Implementation of Virtual PHET Medium in Explaining Kepler's Laws

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Abstract: The analysis of experiences carried out on revealing the advantages using integrated PHET medium during the lesson on Kepler's laws on astronomy has been presented. It has been shown, that using this medium allows us to increase mastery by pupils to 1.5 times in comparison of the traditional teaching using the usual blackboard. It has been revealed that teacher during the lesson can take a passive rather than active role leaving it to the students themselves to carry experiments in accelerated and decreased (to million times) formats of motion of Solar system space bodies. Then the pupil's quantities with excellent and good knowledge have been increased to 21 and 19 %, correspondingly, as the same time ones with the satisfactory and unsatisfactory grades, contra versa, have been decreased to 17 and 16 %, correspondingly.

1 INTRODUCTION

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The information technologies become an integral part of lessons on physics and astronomy. Here virtual laboratory works have the important role. Therefore, in the recent time often the investigations in which aspects using such virtual works are being appeared. Let us review the latest papers where information technologies on physics and astronomy lessons had been used.

For example, in paper (Mugutullina, 2020) having laboratory works had been analyzed, tasks of creation of computer models of physical processes, development comfort user interface, method of carried out laboratory works using interactive laboratory complex had been discussed. Totally, the necessity of using virtual laboratory works in physics teaching, knowing methodic materials and also efficiency of all teaching process had been justified.

In paper (Dmitriyev, 2023) the possibility increasing efficiency of educational process through the implementation information technologies had been considered. There the methodic aspects for creating and using virtual laboratory works intended for organization self-study by students of different sections of physics had been discussed. Analysis of experiences and their application in high educational schools had been presented in which screening form of different virtual laboratory works for carrying

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online experiments, allowing to students prepare for their implementation had been demonstrated clearly.

The possibilities using virtual laboratory works on physics had been studied in paper (Akmatbekova, 2023) as one of containing elements of self-training of students for carry out real laboratory works. There the method for carrying out virtual laboratory works had been developed, preparation and conducting experiential learning had been described and its quantitative and qualitative results had been analyzed. It had been shown that using virtual laboratory works on physics allows show to students the studying efficiency, speed and high accuracy of obtained results, which confirms efficiency proposed method. Thus, students can form independently the practical skills and abilities in convenient for their time, without limiting the time themselves and territorial remoteness from the educational organization. There had been noted that teaching based on the virtual laboratory creates conditions for effective manifestation of intellection fundamental laws, promotes for development and activation of student's creativity and optimizes cognitive process of students teaching.

In paper (Zlobina, 2022) the necessity of virtual laboratory works on the astronomy lessons for observing space objects and creating cognitive interest for subject had been considered. There a sample of virtual laboratory work using Stellarium medium had been proposed. This task also deals with that in recent period calculations carried out then by Kepler using new information technologies are being clarified.

In paper (Yalovenko, 2022a) inconsistencies in Mercury planet orbital rotation had been considered and methods for their elimination had been proposed. And in other paper (Yalovenko, 2022b) extension of first Kepler's law in the new text: "Each planet of Solar system rotates by irregular ellipse and Solar situated in the shortest focus". Solar in such presentation has priority and our representations on the environment space are being expanded. In other paper of same author (Yalovenko, 2020) expansion of motion momentum conservation laws for obtaining gravitation theory and Kepler's laws had been considered.

The wave function of electron in the hydrogen type atom in analogy with the Kepler's task had been chosen which satisfactory Whittaker's equation in any kinematics and any spin (Granovskii, 2021). Then electron being as the pure quantum mechanical object in point of view classic mechanics had been considered which simplifies representation nature of atomic scale.

In paper (Abubekerov, 2020) the algorithm for numerical solution of Kepler's equation with machine accuracy had been represented. The convergence of the iteration sequence of Newton's method on the known initial approach had been proven. The task of finding the numerical solution of Kepler's law as the floating point numbers had been constructed. The aspects conditioned by calculations near machine zero had been taken into account. The accuracy of possible result had been analyzed. The task arising by striving for the highest possible accuracy had been revealed and its solution had been proposed. The estimation of machine time required for solution Kepler's equation using this method had been estimated.

The generalized Kepler's task in the spherical coordinates had been considered (Petrosyan, 2022). The explicit form of the additional motion integral of generalized Kepler's task in the spherical coordinates, wave function of which is spheroidal basis had been given and three-term recurrent representations to which expansion coefficients of spheroidal basis on the spherical and parabolic bases satisfy had been derived.

In all mentioned above papers although aspects for effective using some virtual laboratory works had been considered but in them questions studying pupil's consequence of stages of execution of works and also observing processes in Kepler's laws in the chronological order not yet clearly had been defined.

2 METHOD OF INVESTIGATIONS

In the present paper the analysis of carried out experiments on astronomy lessons has been considered, in which Kepler's laws using virtual integrated PHET medium are explaining. Wherein for clear demonstrating advantages of using virtual medium we held lessons in two classes (11^A and 11^B) on the same title: "Kepler's laws". In 11^A class teacher used PHET medium and during on the lesson he chose a passive role giving pupils themselves conduct experiments with planets (see, Figures 1-3). At the same time in 11^B class teacher conducted lesson without such integrated medium, that is in which he chose active and pupils take passive positions.

