The impact of teaching the "Theoretical mechanics" course using software-based educational tools on learning efficiency

Влияние преподавания курса «Теоретическая механика» с использованием программных образовательных инструментов на эффективность обучения.

Bekmurodova Manzura Bahodir kizi
PhD student, Bukhara State University
(hdd613301@gmail.com; phone: +998 91 247 62 39)

Annotation: This study analyzes the learning performance of students studying in the Physics education field at higher education institutions regarding the subject "Theoretical Mechanics." It presents a comparative mathematical-statistical analysis of learning outcomes when using software-based educational tools during the teaching process versus outcomes from traditional teaching methods.

Keywords: Python programming language, software-based educational tool, learning efficiency, theoretical mechanics.

Аннотация: В данном исследовании анализируется учебная успеваемость студентов, обучающихся по направлению «Физика» в учреждениях высшего образования по дисциплине «Теоретическая механика». Представлен сравнительный математико-статистический анализ результатов обучения при использовании программных образовательных инструментов в процессе преподавания по сравнению с результатами, полученными при традиционных методах обучения.

Ключевые слова: язык программирования Python, программный образовательный инструмент, эффективность обучения, теоретическая механика.

Each student of a higher education institution aims to acquire knowledge, skills, and competencies that will benefit their personal, professional, and social life. The main objective of education is to prepare students to learn new materials, facilitate the perception of knowledge, strengthen practical skills, review and generalize the knowledge and skills, identify and address weak areas, and enable the application of acquired knowledge in real-life situations and behavioral patterns.

During the learning process, by forming the basic competencies related to the subject of "Theoretical Mechanics," which is one of the theoretical courses in Physics, students develop interest in the study of mechanical motion, coordinate systems, phenomena occurring according to the laws of conservation of energy in nature, planetary motion

physics, and the nature of space and time. As a result, students gain sufficient skills to form the foundation for scientific research and physical experimentation.The process of providing in-depth knowledge of the subject "Theoretical Mechanics" is a two-way interaction that incorporates both the teacher's instructional activities and the student's engagement during the lesson.

In this context, it is relevant to analyze the possibilities, advantages, and outcomes of using a software-based educational tool named "Theoretical Mechanics Teaching Program." From this point of view, it is necessary to compare the results of lessons conducted with this software tool and those carried out using traditional teaching methods. When using software-based educational tools during lectures and practical sessions of the theoretical mechanics course, it has been determined that students better comprehend complex topics. This is made possible by the availability of relevant videos, presentations, graphics, complex diagrams, topic-based problems with their solutions, and graphs corresponding to those solutions—all integrated into the software tool. These materials allow students to study both during the lesson and independently, gaining sufficient knowledge, skills, competencies, and core proficiencies related to the subject.

In higher education institutions, alongside delivering theoretical knowledge, the use of software-based educational tools in teaching theoretical mechanics proves to be an effective and reliable method for expanding students' understanding of the subject, enhancing their problem-solving and analytical skills, comprehending the underlying essence of physical phenomena, and fully developing their subject-related core competencies. In order to verify the accuracy and effectiveness of this methodology, a pedagogical experimental trial was organized. This trial aimed to define the content and implementation stages of using software-based educational tools in teaching theoretical mechanics within the Physics education curriculum at higher education institutions. The experimental trial to improve the effectiveness of teaching and develop students' subject-specific competencies using software-based learning materials was conducted in the following stages:

1. Analysis of results obtained during the experimental trial conducted at selected higher education institutions. The generalized results of the experimental trial were compared between the experimental and control groups. These results were then processed using mathematical-statistical analysis methods.

2. Based on the final outcomes of the experimental trial, scientific and methodological recommendations were developed aimed at increasing the effectiveness of teaching and improving students' core competencies. These recommendations are based on using learning materials and tools from the "Theoretical

Mechanics Teaching Program" developed using the Python programming language as a software-based educational tool.

In the study, mathematical statistics-a method used to evaluate the effectiveness of the teaching process-was applied to process and analyze the results of the experiment. During the re-analysis of the results, as specified in mathematical-statistical methods, the effectiveness of the educational process was assessed by determining the difference between the initial and final indicators of students in the experimental and control groups. This evaluation was based on the methodology developed for improving core competencies in the subject of theoretical mechanics among students of physics education at higher education institutions through the use of software-based educational tools.

For this purpose, according to Karl Pearson's criterion, the comparative analysis of the final performance of the experimental and control group students was conducted across the first, second, third, and final stages of the study. A total of 649 students from Bukhara State University, Termez State University, and Karshi State University participated in this research. The experimental group consisted of 326 students, while the control group included 323 students [1].

