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ASTRONOMY, KEPLER'S LAWS AND IBSE - METHODS

MULTI-DIMENSIONAL ASPECTS OF LEARNING AND TEACHING IN SCIENCE AND MATHEMATICS EDUCATION (MALT'14),
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Astronomy is the oldest science. Testifying to the image of the constellation and attempts saving time in the oldest habitat of the human species - the caves. The study, teaching and learning of astronomy leads, directs and monitors the thinking and science in the development of civilization.

In Serbia, the first teaching began within the Faculty of Philosophy in Belgrade, then separated within the natural sciences and mathematics, and finally as an independent department.

In high school - grammar school is first studied through the contents of geography, and then separated during the 20th century as a separate item. In the basic remains the amenities of nature, the world around us and geography.
Problems of teaching astronomy go in two directions, the first by the expert staff.

Still in grammar schools teach astronomy Serbian physicists during the study did not have subject astronomy or astrophysics. This practice is present when astronomy was a separate subject, and escalated when astronomy classes tied to physics class, so that within five hours of physics in fourth grade science - mathematics directions, astronomy taught a lesson. Most of the teachers and the classes used for the teaching of physics!

The socio-linguistic directions astronomy facilities are within the content of physics and in the end, so that the most frequently skipped or used as teaching physics!
The second is methodological, namely, the teaching of astronomy is overcrowded facilities that are not in spite of the greatest efforts of teachers handle except the monologue method. In addition, a small number of schools have a teaching tool in astronomy! All of this is in favor of poor student achievement and teaching astronomy in general.

This paper will deal with the first problem, but will make a contribution to contemporary methodological approach to teaching astronomy.

Using his knowledge acquired during undergraduate, MsC studies in astrophysics and PhD studies in methodologies of teaching physics and consulting his colleague from the Astronomical Observatory in Belgrade the first author carried out a pedagogical experiment in September 2013.
This pedagogical experiment containing parallel pupil groups has confirmed that it is justified to include IBSE (Inquiry – Based Science Education involving experiment, research, self-organised work, critical thinking, treatment of the results and drawing conclusions on the basis of the results, as well as a written report at the end).

- The IBSE method is basically a scientific method which has existed even from the time of Galileo, in modern methodics it is also known as integrated scientific method.

- The dependent variables were scores of pupils, the independent variables were learning methods.
The sample was formed by three classes (90 pupils). All the three belong to the same orientation (science and mathematics), same form (fourth, the last) and school (Šabačka gimnazija, Šabac Gymnasium). The quality of groups was approximately equal, which is confirmed through the general score in learning and the average mark in physics.

The first class formed the Control Group (K). In their case Kepler’s laws were taught in the classical way, the so-called transmission method, in which the pupils listen and the teacher speaks to them (lecturing and adopting knowledge) and all what the teacher uses are blackboard and chalk.

In the case of the experimental group 1(E1), the second class, the experimental factor, or independent variable, is the teaching following IBSE. In the second experimental group 2(E2), the third class, the experimental factor is the teaching supported with a demonstration experiment and multimedia. At the end of the study the final knowledge evaluation was done in each group. This evaluation was carried out by means of a test.
The study was aimed at establishing if the teaching following IBSE enlarges the quantity of knowledge of the pupils. On this basis the tasks were defined and the hypotheses formulated: the zero one (IBSE has no influence upon the knowledge of the pupils, i. e. the groups have equal scores) and the alternative one (IBSE leads to enlarging in the quantity of knowledge of pupils, i. e. there are statistically significant differences among the groups).

In the treatment of the results the descriptive statistics with its parameters was used. In order to establish statistically significant differences in the results the variance analysis (ANOVA) was used, as well as the tests of Tukey, group and individual.
The descriptive statistics of the final test shows that the quantity of knowledge was highest in the case of E, and lowest for Group K. The values of the descriptive statistical parameters indicating this fact are given in Table 1:

<table>
<thead>
<tr>
<th>Group</th>
<th>AS</th>
<th>SD</th>
<th>Se</th>
<th>CV</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>18.25</td>
<td>3.25</td>
<td>0.7623</td>
<td>18.46</td>
<td>11.00</td>
<td>25.00</td>
</tr>
<tr>
<td>Experimental 1.</td>
<td>24.35</td>
<td>2.72</td>
<td>0.6873</td>
<td>10.43</td>
<td>19.00</td>
<td>30.00</td>
</tr>
<tr>
<td>Experimental 2.</td>
<td>21.95</td>
<td>2.92</td>
<td>0.6886</td>
<td>13.30</td>
<td>18.00</td>
<td>29.00</td>
</tr>
</tbody>
</table>

AS – arithmetic mean, SD – standard deviation, Se – standard error of arithmetic mean, CV – variation coefficient and (Min, Max) – variation interval.
The results of the final test allow to establish a high quantity of knowledge in E1 and E2, compared to Group K. Between E1 (82.50%) and E2 (73.83%) there is a difference in the knowledge quantity. The circumstance that it is higher in E1 than in E2 can be explained by introducing IBSE. The plot of knowledge quantity is presented in Fig. 1:

**FIG. 1.** Knowledge quantity for pupils in % for the final test
The statistical significance for the differences between the examined groups for the final test is given in Table 2.

<table>
<thead>
<tr>
<th>Group</th>
<th>AS</th>
<th>Experimental 1.</th>
<th>Experimental 2.</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental 1.</td>
<td>18.35</td>
<td>/</td>
<td>1.60</td>
<td>6.35*</td>
</tr>
<tr>
<td>Experimental 2.</td>
<td>24.35</td>
<td>/</td>
<td>/</td>
<td>5.20*</td>
</tr>
<tr>
<td>Control</td>
<td>21.95</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
</tbody>
</table>

* r<0.01 – significance coefficient
Based on the analysis of the present results it is possible to conclude that the alternative hypothesis: the IBSE method enlarges the quantity of knowledge for pupils – there are statistically significant differences between the groups, is here confirmed.

In other words applying the IBSE method results in a higher quantity of knowledge for pupils; therefore this method appears as an efficient one and it deserves to be recommended to the teachers!
Thank you for your attention!