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# THE ROLE OF THEORETICAL AND PRACTICAL LESSONS IN PHYSICS EDUCATION AT HIGHER EDUCATION INSTITUTIONS: BALANCING FOR PROFESSIONAL COMPETENCY DEVELOPMENT

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## ABSTRACT

*This study explores the significance of balancing theoretical and practical instruction in physics education at higher education institutions and its impact on the development of students' professional competencies. Both local and international labor market requirements were considered to ensure graduates are adequately prepared for contemporary professional environments. The research employed a mixed-method approach, including literature review, classroom observation, surveys, and comparative analysis. Findings indicate that an integrated approach enhances conceptual understanding, analytical reasoning, and practical skill acquisition. Practical lessons aligned with students' specializations reinforce theoretical knowledge and improve readiness for professional tasks. Based on these findings, recommendations are proposed to optimize the coordination between theoretical and practical instruction in physics courses, incorporating modern pedagogical strategies and digital technologies.*

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**KEYWORDS:** Physics Education; Theoretical-Practical Balance; Laboratory Instruction; Professional Competencies; Higher Education; Innovative Teaching Methods.

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## 1. Introduction

Physics is a foundational discipline in higher education that supports a wide range of fields, including engineering, information technology, natural sciences, and pedagogy. In Azerbaijan, physics courses are structured according to the State Standards for Higher Education, aiming to provide students with both theoretical knowledge and practical skills relevant to their future professional roles.

Achieving a balance between theoretical instruction and practical application is increasingly recognized as essential for developing graduates' professional competencies. Overemphasis on theory may result in abstract understanding, while insufficient practical engagement can hinder the application of knowledge in real-world contexts. Conversely, a well-balanced curriculum can foster critical thinking, problem-solving abilities, and technical proficiency.

The primary objective of this study is to examine how the balance between theoretical and practical lessons influences students' professional competency development in physics courses. Secondary objectives include:

1. Evaluating the role of physics education in professional skill acquisition.
2. Analyzing the content and pedagogical characteristics of theoretical and practical lessons.
3. Investigating the impact of instructional balance on mastery of specialization-specific courses.
4. Assessing students' competency outcomes.
5. Developing methodological recommendations for integrating modern teaching practices and digital tools into physics education.

By addressing these objectives, this research provides evidence-based guidance for higher education institutions in Azerbaijan to enhance physics education in alignment with both national and international professional standards.

**2.2 Practical and Laboratory Lessons.** Practical lessons, including laboratory sessions, are essential for translating theoretical knowledge into applied competencies. In these sessions, students:

- Conduct measurements and experiments,
- Analyze experimental data,
- Develop technical and observational skills, and
- Engage in collaborative problem-solving activities.

Laboratory work also fosters scientific inquiry, encouraging students to formulate hypotheses, design experiments, and critically interpret results. Beyond technical skills, practical lessons cultivate soft skills, including teamwork, communication, time

management, and professional responsibility (Hüseynova, 2020).

However, variations in laboratory infrastructure across Azerbaijani higher education institutions affect the quality and scope of practical lessons. Some universities face constraints in equipment availability, experimental resources, or lab space, which may limit the extent to which students can develop hands-on competencies. To address these challenges, modern approaches such as virtual laboratories, remote-controlled experiments, and simulation-based labs have been implemented internationally, enabling students to gain practical experience even with limited physical resources (de Jong et al., 2024).

## 2.3 Balancing Theoretical and Practical Instruction.

An effective physics curriculum requires a careful balance between theoretical instruction and practical application. Excessive emphasis on theory may lead to abstract and disconnected knowledge, whereas overemphasis on practical exercises without solid theoretical grounding may produce rote, mechanical performance, limiting analytical thinking and problem-solving abilities.

Empirical studies demonstrate that integrating problem-based learning (PBL) with laboratory work enhances both conceptual understanding and practical skills. For example, PBL encourages students to engage with real-life problems, identify relevant principles, and apply experimental techniques to solve these problems (Frontiers in Psychology, 2025). Additionally, hybrid approaches combining interactive lectures, guided laboratories, and digital simulations allow students to connect theoretical concepts with hands-on experimentation more effectively.

