

HISTORICAL EXPERIMENT USING VIRTUAL OBSERVATION

M. Csatáryová

University of Presov, Prešov, Slovakia, maria.csataryova@unipo.sk

ABSTRACT

Effective and interesting physics education is conditioned by exploratory character of student's activity. One aspect of how to support pupils' curiosity and imagination, as well as observation is to integrate teaching with historical observations of the night sky. Within the informal education we can use virtual observations by means of astronomical computer programs EURO – VO (The European Virtual Observatory) that allow us to conduct simulations in space and time and help us explain individual phenomena in their historical context and discovery. The author presents a case study of including selected historical components of observations in physics education by means of interactive computer programs and also describes her experience with such work.

INTRODUCTION

The current period of astronomical development is accompanied by a huge increase in information data, which has prompted a new way of archiving them. The digitization of astronomical data marks a new era not only in the processing and use of these data by the professional community, but also in making it available for educational needs as well as to the general public. The rapid development of information technology in recent years has greatly expanded opportunities in education. It stimulated new forms of education and significantly reshaped the aims and methods of teaching. The inclusion of interactive computer programs in teaching can be seen as an essential element to promote a quality learning environment. At present, the implementation of innovative technologies in teaching has been discussed by various educational researches not only abroad but also in Slovakia [1, 2]. Virtualization and interactive programs have become a key method in many educational standards and encourage an active learning method at all levels of education.

It turns out that inclusion of the practical part of the learning process in different areas of astronomy, e.g. the virtual observatories, promotes pupils' active learning process. The biggest attraction for pupils of primary and secondary education level is, undoubtedly, the observation. A very practical astronomical observation in the context of teaching, however, is associated with a number of problems – ranging from schools being poorly equipped with observational techniques, light pollution of the site, the weather changes to time requirements. Additional restrictions stem from the fact that observations at night cannot be conducted during regular school hours and thus require special arrangements that are not easily made in most of the primary and secondary schools. Astronomical interactive virtual programs are thus an excellent substitute for the real observations. Their inclusion in the process of teaching is currently highly relevant.

We know a number of European projects which aim to streamline the teaching of astronomy through modern technology education. European Virtual Observatory project EURO – VO offers special products - computer programs that enable global electronic access, offer software tools for search, virtualization, and data analysis for research and educational purposes [3]. Computer programs Stellarium and Aladin can rightly be called virtual observatories. Their application introduces us into story lines of the night sky in real time, in the past or in the future. Using the displayed data the phenomenon in its historical continuity of the discovery process as well as the latest astronomical data can be explained. In this paper, we focus on the application of certain options listed in computer programs to physics lectures or to working with interest groups.

STELLARIUM

Stellarium [4] is a computer planetarium that displays a realistic sky as it can be seen with the naked eye or binoculars. However, it is not restricted to visualization of the celestial sphere. It also allows to view different parts of the universe both in space and in time. It is mainly based on the Hipparcos catalog. Stellarium Basic Catalog contains 600,000 stars with their basic identification data. The virtual observatory Stellarium with its software suite provides the user with a number of variations of creating the outputs. In our contribution we focus on those that can be used in teaching.

The student's ability to navigate in the night sky is one of the goals of teaching astronomy in our schools. Due to the fact that Stellarium can specify the location of the observation points, in this virtual world we can demonstrate the beauty of not only the northern but also the southern night sky. To determine the constellations we can use an "assistant" to determine the name of the constellation and its brightest stars, to determine the shape, but also its mythological representations (Fig.1). Attached circles allow us to visualize the constellations according to the basic distribution, to track astronomical phenomena, such as the position of planets, stars occultation by the Moon, and also, for example, meteor showers. For an explanation of real phenomena in the sky, Stellarium provides additional programs (scripts), which can be downloaded from the Internet. Furthermore, new customized programs can be created. Stellarium has been developed as an open source software project under the GNU GPL license and allows users to add their own plug-in modules (satellites, control of telescopes etc.). The scripting language ECMAScript offers the users possibility to create their own views, to find positions of various objects or to demonstrate different phenomena.

The existing scripts contain examples of eclipses of the Sun and the Moon, projection of the Earth from other planets, as well as surface maps of particular planets.

The program allows the users to monitor real orbits of planets and their moons. We can see, for example, Jupiter moons, as they were first seen by Galileo Galilei. Stellarium allows much more, their zoom and even their movement over time. For a few seconds we can see the whole circulation of the moons around the planet. In Stellarium, information can be found on parallax, spectral type and absolute magnitude of the brightest stars, which allow us its use in teaching. In this way it is possible to construct, for example, the HR diagram of the brightest stars of the night sky.

