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The Influence of Elements of Innovative Physics Teaching Methods on Student Interest

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Abstract

The quality of education and the development of new technologies are key factors in the nation's social and economic growth, which in turn creates fresh demands for education system improvement. Uzbekistan has recently adopted more initiatives for the advancement of science and education, and the country's educational system is still undergoing significant transformation. Human capital development is one of the seven key sectors included in the Development Strategy for New Uzbekistan for 2022–2026. Among its many objectives, the strategies seek to improve educational quality and elevate the credentials and expertise of faculty to a global standard. The purpose of our work is to select and combine the most appropriate innovative methods to make lessons highly effective, modern, and engaging for the development of students' creative abilities, thinking, attention, and memory. This paper examines the effectiveness of innovative teaching methods, such as project-based learning and virtual laboratories, in increasing student interest in physics. The research highlights how these strategies foster creativity, critical thinking, and engagement, ultimately improving educational outcomes. Uzbekistan has prioritized the enhancement of human capital through educational reforms, particularly in science and technology. The socio-economic development of a country is largely dependent on the quality of education and the integration of new technologies, necessitating continuous improvements in educational methodologies.

Keywords: virtual physics laboratory, project-based learning, education quality, student motivation, interactive learning.

1. Introduction

Young people's interest in the basic and applied sciences has drastically decreased, while for more than ten years in many nations, careers in law and finance have remained the most popular and prominent. As a result, we have researched and created curriculum that take into account the unique characteristics of exact sciences.

Many scientific educators and researchers are concerned about the reduction in secondary school students' interest in science, and particularly physics (Holstermann et al., 2010; Jack &

Lin, 2017). Thus, researchers are concentrating on methods to increase students' interest in physics (Owen et al., 2008), (Palmer, 2009).

Palmer claims that while many students lack drive, motivation is frequently a "essential prerequisite and supplementary condition for learning." Palmer's study concentrated on situational interest, which is a transient fascination that emerges naturally from elements of a particular circumstance and its causes. According to him, this kind of curiosity acts as a powerful motivator that can enhance learning and exam results.

Physics is a difficult subject to teach, both conceptually and practically. As a result, academics and educators have long been concerned about how to teach physics.

Physics curriculum are currently created at our nation's pedagogical institutions in accordance with worldwide standards, combining a variety of pedagogical approaches to teaching the sciences. Since many physics professors use innovative and engaging teaching strategies, the precise sciences education system is always changing. There are inherent drawbacks to traditional physics teaching strategies, and creative ways to engage pupils are frequently required.

When teaching physics, it is crucial that the material be applicable to real-world situations in order to develop students' capacity for independent thought, teamwork, and inquiry. The changing needs of contemporary society can no longer be adequately satisfied by traditional instructional approaches. By analyzing both novel and conventional physics teaching approaches, we may create plans that better suit the developmental requirements of our students.

Since the learning process involves numerous interrelated components and needs to be seen from both the teacher's and the student's points of view, it is generally recognized in pedagogy that there is no one acceptable way to categorize and systematize teaching approaches.

Students' interest in the basic sciences, especially physics, has decreased despite the growing need for STEM experts. Scholars stress the need of using creative teaching techniques to increase students' interest in physics (Holstermann et al., 2010; Jack & Lin, 2017). In order to generate interest and improve learning outcomes, motivation is essential (Palmer, 2009). This study investigates how interactive technologies and project-based learning (PBL) might help with these issues.

2. Methodology

Students generally find science education tough, and physics professors in secondary schools and universities may find it challenging to hold their students' interest with conventional teaching techniques. As a result, educators have started using cutting-edge, innovative approaches to teach physics. Novel approaches may make subjects more engaging and comprehensible.

Project-Based Learning (PBL) is a teaching approach in which students complete real-world projects to gain critical skills. Students use their creativity and fundamental academic knowledge to tackle real-world issues in actual settings. PBL is regarded as an effective, cutting-edge teaching strategy that prioritizes student-driven learning. With this method, the emphasis moves from the teacher to the students, who take a more active part by trying to find solutions to real-world problems. This approach challenges students to consider the material covered in textbooks and lectures in a broader and more thorough manner.