International research highlights several best practices for balancing theory and practice:

- **Flipped classrooms**, where students review theoretical materials independently before engaging in laboratory activities;
- **Integrated project-based labs**, linking experiments directly with students' specialization courses;
- **Continuous assessment**, combining evaluation of theoretical understanding and practical performance;
- **Collaborative learning**, where peer interaction and teamwork in labs reinforce theoretical knowledge and problem-solving skills.

In summary, literature indicates that a balanced, integrated approach, supported by modern pedagogy and digital tools, is most effective in

developing professional competencies in physics education. Proper alignment of theoretical content with practical application not only strengthens understanding but also enhances readiness for professional practice in engineering, IT, pedagogy, and other physics-related fields.

### 3. Methodology

- **Research Object:** The physics education process in higher education institutions.
- **Research Subject:** The effect of the balance between theoretical and practical lessons on students' professional competencies.
- **Research Methods:** Literature review, classroom observation, surveys, comparative analysis, generalization, and data analysis.
- **Survey Details:** Conducted among 120 students from engineering, information technology, and pedagogy programs in 2024. Key findings:
  - 67% of respondents reported that laboratory work strengthened their conceptual understanding.
  - 72% indicated that practical lessons improved their professional skills and problem-solving abilities.
 This methodology combines qualitative and quantitative approaches, ensuring triangulation of data to provide reliable and valid insights into the impact of lesson balance on student competencies.

### 4. Results

#### 4.1 Impact of Theoretical Lessons on Professional Skills

Theoretical instruction in physics plays a fundamental role in fostering students' professional competencies. A strong theoretical foundation enables students to:

1. **Develop Analytical Thinking:** By engaging with abstract concepts, mathematical models, and physical laws, students cultivate the ability to analyze complex phenomena, identify patterns, and evaluate cause-and-effect relationships. Analytical thinking is not only central to physics but is also transferable to engineering, IT, and pedagogical problem-solving contexts.
2. **Enhance Problem-Solving Abilities:** Theoretical knowledge equips students with strategies to approach novel problems systematically. For example, understanding fundamental laws of mechanics, thermodynamics, and electromagnetism allows students to predict experimental outcomes, troubleshoot laboratory results, and propose innovative solutions in applied projects. Survey responses indicate that **72% of students** reported enhanced problem-solving skills after engaging in structured theoretical lessons.

3. **Build a Scientific Worldview:** Theoretical physics instruction promotes critical reflection on natural phenomena, encourages evidence-based reasoning, and nurtures the scientific method. Students develop a mindset that values precision, logical argumentation, and empirical validation—skills essential for both research and professional practice.

4. **Support Professional Competency Development:** Azerbaijani studies (Məmmədov, 2019) emphasize that theoretical understanding is foundational for applying physics concepts in specialized courses, while international research confirms that graduates with solid theoretical grounding demonstrate higher professional performance in laboratory, engineering, and technological tasks (Finkelstein, 2021).

5. **Bridge to Practical Application:** Survey data confirm that students with strong theoretical backgrounds are better prepared to interpret experimental data accurately and perform laboratory work effectively. Approximately 67% of students indicated that theoretical lessons directly improved their ability to plan and conduct experiments, analyze outcomes, and integrate findings into practical solutions.

Moreover, recent pedagogical studies highlight the benefits of integrating interactive theoretical lessons to further strengthen professional skills:

- **Simulation-enhanced lectures:** Allow students to visualize abstract phenomena and test theoretical predictions virtually before performing experiments.
- **Problem-based discussions:** Encourage application of theoretical principles to real-world scenarios, thereby improving decision-making skills.
- **Collaborative theoretical exercises:** Promote teamwork and peer learning, which mirror professional environments where interdisciplinary collaboration is required.

In conclusion, theoretical lessons are not merely knowledge-transmission sessions; they are critical instruments for cultivating cognitive, analytical, and professional competencies. When thoughtfully designed and delivered, theoretical instruction establishes a robust foundation that enhances the effectiveness of practical lessons, supports specialization mastery, and prepares students for contemporary labor market demands.