In the next section, we present an example how to compare the age of three open star clusters. We choose the best-known open star clusters: the Pleiades, Hyades and the Beehive (Praesepe). Stellarium program will allow us to locate the clusters and the necessary data for the stars, in particular – absolute magnitude and spectral class (Fig.2). These data were processed in the table editor. The displayed diagram represents a shift from individual stars on the main sequence of the HR diagram.

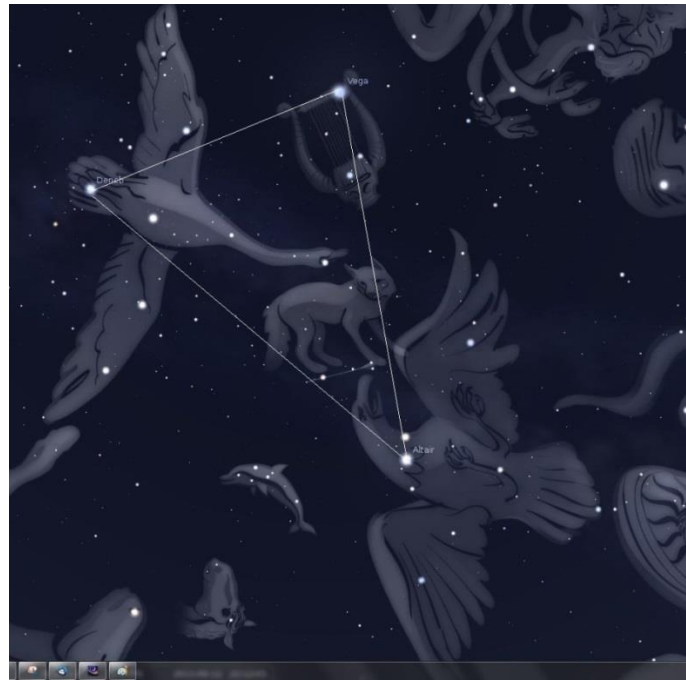


Fig.1. Exploring constellations asterisms Summer Triangle

The HR diagram basically shows the relationship between the stars' brightness versus their spectral type. The stars of the Pleiades are listed on the main sequence, which documents their younger age compared to the stars in the Hyades, for which the offset from the main sequence on the HR diagram is larger [5].