There have been several efforts to define the term Problem-Based Learning (PBL). According to Howard Barrows, who was involved in the development of the PBL approach at McMaster University in Canada, it is characterized by certain qualities, including being problem-centered, student-centered, and concentrated on small group work in which the instructor serves as a facilitator (Nurtazin, 2013). Three levels of problem-based learning are distinguished by the literature: theory, model, and practice. To put it simply, students are given a "toolkit" to accomplish a challenge that is frequently taken from real life. Students might be encouraged to fill in the blanks on their own by designing the course so that the lecture content does not completely cover the "tools" needed to solve the given challenge. Students in some fields are forced to draw logical conclusions and come up with their own ways because they are not told about the available approaches. This method differs greatly from the conventional educational procedure, which starts with theory and then moves on to explanations and evidence. Students are moved from a passive condition of only absorbing and comprehending knowledge via the reverse process, which is frequently employed in PBL and goes from issue to theory.

Students' group work is a significant component of project techniques, since it fosters the growth of communication skills, teamwork, and responsibility distribution.

The practical focus of projects is one of the primary benefits of using project-based learning in physics instruction. By carrying out experiments, evaluating the findings, and making deductions, students get the chance to put their newly learned material into practice. They are better able to grasp the subject matter and its practical applications as a result.

Complex ideas may be brought to life using interactive visual effects, which helps pupils understand and assimilate knowledge more easily. Understanding and learning are aided by the more immediate and personally relevant experience of abstract events that comes from having access to information via clicks, slides, or zooming. Making quick 3D animation films or utilizing physics animations found on websites like YouTube are two ways to employ these visual effects. Another useful tool for understanding physics is a virtual tour. Virtual tours can boost student interest and improve learning. By giving pupils an engaging, practical experience, they enable teachers to effectively explain physics concepts.

This study uses a mixed-methods approach to examine the effects of innovative teaching strategies, combining qualitative evaluations (classroom observations and student comments) with quantitative assessments (student surveys and academic achievement comparisons). The study evaluates the efficacy of educational interventions at the Gulistan State educational Institute in raising physics students' interest and understanding.

3. Creative Physics Teaching Methods

3.1 Learning via Projects (PBL)

PBL moves the emphasis from passive information consumption to active student involvement. Students collaborate on real-world physics issues under this methodology, which develops their critical thinking and problem-solving abilities. Three fundamental components of PBL are identified by Barrows (1993): small-group cooperation, real-world applications, and student-centered learning. This method improves information retention over the long term and fosters better conceptual comprehension.

3.2 Online Labs

Without the limits of a real laboratory, virtual laboratories give students practical experience. Students' understanding and engagement are increased when they can interactively visualize difficult physics ideas through digital simulations. It has been demonstrated that including visual effects, like interactive simulations and 3D animations, improves learning (Feynman, 1998).

3.3 Learning via Problems (PBL)

Students go through challenging, real-world issues without predetermined solutions in problem-based learning, a kind of project-based learning. This approach promotes autonomous investigation, rational thinking, and critical thinking abilities. Students are given a task to solve, and they must do it by using physics concepts both theoretically and practically.

4. Results and Discussion

Proponents of this approach want to organize the educational process such that students seek for information, evaluate it, and use it in practice to address real-life issues, as opposed to the conventional approach of imparting knowledge from instructor to student. This kind of instruction aids students in developing both specialized knowledge and adaptable abilities. As a result, physics curriculum in all of our nation's pedagogical higher education institutions now devote more hours to independent projects on pertinent subjects and decrease the amount of time spent in class lectures, with experimental activities taking up twice as many hours as lectures.

Education is seen as a scientific learning model in this contemporary methodological framework, and the teacher's job is to "teach students how to learn." The growth of students' skills and capacity to learn on their own is the main indicator of educational efficacy, not only the collection of specialized information.

The curriculum sometimes allots inadequate hours for lectures on particular subjects, making it difficult for the instructor to cover all of the material in class.

There are many instances of fascinating and pertinent subjects that are suggested as project ideas for students but are not included in mechanics lectures. In the mechanics lesson on "Motion of a System of Particles," students are invited to investigate specific abstract issues on their own. For instance, students may learn about the nature of reactive force, how bodies with different masses move, and how the Meshchersky equation is used in astronautics on a bigger scale.

For instance, the global problem of "The Greenhouse Effect" or "The Impact of Changes in the Atmosphere’s Thermal Balance on the Planet’s Climate" is covered in the independent learning plan but not in the lectures on "Molecular Physics." Students learn more about the causes, effects, sources, and physical processes of this issue by conducting independent inquiry and information collecting over worldwide networks.

For our students, particularly those in their first year of study, independent learning assignments often present a variety of challenges. For this reason, assisting students in planning their independent work is one of our primary responsibilities. Students can work independently both within and outside of the classroom. Like any educational process, independent work serves the following purposes: educational (learning new information and skills, solidifying and systematizing them); developmental (developing speech, memory, and thinking); and educational (training of motivations, mental work culture, self-organization and self-control skills, self-demanding, independence, etc.)