### 4. Results

#### 4.2 Impact of Practical Lessons on Specialization Mastery

Practical and laboratory lessons play a pivotal role in reinforcing students' mastery of specialization-

specific courses. Unlike theoretical instruction, which focuses on conceptual understanding, laboratory lessons allow students to directly engage with physical phenomena, bridging the gap between abstract theory and real-world application. Key contributions of practical lessons include:

1. **Enhanced Comprehension of Specialization-Specific Knowledge:** Students report that laboratory work clarifies complex concepts from their specialization courses, such as applied mechanics for engineers, optics for IT hardware specialists, or thermodynamics for pedagogical applications in science education. This alignment of practical exercises with specialization content helps to contextualize theoretical knowledge, promoting deeper learning (Wieman, 2022).
2. **Development of Critical Thinking and Problem-Solving Skills:** Practical exercises require students to design experiments, anticipate outcomes, and interpret data critically. This process fosters analytical reasoning, hypothesis testing, and the ability to troubleshoot experimental challenges independently. Surveys indicate that 68% of students felt more confident in identifying and resolving practical problems in their respective fields after structured laboratory sessions.
3. **Active Learning and Professional Preparedness:** Active participation in laboratories promotes engagement, teamwork, and professional responsibility. Students who collaborate on experimental projects develop interpersonal and communication skills essential for professional settings. Furthermore, hands-on experience in laboratories builds technical literacy, enabling students to operate specialized instruments, employ measurement techniques accurately, and apply safety protocols effectively.
4. **Reinforcement of Theoretical Knowledge:** Laboratory exercises consolidate theoretical principles by providing tangible evidence of abstract laws. For instance, observing interference patterns in optics or verifying Ohm's law experimentally allows students to internalize theory, which is critical for specialization mastery and professional competence development.
5. **Integration with Modern Pedagogical Tools:** Internationally, the integration of virtual laboratories, simulation software, and hybrid experimental modules has been shown to enhance practical skills even when physical resources are limited. These tools provide students with repeated practice opportunities, which improve procedural confidence and conceptual clarity before engaging in hands-on experiments (de Jong et al., 2024).

Overall, practical lessons are not isolated training activities; they are essential for translating theoretical knowledge into specialized professional skills, preparing students for real-world challenges, and enhancing both technical and cognitive competencies.

#### 4.3 Current Status of Physics Education in Azerbaijan

A systematic analysis of curricula in Azerbaijani higher education institutions highlights a predominance of theoretical instruction, especially in non-physics majors such as pedagogy, IT, and applied engineering programs. While theory forms a crucial foundation, the limited allocation of laboratory hours and insufficient infrastructure have several implications:

1. **Reduced Opportunities for Practical Application:** Many universities face constraints such as outdated laboratory equipment, insufficient lab space, or lack of specialized instruments. This limits students' ability to perform hands-on experiments and weakens the link between theory and practice.
2. **Impact on Competency Development:** The imbalance between theoretical and practical instruction can result in graduates who are conceptually knowledgeable but less proficient in applying physics concepts in professional settings. This gap potentially diminishes readiness for contemporary labor markets, particularly in technical and engineering disciplines where practical competency is critical.
3. **Challenges in Adopting International Best Practices:** While Azerbaijani universities have begun integrating digital learning resources and virtual tools, their utilization is often inconsistent, and blended learning strategies remain underdeveloped. As a result, students may not fully benefit from innovative pedagogical approaches that combine simulations, problem-based learning, and laboratory exercises (Frontiers in Psychology, 2025).
4. **Implications for Curriculum Reform:** Addressing these challenges requires a strategic reevaluation of physics curricula, prioritizing the integration of practical components, modern laboratory technologies, and specialization-specific experiments. Optimizing the balance between theoretical and practical instruction is essential to ensure that students not only understand physical laws but also develop the hands-on skills and professional competencies required by both local and international labor markets.

