ISSN: 2639-0108

Review Article

Advances in Theoretical & Computational Physics

Exploring the Celestial Sphere with the Telescope and Computational Analysis of the Images

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Submitted: 08 Oct 2018; **Accepted**: 03 Nov 2018; **Published**: 18 Feb 2019

Abstract
One of the modern methods of teaching astronomy is the Investigation, one of Inquiry Based Learning methods, used as an educational method in the elaboration of extracurricular projects, as an example for the students of the Faculty of Sciences, from University of Craiova, Romania. The paper presents a join approach to research in Astronomy and Computer Science, using Scientific Inquiry methods and Computer programming skills to study the asteroid dynamics in the Solar System. Starting with the image analysis with the software Astrometrica, necessary for the determination of moving objects astrometry in astronomical images, the students developed, under supervision of the author, some software tools oriented to fast identification and classification of the founded asteroids. Theirs tools where tested on real astronomy data, namely raw images, obtained with the INT telescope in La Palma, the Canary Islands. Following this methodological experiment the students arrive to develop within a short time advanced practical skills for research in Computational Astronomy, increasing in the same time theirs knowledge as Web programmers.

Keywords: Computational Astronomy, Inquiry Based Learning

Introduction
In recent times, the ability to study scientific fields in continual ‘expansion’ has increased, so the knowledge horizons, expanded in a similar manner with the expansion of the universe [1]. This “expansion”, being coupled with the exponential growth of data, requires training of the next generation of students in the art of intelligent understanding and processing of data, for the success of science.

Astronomy is a science that studies the movements, structure and evolution of the celestial bodies and the systems formed by them, being considered the most extensive of the natural sciences. Beginning with the first small steps, small every day and up to the Earth’s greatest step in the Cosmic Space, everything means space. Wherever we go, wherever we are, we are surrounded by space, space in a room, space or air space, or Cosmic Space, in a well-established reference system both on the Earth and on the celestial sphere.

Astronomy is considered an emerging science, which can be addressed in two contexts of formal education and scientific research, both of which are underwritten by ‘lifelong learners’ [2].

The integration of the Astronomy Science in the teaching-learning process of the Information and Communication Technologies presents various advantages, by proposing interesting subjects for soft developers, kipping at high level the attention of students and improving the generally attitude of the students toward learning. The study of the Solar System is one of those topics that interest students and many documentary books provide information text to respond to their curiosity [2].

In this context, the approach presented here is a join approach to research in Astronomy and Computer Science, using Scientific Inquiry methods and solid programming knowledge to study the asteroid dynamics in the Solar System. This approach presents clear advantages for the teaching process of Information Technologies, by improving the attitude of the students toward learning and discovery.

Teaching Computer Sciences trough Astronomy
In combination with the EURONEAR project, which studies the Near Earth Asteroids (NEA) [3], an experimental approach to astronomy teaching was tested at the University of Craiova, based on a blended-learning method that alternates an Inquiry Based Learning process of the astrometry with the development and implementation of some software tools by the students, applications that deal with the recognition and classification of asteroids.

The experimental Astronomy-Computer Science mo-dules were proposed to a group of students in Sciences, during their second year of study at University of Craiova (in May- June 2018). The experimental approach described below represents a continuation of a series of methodological experiments started in 2016 [4].

The Computational Astrometry modules have implemented in four modules, as presented in (Figure 1).

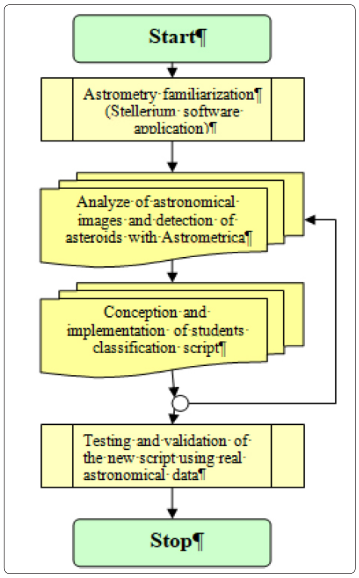

Figure:1 The diagram of the learning modules

If the *Introduction in Astrometry module* (1) was conducted using classical teaching methods and a well-known planetarium software [5], the second module deal with the application of theory in practice– *the Analyze of astronomical images and the detection of asteroids* (2) - and used the specialized tool Astrometrica [6]. This module involved the Investigating and Inquiry Learning as teaching methods, the students working individually for the discovery of moving astronomical objects, under the supervision of a tutor.

In the next module, the students develop and implement some utilitarian scripts, writhed in PHP, that allow a user not necessarily expert to validate the accuracy of the results obtained with Astrometrica, to determine whether a previously detected moving object is a known asteroid or a new one. The *Student's Script Design module* (3) was conducted under the direct guidance of the tutor in the form of a brain-storming, starting with the identification of the necessary input data, the output information, the necessary numerical and graphical processing.

In the final modules (3 and 4), the students have implemented ant tested the scripts working in small groups, using their basic knowledge of Data Bases and Web Design. The validation of the new software tool involved a comparison with the data from Minor Planet Center Database (MPC [7]),

Example of students' applications

- The asteroids' classification tool takes a set of astronomical observations (also in MPC format), determines the apparent motion of the object in the sky (the Proper Motion - in arc seconds per minute), and the Solar Elongation (Eps).of asteroids. The ratio of the two sizes makes it possible to quickly identify asteroids that have a high orbit (less eccentric) radius below the 1.3 AU limits, asteroids that are by definition classified as Near Earth Objects (NEAs), the 3.5 AU define the outer Main Belt Limit, when the Trojan asteroids are localized around 5.2 UA. The determination of the NEA limit was made on the basis of a formula proposed in [8].
- The pre-recovery tool determines the position of all known asteroids inside an observation window at a given moment of time (see figure 2), using a connection at the AstDyS-2 database [9]. The tool represents also the relative position of the asteroids inside the windows. The purpose of this software script was to permit a fast visual identification of known asteroids during the analysis with Astrometrica of astronomic images, which is very useful to recover lost asteroids ([10]).

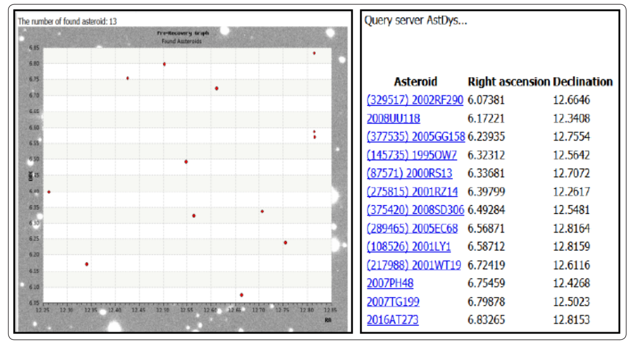

Figure 2: The Pre-Recovery Tool

Conclusions

The blended learning example presented here proved a combination of the best elements of face-to-face, discovery and online learning and it was proposed to emerge as an experimental mode of teaching and learning for today's digital native students.

This approach of the research area in astronomy, using the discovery and project programming methods produced good result at very short term, the students acquiring very fast the capacity to understand the astronomy research in our days, increasing in the same time theirs knowledge as Web programmers, which was only expected at the end of the last year of license studies in Computer Sciences.

Acknowledgements

This work was partially supported by Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering, Magurele, Romania. I wish to thank Prof. Ovidiu Vaduvescu from the Isaac Newton Group of Telescopes (La Palma) for providing the astronomical images processed by students.

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