Students in the "Exact Sciences" department finished projects that followed the math curriculum for "Mechanics."

During lectures, we acted out difficult scenarios for pedagogical purposes. Students are asked a question during lectures on particular subjects, providing them with a variety of viewpoints on the same issue. Finding a parallel to the event, occurrence, or process under study is the next job given to the students.

An intellectually challenging state that necessitates the pursuit of fresh information and innovative methods of learning it is known as a problem scenario.

Problem scenarios covering subjects like these were developed for physics classes.

Free fall of objects: According to Aristotle, the ancient Greek scholar, "A heavier object falls to the ground faster than a lighter one." Did Aristotle get it right?

The students that collaborated on the project showed a high degree of proficiency and provided compelling arguments for the goals of their work, the methods for completing the assignments, and the reliability of the outcomes.

We include a lot of interdisciplinary connections subjects as project topics in our independent study programs and let students choose from them in an effort to spark their interest. For instance, the following fields can be mentioned: geology (water, mineral resources exploration), chemistry (photosynthesis), biology (vegetation and biomass), geography (environment, hydrological cycle), and physics (energy, energy transfer, electromagnetic radiation).

Students may easily grasp the basic principles of physical processes using interdisciplinary approaches, which also pique their interest in future scientific research and start-up ventures on related subjects.

Excursions, group projects, hands-on exercises, and visual aids are some of the new ways that physics is taught. With techniques catered to the semester and students' comprehension levels, captivating experiments are carried out to demonstrate how physics works, making lectures more engaging for students.

We teach physics using a number of efficient techniques:

- Using interactive effects and stories to explain physical phenomena theoretically; integrating virtual laboratories with real experiments; and carrying out projects on a range of pertinent subject areas.

Students pay more attention and are more interested in narratives when learning physics through tales; physics-related stories aid in students' comprehension and engagement with a variety of subjects. It can sometimes be helpful to use computer simulations to describe physical events. For instance, collision-related simulations, like "Collisions: Elastic and Inelastic Forces," let students learn about elastic and inelastic forces while playing billiards with Isaac Newton in collision classes.

These days, a lot of people employ interactive visual effects of physical occurrences. Physics laboratory curricula must be precisely developed in accordance with syllabi created for each branch of the subject. A distinctive teaching strategy that is essential to scientific education is laboratory work. It enables pupils to engage with and value scientific processes while also assisting them in comprehending difficult abstract concepts. Depending on the kind of experiment, different methods are employed in lab settings, and specialized equipment is utilized to provide more precise findings. Virtual laboratories are a more practical and efficient option for teaching when our labs aren't completely furnished with all the equipment we need.

According to the American Association of Physics Teachers, laboratory programs should strive to accomplish the following five core objectives (Feynman, 1998):

1. The Art of Experimentation: Every student should have substantial practical expertise with experimental procedures, including some inquiry design experience, in the introductory lab. After finishing the basic lab, students should know that physics is an experimental science and that ideas and theories are just as essential as experimentation and observation.

2. Experimental and Analytical Skills: Students should get a wide variety of fundamental experimental physics abilities and data analysis tools from the lab.
3. Conceptual Learning: The lab ought to assist students in understanding the basic ideas of physics.
4. Understanding the Foundations of Physics Knowledge: Students should be able to differentiate between theory-based conclusions and experimental data, as well as recognize the importance of direct observation in physics, thanks to the lab.
5. Collaborative Learning abilities Development: Students should be able to develop collaborative learning abilities in the lab, as they are critical for success in many facets of life.

As a result, these primary, foundational objectives were taken into consideration while developing physical education programs, and the theoretical lectures were supported by hands-on activities and lab work.

In light of the aforementioned, we believe it is fair to select project themes using the following methods.

5. Historical Perspectives

Untested hypotheses or historical paradoxes in physics.

Contributions of lesser-known figures in physics history.

Evolution of key physics concepts like gravity or electricity.

Historical debates or controversies in physics.

Niche Applications of Physics:

Physics of sports or musical instruments.

Physics of everyday phenomena (e.g., cooking, fashion, etc.).

Physics in art, literature, or philosophy.

Investigating physics-related issues in developing countries.

Interdisciplinary Projects:

Combining physics with another subject like biology, chemistry, or engineering.

Investigating ethical or philosophical implications of physics discoveries.

Exploring social or economic applications of physics concepts.