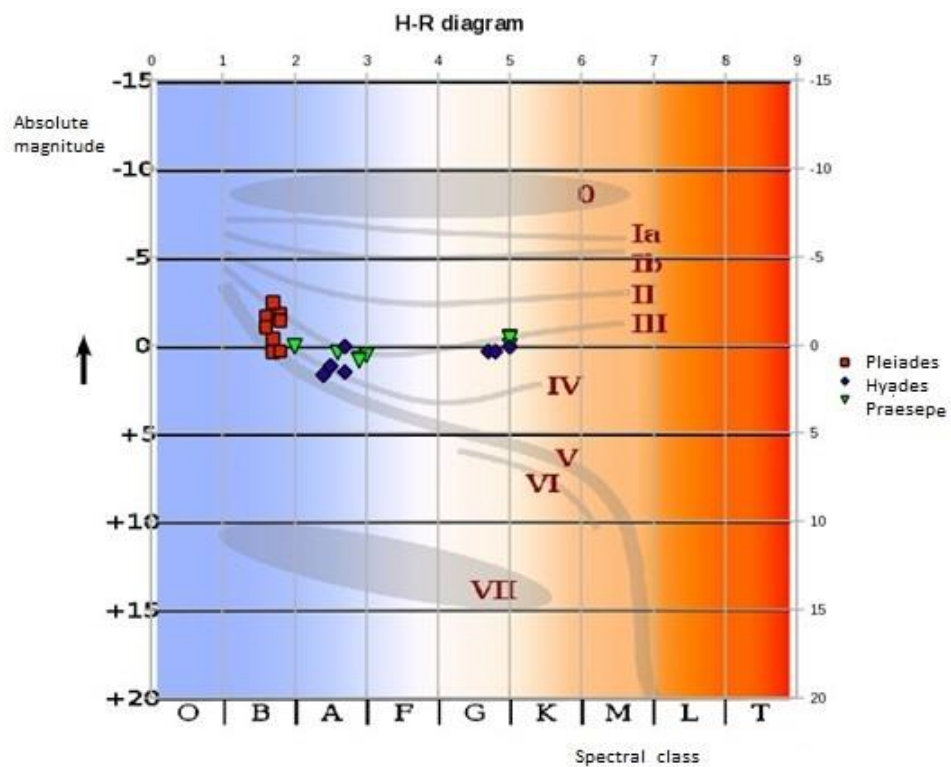


Fig.2. The HR Diagram for the open clusters Pleiades, Hyades and Praesepe

ALADIN

The interactive computer program Aladin [6] acts as a space atlas which allows the user to visualize digitized astronomical images, to search astronomical catalogs of data and databases (e.g. Simbad, VizieR) and to connect all the servers of virtual observatories. In teaching it allows students to reproduce astronomical discoveries by providing the necessary data. It includes a built-in spreadsheet for calculations which other programs lack. Having in mind the complexity of the program it is more suitable for students who have learned the basics of working with a computer as well as basic knowledge of astronomy. In settings, the control level can be selected, one of the possibilities is the student profile. ALADIN is a basic environment that can run specialized tools of virtual observatories available on the Internet in the form of modules, for example for data visualization and spectrum analysis. For the first orientation in available options for computations needed in astronomy, methodically worked examples on the web EURO-VO can be used.

For illustration, we can give an example of using the ALADIN program to help determine a distance of a galaxy. Firstly, a distance of the galaxy M31 in the constellation Andromeda was determined by Edwin Hubble. In determining a distance, he used characteristics of Cepheid variable stars (Ceph). Period changes in brightness of the variable star depend on the absolute magnitude according to the equation

$$M = -1,43 - 2,81 \log P, \quad (1)$$

where M is the absolute magnitude of a given star, P is the period of the star's brightness changes. The distance of the galaxy can be determined by the distance module, which is a function of the absolute magnitude. The module distance can be expressed as

$$m - M = 5 \log r - 5, \quad (2)$$

where M is the absolute magnitude, m the apparent magnitude of the star and r is the distance expressed in parsecs. In the following section we present a practical application of the procedure for determining the distance of the galaxy M81 in the constellation Ursa Major. In the ALADIN program we open the catalog VizieR M81 and find an object and choose the type of variable star Ceph. The program displays the stars and a data sheet. In the table of data we are interested in a column with a period. To calculate the absolute magnitude of stars found we can use a built-in calculator of the ALADIN program, or process the data by other means (Fig.3 a, b).

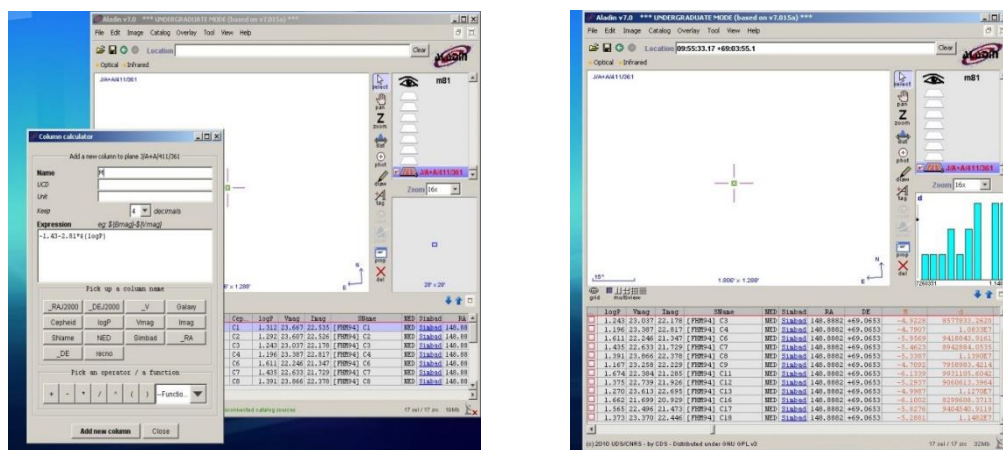


Fig.3 a) calculation of the absolute magnitude and b) distance Ceph in M 81 in the program Aladin

PROJECT OF KNOWLEDGE ACTIVE CREATION THROUGH AN INTERACTIVE STELLARIUM.

1. In the pilot project we investigated the extent to which the learning process will be influenced by such computer applications. We chose the interactive computer program Stellarium, which is a product of the European project EURO-VO (The European Virtual Observatory). We focused on the possible inclusion of certain topics from astronomy to physics and worked out simple tasks using Stellarium. For the pilot survey, two first grade classes of the secondary school in Snina were selected, where in the physics curriculum astronomy was included. Students solved problems involving several virtual observations - according to the covered thematic topics – the orientation of the Solar System in the sky and Kepler's laws. Students in both classes were comparable (23 students in the class where the program Stellarium was used, and 25 students, where the topic took on the traditional way). The conclusion was made by a knowledge test of the topics covered. The test results clearly show that students who have taken over the curriculum using the computer program Stellarium acquired much more basic terms.

