nature of pharmacy subjects highlights the importance of prioritizing content development in pharmacy courses. Conversely, the curriculum framework of the Indonesian Higher Education Pharmacy Association for Bachelor of Pharmacy Education reveals that basic sciences such as mathematics, physics, general chemistry, organic chemistry, physical chemistry, and analytical chemistry make up only about 10-15% of the overall curriculum, as seen in Table 1.

Table 1. Curriculum Framework for Undergraduate of Pharmacy Education from the Indonesian Higher Education Pharmacy Association

No	Curriculum Content		Weighting
1.	Compulsory Content for Undergraduate's Education (Religion, Pancasila, Citizenship, Indonesian Language)		5-10%
2.	Core Curriculum Content:		65-75%
	Principles of Scientific Method & Basic Sciences	10-15%	
	Basic Biomedical Sciences	15-20%	
	Pharmaceutical Sciences	20-25%	
	Clinical, Social, Community Pharmacy Sciences	15-20%	
	Management, Administration, Regulation	10-15%	
3.	Local Curriculum Content (Supporting Content and/or Other Content)		15-30%
	Total of Credit Hours (minimum):		144 SKS

The mismatch between the relative emphasis on basic scientific concepts and the complex nature of pharmaceutical research calls for a thorough review of the educational curriculum. The value of integrating physics concepts directly relevant to pharmaceutical principles aligns with the recognition of the need for comprehensive pharmacological knowledge. The results above demonstrate how crucial it is to scrutinize the curriculum carefully and consider how it can be modified to encompass a comprehensive mix of physics principles that align with the needs of modern pharmaceutical practice. By achieving harmonious integration between pharmaceutical science and basic science, educational institutions have the capacity to equip pharmacy graduates with a range of skills, effectively preparing them to address various complex challenges encountered in the profession.

Identification of Thinking Skills to be Developed in Pharmacy

Findings from a survey conducted among pharmacy faculty members to assess the skills required for pharmacy students indicate a consensus of ideas. This consensus identifies five thinking skills, visually represented in Figure 4. The mentioned skills include critical thinking (23%), analytical thinking (45%), logical thinking (14%), systemic thinking (9%), and problem-solving (9%). The cultivation of these cognitive skills holds significant meaning in the context of pharmacy education, which encompasses the fundamental principles of physics. The development of a basic physics curriculum that can effectively promote mastery of these essential skills is of great urgency.

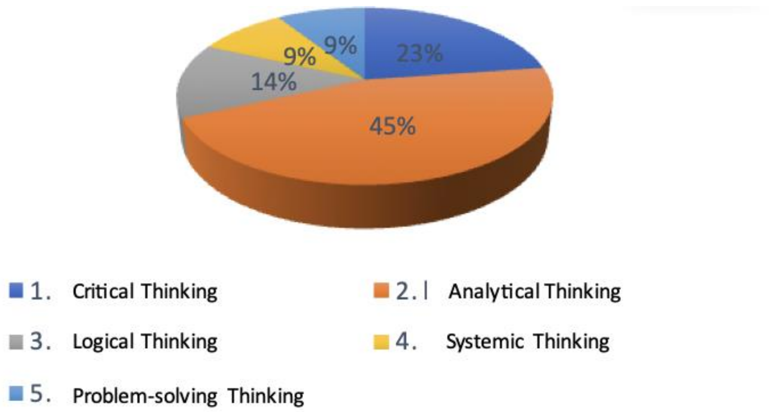

Figure 4. The Thinking Skills Required for Pharmacy Students

The development of thinking skills holds significant meaning in pharmacy education, especially when considering the position of this field in the healthcare sector. These skills enable pharmacists to effectively address the complexities of current socio-economic challenges. Competencies set for pharmacy graduates, as outlined by the Indonesian Higher Education Pharmacy Association (APTFI), align with the four pillars of learning established by UNESCO (Musliman, 2019; Priscilla & Yudhyarta, 2021).

The first pillar, "Learning to know," places emphasis on learners' cognitive abilities to understand various aspects of nature, humanity, the environment, and life while simultaneously gaining satisfaction from the process of acquiring knowledge, exploring new information, and achieving understanding. The second pillar, "Learning to do," emphasizes the practical application of information, problem-solving abilities, teamwork, proactive initiative, and effective risk management. This pillar undergoes a transition from skill-based learning to competency-based learning, including the development of effective communication skills, adaptability, creativity, innovation, and conflict management skills.

The third pillar, "Learning to live together," nurtures self-awareness, empathy, respect, cooperation, and conflict resolution skills within diverse groups. The fourth pillar, "Learning to be," aims to facilitate comprehensive personal development by achieving proficiency in information, skills, and principles across various intellectual, ethical, cultural, and physical domains. The inclusion of the fifth pillar, titled "Learning to transform oneself and society," recognizes the importance of education in shaping individuals' awareness and commitment to the environment and society. This pillar emphasizes the formation of values, acquisition of information, and acquisition of skills to facilitate the transformation of habits, behaviors, and lifestyles toward sustainability.