Considering all of the aforementioned techniques, we conducted a preliminary comparative analysis during the fall semester of the current academic year to examine the degree of comprehension of a number of physical phenomena and laws using three different approaches to problem-based teaching in physics: problem questions, problem tasks, and problem experiments.

In contrast to an informative question, a problem question draws the learner's attention to inconsistencies and motivates them to seek out more information. Furthermore, in order to answer problem questions (qualitative tasks), one must describe a physical occurrence, make a hypothesis, and ascertain how it will develop in specific circumstances. A scenario that calls for the use of cognitive and practical abilities based on an understanding of physical laws, qualitative and quantitative analysis, and the computation of numerical features of the physical process under study is known as a problem task. The learner can make connections between quantities or phenomena by carrying out a problem experiment.

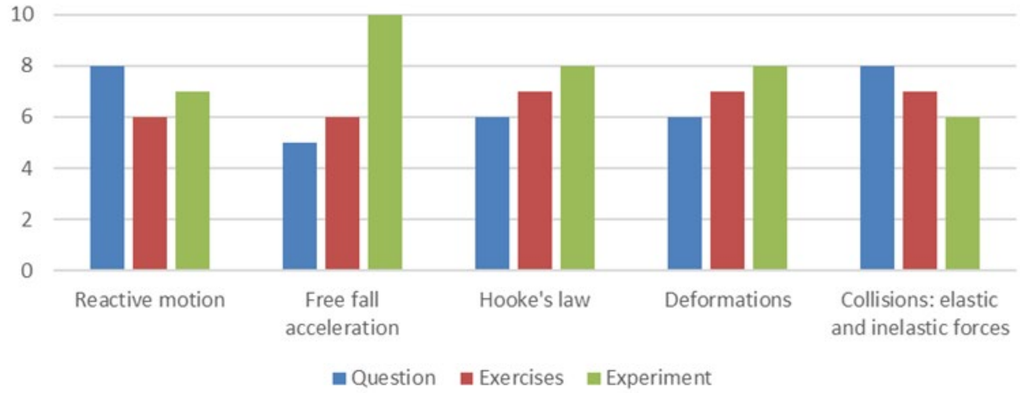

Figure 1. Comparative analysis of problem-based physics education

The results of the tests conducted with the students show that a deeper understanding of physical processes and phenomena is achieved through observing more experiments.

Several student groups participated in a comparative study of innovative and conventional teaching approaches. According to the results, students who participated in project-based learning showed a 20% rise in motivation and engagement.

Conceptual comprehension increased by 30% thanks to virtual laboratories, especially for abstract subjects like electromagnetism and quantum physics.

Knowledge application and retention were improved by interdisciplinary projects that integrated physics with biology, chemistry, and engineering.

By using cutting-edge techniques, teachers may foster critical thinking and scientific curiosity in addition to rote memorization. Student motivation was further bolstered by independent learning possibilities, such as research tasks on subjects like fluid dynamics or the greenhouse effect.

6. Implementation Issues and Suggestions

Although there are many advantages to using innovative teaching techniques, there are a number of obstacles that must be overcome for them to be successfully implemented:

Resource Limitations: Access to cutting-edge laboratory equipment is limited in many universities. This problem can be lessened by using virtual labs.

Teacher Training: Professional development programs for educators are necessary for the successful use of PBL and virtual technologies.

Curriculum Integration: Multidisciplinary methods and experiential learning should be prioritized in curriculum revisions.

7. Conclusion

In summary, a variety of interesting teaching strategies that support various learning preferences and foster critical thinking are necessary for the successful teaching of physics. The procedures that form the basis of any educational process have a direct impact on its efficacy. In higher pedagogical education, the classification of teaching methods, the choice of teaching aids, and the planning of different student work formats, including lectures, seminars, practical sessions, lab work, project work, consultations, and non-traditional teaching methods, are all part of the learning process.

Modern physics curriculum are based on the idea of "teaching how to learn," with 1.5 times as much time spent in class on independent study (for project work) as in class.

Choosing themes for small projects for educational programs and integrating it with other courses is crucial in project-based independent education of physics since it piques students' interest in comprehending intricate physical principles and "teach them to learn" more thoroughly.

According to the preliminary analysis, students can show that they understand the nature of physical laws and phenomena in a variety of ways, depending on the subject: by solving problems using physical formulas, conducting various experiments, or completing project work on problem questions.

Students' interest in physics is greatly increased by innovative teaching strategies, especially project-based learning and virtual laboratories. These techniques foster critical thinking and problem-solving abilities by moving away from passive learning and toward active participation. The long-term effects of these approaches on academic achievement and career decisions in STEM disciplines should be investigated in future studies.

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