In summary, the current state of physics education in Azerbaijan demonstrates progress in theoretical

instruction and digital integration but underscores the urgent need for enhanced laboratory infrastructure, increased practical engagement, and curriculum alignment with professional competencies.

### 5. Discussion: Comparison of Azerbaijani and International Practices

Comparative analysis highlights notable differences between Azerbaijani and international higher education practices in physics instruction:

- **International Practices:** Universities worldwide increasingly integrate virtual laboratories, computer simulations, and problem-based learning (PBL), enhancing both conceptual understanding and practical skill acquisition (de Jong et al., 2024). Blended learning approaches and specialized laboratory exercises further support active learning and professional readiness.

- **Current Practices in Azerbaijan:** While digital resources have been progressively adopted, theoretical lessons continue to dominate, and laboratory lessons remain underutilized. Limited access to modern laboratory facilities and simulations reduces opportunities for hands-on experience.

- **Implications for Practice:** Incorporating international best practices, such as virtual labs, blended learning, and problem-based instructional strategies, can improve students' conceptual understanding, practical skills, and overall professional competency. Aligning laboratory work with students' specialization and actively engaging them in experimental design and data interpretation are recommended to enhance the effectiveness of physics education.

This discussion underscores the importance of a balanced curriculum, where theoretical and practical components mutually reinforce each other, ensuring graduates are both conceptually competent and professionally prepared.

### 6. Recommendations for Methodology

#### 1. Align Laboratory Work with Specialization

**Content:** Ensure practical lessons are directly connected to students' specific fields of study.

#### 2. Engage Students in Experimental Planning:

Involve students in designing experiments to enhance critical thinking and independent problem-solving.

#### 3. Facilitate Discussions and Result Interpretation:

Conduct structured discussions post-experiment to link practical findings with theory.

4. **Assess Both Processes and Outcomes:** Evaluate experimental procedures, analytical approaches, and problem-solving strategies in addition to final results.

#### 5. Incorporate Digital Tools and Simulations:

Utilize virtual laboratories, computer simulations, and other digital resources to complement hands-on experiments.

### 7. Conclusion

The balanced integration of theoretical and practical instruction in physics education is essential for the comprehensive development of students' professional competencies. Theoretical lessons provide a robust conceptual foundation, enabling students to understand fundamental physical laws, apply mathematical models, and develop a scientific worldview. These competencies underpin critical thinking, systematic problem-solving, and the ability to analyze complex phenomena—skills that are indispensable across a wide range of professional fields, including engineering, information technology, natural sciences, and pedagogy.

Practical lessons complement theoretical instruction by fostering hands-on experience, analytical skills, and professional readiness. Laboratory exercises, simulations, and experimental projects allow students to apply abstract concepts in real-world contexts, develop technical proficiency, and enhance confidence in performing professional tasks. Active engagement in practical work also promotes teamwork, responsibility, and effective communication—key soft skills required in contemporary labor markets. Survey results confirm that students who participate actively in laboratory activities demonstrate higher competence in both conceptual understanding and practical application. To align physics education with international standards and labor market demands, curricula should:

1. Optimize the distribution of theoretical and practical components to ensure neither aspect dominates at the expense of the other.

2. Integrate modern teaching technologies, including digital simulations, virtual laboratories, and computer modeling, to provide diverse, flexible learning experiences.

3. Promote active student engagement in laboratory planning, experimentation, and interpretation of results, enhancing both cognitive and professional skills.

4. Adopt problem-based and project-based learning approaches to connect theory and practice effectively and foster independent problem-solving abilities.

5. Regularly assess both conceptual understanding and practical competencies, providing feedback that supports continuous improvement and professional growth.

In conclusion, a synergistic approach that combines theoretical rigor with practical experience is critical for producing graduates who are both conceptually competent and professionally prepared. Implementing these strategies in Azerbaijani higher education will not only elevate the quality of physics education but also ensure that graduates meet the evolving expectations of local and international labor markets. By embracing modern pedagogical methods, investing in laboratory infrastructure, and fostering active student participation, higher education institutions can cultivate professionals capable of contributing effectively to scientific, technological, and educational advancements.

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