Miller's competency achievement pyramid (Figure 5) emphasizes that in the early stages of competency development, there is a strong focus on cognitive abilities, such as knowledge acquisition and practical skills, i.e., mastery of knowledge (knowledge) and skills (skills) to achieve the "knows" and "knows how" levels. Furthermore, the mastery of knowledge heavily relies on the development of thinking skills. The use of systemic thinking, which is a specific cognitive ability, is expected to make a substantial contribution to the enhancement of cognitive abilities (Williams et al., 2016; Witheridge et al., 2019).

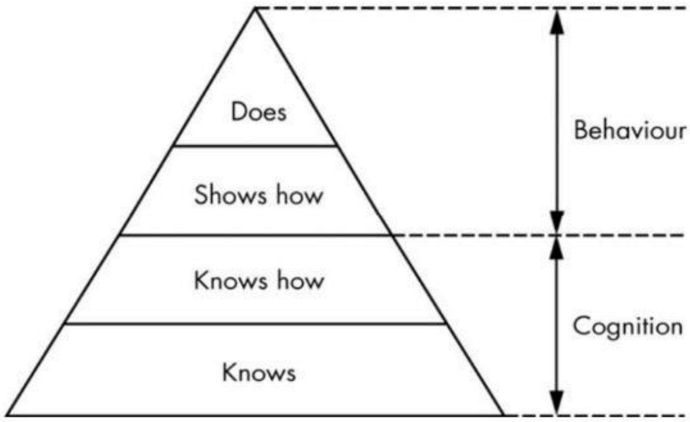

Figure 5. Miller's Piramyd

The primary goal of pharmacy education is to produce graduates with a high level of expertise in the field of healthcare. The healthcare field is characterized by sophisticated complexity, operating at multiple levels. Therefore, it is essential to apply systemic thinking to fully understand the complex interdependencies that influence behavior at various levels. The integration of systemic thinking into the healthcare sector is crucial as it equips individuals with the skills needed to navigate complex situations, manage crises, identify errors, enhance quality, and implement changes (Plack et al., 2019). The field of physics education serves as an effective platform for developing thinking skills in the context of systems (systems thinking) (Bao & Koenig, 2019). Therefore, continuous efforts to develop physics education specifically designed for the healthcare field, with a particular focus on pharmacy, are crucial. This requires the implementation of appropriate learning approaches that encourage the development of essential cognitive abilities while remaining aligned with the fundamental principles of physics. This strategy ensures that students view physics education as an essential element in their field, involving more than just theoretical knowledge.

Student perspectives on the relevance of basic physics principles in the context of pharmacy studies

Findings from the questionnaire indicate that students have the view that basic physics content is not sufficiently connected to other topics relevant to pharmacy. Many students perceive basic physics principles as focusing more on complex equations, with limited emphasis on establishing coherent relationships with the fundamental concepts required to understand other courses in pharmacy.

This observation underscores the current gap between the curriculum of basic physics courses and the practical implementation of these ideas in the field of pharmacy. The lack of possible connections may be attributed to traditional teaching methods that prioritize rote learning over demonstrating how it applies to pharmacy. This gap has the potential to cause students to doubt full engagement in the study of physics, as they may perceive it as an isolated field of study rather than a practical tool beneficial to their future careers.

To effectively address this issue, it is important to bridge the gap between basic physics teaching and its concrete implementation in pharmacy. Educators can raise awareness of the significance of physics in pharmacy by integrating relevant illustrations and situations that clearly link physics principles to pharmaceutical events. This approach has the potential to enhance students' understanding of the fundamental role of physics in many aspects of pharmaceutical science and its application in the context of healthcare.

Conclusion

The main purpose of this initial investigation was to examine the integration of basic physics learning into the pharmacy curriculum and evaluate its suitability for developing the systemic thinking skills required by pharmacy students. The results of this research provide valuable insights into various critical aspects of physics learning in the field of pharmacy. The study has revealed interesting findings related to the teaching dominance of traditional techniques, particularly lectures, in the context of pharmaceutical education. Furthermore, the research explored the expressed need to incorporate essential physics concepts into the pharmacy field. Moreover, the study investigated students' perceptions of the significance and applicability of basic physics principles in the context of pharmaceutical education. Additionally, the research has highlighted the significance of fostering thinking skills, particularly analytical thinking and systemic thinking, in the realm of pharmaceutical education. The findings presented in this study offer valuable insights into the complexity and potential benefits associated with the integration of basic physics principles into the pharmacy field. These findings underscore the importance of developing effective teaching strategies tailored to the specific needs of pharmacy students. Furthermore, they highlight the significance of providing contextually relevant basic physics education to equip future pharmacy graduates with the necessary skills to address the complexities of the healthcare industry and the broader society.

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