Based on the data provided in Table 1, the academic performance indicators of students from the three higher education institutions in the subject of "Theoretical Mechanics" were analyzed using mathematical-statistical methods as follows:

Initial Results of the Students:

$$\chi^2_{emp} = 326 \cdot 323 \cdot \left[\frac{(\frac{15}{326} - \frac{16}{323})^2}{15+16} + \frac{(\frac{157}{326} - \frac{153}{323})^2}{157+153} + \frac{(\frac{138}{326} - \frac{142}{323})^2}{138+142} + \frac{(\frac{16}{326} - \frac{12}{323})^2}{16+12}\right] \approx 0.7;$$

$$\overline{x} = \frac{1}{326} \cdot [2 \cdot 15 + 3 \cdot 157 + 4 \cdot 138 + 5 \cdot 16] \approx 3{,}47;$$

$$\overline{y} = \frac{1}{323} \cdot [2 \cdot 16 + 3 \cdot 153 + 4 \cdot 142 + 5 \cdot 12] \approx 3{,}47;$$

$$\eta = \frac{3{,}47}{3{,}47} \approx 1{,}00.$$

Overall results of experimental trials conducted in three higher education institutions

Table 1

Name of HEI	Indicators	Experimental groups				Control groups			
		Number of students at the start of experiment	%	Number of students at the end of experiment	%	Number of students at the start of experiment	%	Number of students at the end of experiment	%
In terms of three higher education institutions	Excellent	16	5	43	13	12	4	20	6
	Good	138	42	227	70	142	44	150	46
	Satisfactory	157	48	56	17	153	47	147	46
	Unsatisfactory	15	5	0	0	16	5	6	2
Total:		326	100	326	100	323	100	323	100

The obtained empirical value is less than the critical value, $0{,}7 < 7{,}81$ which indicates that H_1 hypothesis can be accepted at the beginning of the experiment. In other words, there was no significant difference in the knowledge levels of students in the experimental and control groups prior to the experimental trial.

Final results of the students in the experimental phase:

$$\chi^2_{emp} = 326 \cdot 323 \cdot \left[\frac{(\frac{0}{326} - \frac{6}{323})^2}{0+6} + \frac{(\frac{56}{326} - \frac{147}{323})^2}{56+147} + \frac{(\frac{227}{326} - \frac{150}{323})^2}{227+150} + \frac{(\frac{43}{326} - \frac{20}{323})^2}{43+20}\right] \approx 70{,}8;$$

$$\overline{x} = \frac{1}{326} \cdot [2 \cdot 0 + 3 \cdot 56 + 4 \cdot 227 + 5 \cdot 43] \approx 3{,}96;$$

$$\overline{y} = \frac{1}{323} \cdot [2 \cdot 6 + 3 \cdot 147 + 4 \cdot 150 + 5 \cdot 20] \approx 3{,}56;$$

$$\eta = \frac{3,96}{3,56} \approx 1,11$$

The obtained empirical value is greater than the critical value, $70,8 > 7,81$ which means that the proposed methodology is effective, and therefore, the alternative H_1 hypothesis can be accepted. That is, after the experimental trial, a significant difference was observed in the knowledge levels of students in the experimental and control groups. The results from the three regional higher education institutions demonstrated that the performance indicators of the experimental group 11% $(1,11 - 1,00 = 0,11)$ were higher than those of the control group.

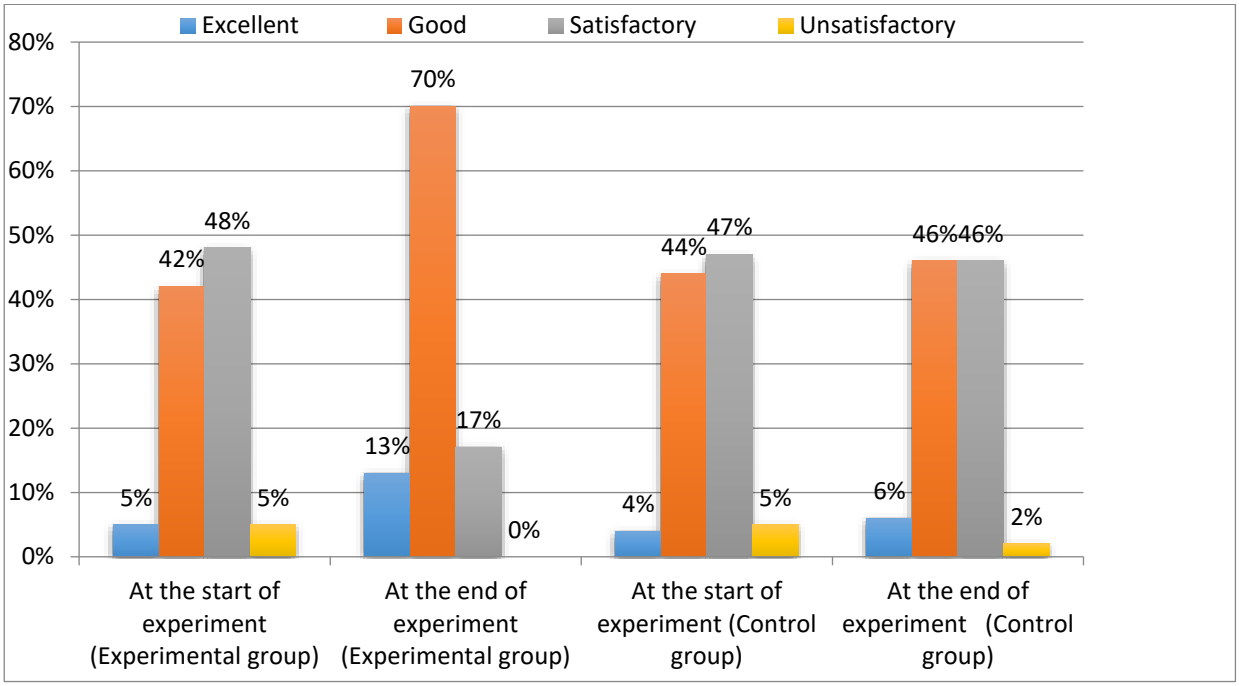

Figure 1. Diagram of academic performance indicators across three higher education institutions