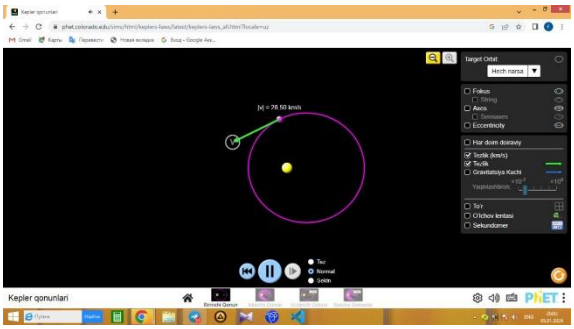

Figure 1: Fixation a moment of the astronomy lesson for studying Kepler's first law.

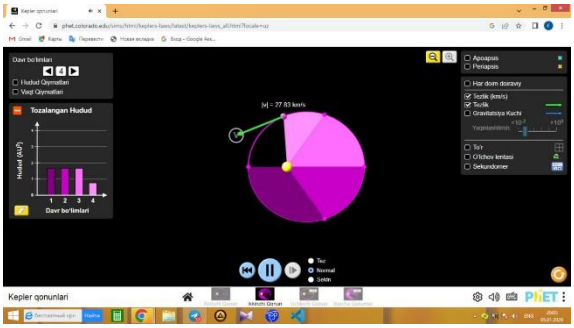

Figure 2: Fixation a moment of the astronomy lesson for studying Kepler's second law.

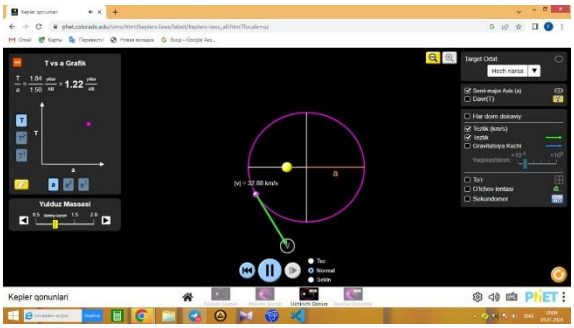

Figure 3: Fixation a moment of the astronomy lesson for studying Kepler's third law.

It should be noted that lately in our previous investigations (Nasirov, 2023) pupils could get acquainted with the picture of the physical world in small (10^{-10} *meter*) distances, now in the present investigations the advantages of integrated PHET medium, controversy, for explaining essential big distances have been shown, for observing which by naked eyes several ten years and working contribution of many researchers would be required.

3 EXPERIMENTAL RESULTS

Before ending each lesson, teacher required fill out Table: "I know & I don't know & I found out", consisting 10 questions dealing with Kepler's laws (Table 1).

Table 1: questions on revealing the pupil mastery of Kepler's laws.

№	Questions	I know	I don't know	I found out
1	The meaning of the word "Planet"			
2	The essence of Kepler's first law			
3	The essence of Kepler's second law			
4	The essence of Kepler's third law			
5	Half shaft			
6	Focus			
7	The planet velocity			
8	The planet period			
9	Aphelion			
10	Perihelium			

Pupils mastery have been estimated by criterium: selecting the "I know" in 9-10 cells are 5 (perfectly); in 6-8 cells are 4 (good); in 3-5 cells are 3 (satisfactory) and less than 2 cells are 2 (unsatisfactory). Results of for each class have been presented on Table 2. Here *pupil's mastery* we have calculated by representation:

$$pupil's\ mastery = \frac{perfectly + good + satisfactory}{all\ pupils} \cdot 100\%$$

Here *perfectly*, *good* and *satisfactory* are the pupil's quantity, received 5 (perfectly), 4 (good) and 3 (satisfactory) grades, correspondingly.

Table 2: pupils mastery of Kepler's laws.

№	Pupils grades	In 11^A class		In 11^B class	
		Quantity of pupils	Fraction to all pupil's quantity (%)	Quantity of pupils	Fraction to all pupil's quantity (%)
1	5 (perfectly)	10	38	4	15
2	4 (good)	12	42	6	23

3	3 (satisfactory)	4	14	8	31
4	2 (unsatisfactory)	2	7	6	23
5	*Pupils mastery*	26	93	20	69

As we can see from Table that *pupil's mastery* of 11^{A} class more to 1,5 times approximately than one of 11^{B} class. As to the pupil's grades comparison, then pupils with perfectly grades in 11^{A} class more to 21 % in comparison of 11^{B} class, pupils with good grades in 11^{A} class more to 19 % in comparison of 11^{B} class. At the same time pupils with grades satisfactory and unsatisfactory, then contra versa, in 11^{A} class less to 17 % (satisfactory) and 16 % (unsatisfactory) in comparison of 11^{B} class, correspondingly.

4 CONCLUSIONS

Thus, based on the analysis of experiments carried out on revealing advantages of using integrated PHET medium in lesson entitled "Kepler's laws" on astronomy we can conclude that:

the first, using such medium allows us increase pupil's mastery to 1,5 times in comparison of the traditional lessons using usual blackboard;

the second, teacher during the lesson can take a passive role leaving it to pupils themselves conduct experiments in the accelerated and decreased (to million times) scales of motion of space bodies of Solar system.

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