2. Regarding attitudinal questions, 75% of the pupils who worked with Stellarium answered that learning astronomy was interesting for them (in the experimental classes such statement was given by 50% of pupils).

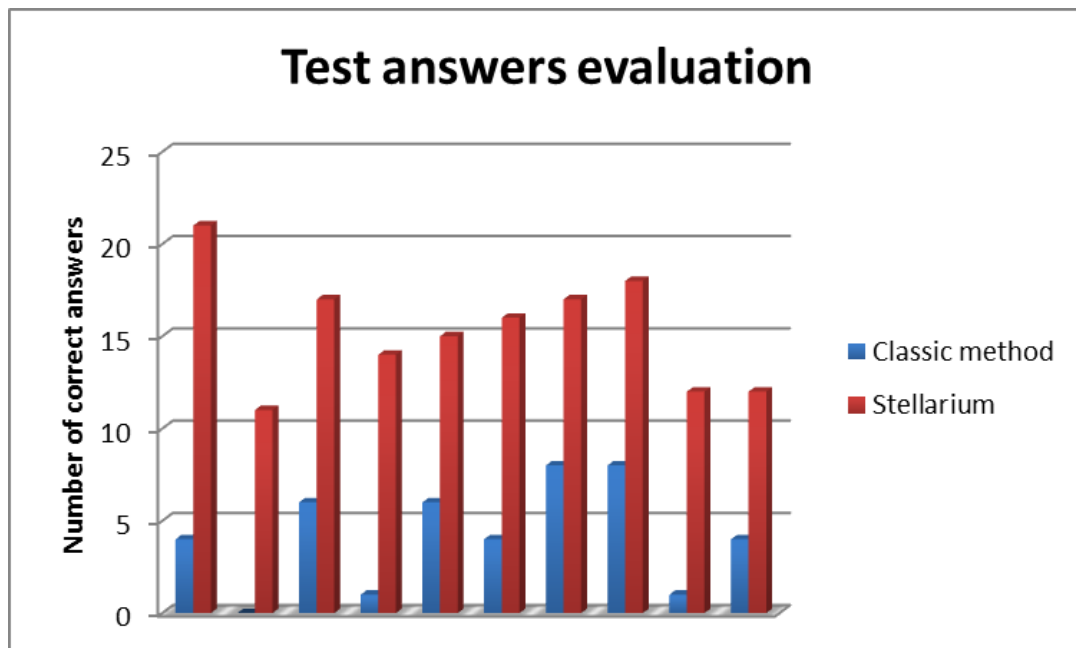


Fig.4. Test answers evaluation

CONCLUSION

The results of our pilot survey confirm that the inclusion of interactive computer programs in teaching supports increasing the knowledge level in the field. We can conclude that teaching with Stellarium was also very interesting for pupils. The active work aroused greater interest in them in the discussed topics than in students who took the traditional way. Moreover, as demonstrated by the final test, they showed more acquired knowledge than students in classical teaching. It turns out that the inclusion of topics from astronomy to physics teaching using Stellarium is a motivator for learning and may be one of the factors that will help determine further orientation of pupils towards studying natural sciences.

ACKNOWLEDGEMENTS

The presented work was supported by the project Kega č. 007UPJŠ-4/2013, Moderné technológie vo vyučovaní astronómie a astrofyziky (Modern technologies in teaching astronomy and astrophysics).

REFERENCES

1. Beták, N., Ožvoldová, M.: The role of critical thinking in question designing in teaching with student response system, *Journal of Technology and Information Education* **5**, 5-11. (in Slovak language). ISSN 1803-6805 (2013).
2. Gerhátovej, Ž.: Experiments on the Internet – removing barriers facing students with special needs, *Procedia – social and behavioral sciences* **114**, 360-364 (2014). ISSN 1877-0428.
3. Freistetter, F., Iafrate, G., Ramella, M.: The Sky is for Everyone – Outreach and Education with the Virtual Observatory, 2011, arXiv:1101.3061v1
http://arxiv.org/PS_cache/arxiv/pdf/1101/1101.3061v1.pdf
4. <http://www.stellarium.org/sk/>
5. Csatóryová, M., Parimucha, S.: Virtual laboratory in the teaching of astronomy and astrophysics in Slovakia, in: *Proceedings of the 18th edition of the Multimedia in physics teaching and learning conference*, European Physical Society, pp. 129-133, 2013. ISBN 2-914771-90-8
<http://mptl18.dia.uned.es/mptl18/files/MPTL18-PROCEEDINGS.pdf>
6. <http://aladin.u-strasbg.fr/>