As a result of the experimental trials, it was observed that the knowledge level of students in the experimental group was higher than that of students in the control group. This proves that the use of the software-based educational tool—designed to improve the methodology for developing students' core competencies—yielded positive and effective results, as confirmed by the outcomes of the experiment.

References

1. Пирсон К. “Математический вклад в теорию эволюции. III. Регрессия, наследственность и панмиксия”. Философские труды Лондонского королевского общества. –1896 г.

2. Avezmuratova Z.A. Umumiy o'rta ta'lim maktablarida astronomiya fanini o'qitish metodikasini takomillashtirish. Pedagogika fanlari bo'yicha falsafa doktori (PhD). Diss. –B.: 2023 y. – 47, 68 b.
3. Axmedov Y.O. Akademik litseylarda fizika fanini o'qitish metodikasini dasturiy ta'lim vositalari asosida takomillashtirsh Avtorefer. Ped.fan.nom.diss. avtoref.- B-2023y. 12-b.
4. Axmedova M.P edagogik kompetentlik. Uslubiy qo'llanma- Toshkent, 2018y.-9-b, 44-b, 77-b.
5. Azizxo'jayeva N.N. Pedagogik texnologiyalar va pedagogik mahorat. O'quv qo'llanma-Toshkent.: "O'zbekiston Yozuvchilar uyushmasi Adabiyot jamg'armasi", 2006 y. 40-50 b.
6. Bekmurodova M.B . Moddalalarning tuzilishiga oid tushunchalarni yoshga xos xususiyatlarni hisobga olgan holda interfaol metodlar yordamida tushuntirish // Eurasian journal of academic research. 21.04.2021. –B.415-420.
7. Bekmurodova M.B . Moddalarning tuzilishiga oid tushunchalarni interfaol metodlar yordamida tushuntirish // Дистационниэ возможности И достижения науки. Kiev.Ukraina . may-iyun. 2021. –B.40-41.
8. Bekmurodova M.B . Qahhorov S.Q. The issue of teaching the equations of motion and heat exchange // Pedagogik mahorat 5-son may 2024. –B 120-126.
9. Bekmurodova M.B . Saidov Q.S Complex movement of object // International Scientific Journal Theoretikal Applied Science. Impact Factor OAJI(USA) 0.350. ISSN 2308-494X Philadelphia, USA.18.05.2020.-pp.316-322.
10. Bekmurodova M.B . Saidov Q.S Nuqtaning impuls momentini slindrik koordinatalar sistemasida isodalashning yangi pedagogik usullari // "Involta" ilmiy jurnali Vol 1.№6. 2022 –B.113-119.
11.Bekmurodova M.B. Fizikaning nazariy kurslarini o'qitish jarayonini kompetensiyaviy yondashuv asosida dasturiy ta'lim vositalaridan foydalangan holda tashkil etish istiqbollari // International conference on modern devolopment of pedagogy and lingiustics vol.01, issue. 01. 2024. -PP 37-42.
12.Bekmurodova M.B. In theoretical mechanics, the issue of using a software tool to express the relationship between the cylindrical coordinate systemand the dekart coordinate system // Web of discoveries:Journal of analysis and inventions volume-2 04.04.2024. –pp 119-125.
13.Bekmurodova M.B. Nazariy mexanika fanini o'qitish jarayonida dasturiy ta'lim vositalaridan foydalanishning imkoniyatlari // Муғаллим ҳем узликсиз билимлендириў. Илмий методиқалық журнал// 2/1-сан 2025. –B.312-319

14.Bekmurodova M.B. Opportunities for teaching the therotical mechanics section physics using educational software tools // International journale of pedagogics. Vol.5 issue. 2 2025. -pp 196-200
15.Bekmurodova M.B. Qahhorov S.Q. Use of interactive methods in expressing motion equationsin different coordinate systems // Science in innovation International scientific journal ISSN: No:2118-3337 05.05.2023-pp19-24
16.Bekmurodova M.B. Use of interactive methods in expressing the equations of motion in the cylintrical coordinate system // Лучшие интеллектуалные исследования часть-10 том-3 12.12.2023- ст.61-64
17.Bekmurodova M.B. Using the methods of “matryoshka” and “consecutive contraction” to explain the theory of motion of a material point // NOVATEUR PUBLICATIONS JournalNX-A Multidisciplinary Peer Reviewed Journal ISSN: No: 2581-4230 04.04.2022.- pp.67-70.