# Mixed E-Learning Methods for Study the Modern Astronomy

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**Absatract:** ***The paper presents some informal e-learning methods, adapted for teaching and learning the Observational and the Computational Astronomy and tested recently on groups of students from University of Craiova. The finality of the experiment was to insert the students directly into some hot topics of astronomical research, starting only with the basically knowledge derived from astronomy popularisation sites and studying in small interactive autonomous groups. The approach included three steps: a formalization of some recent problems in Astronomy, with a continuous feed-back inside the testes group of students, an extended individual documentary research, based on the virtual lab principle, and a final analysis of the results of this investigation, when the students were asked to propose and sustain a planning of lessons in astronomy for teaching the studied concepts and facts to secondary level scholars.***

***Keywords:** E-learning Methods, Observational and Computational Astronomy)*

## I. Introduction

The recent development of the Internet, associated with the new facilities for dissemination of scientific information in the world, have produced a deep change in the approach and the learning of some scientific fields that where considered long-time as not relevant in basically education. In this case it is Astronomy itself, a life science that has been unjustly banished from most formal educational programs.

The informal environment of the Observational Astronomy represents a significant reservoir of knowledge and can be a major source of innovation for new methods of teaching and learning sciences in schools and universities.

The teaching of modern sciences includes the construction of a rational representation of the matter and reasoned analysis of phenomena that arouse the curiosity of the students. In this context, the study of the Solar System is one of those topics that profoundly interest the scholars and many documentary books or sites provide popular information to respond to theirs curiosity [1].

The theme of the Solar System therefore requires a study about how to engage the students in Sciences to the path of building a scientific model, with an introduction to documentary reading to learn in order to find information in an encyclopaedically support (books or sites), starting from an understanding of the organization of its content. In the world of 'astronomy training science', accustomed to the jumps between observational facts and the scientifically interpretations, the notion of informal learning appears today as an alternative way to explore.

In the context of informal learning, the role of the teacher is to develop the teaching environment so that the student can find resources to invest the problem and solve it, by making available numerous documentary means and by organizing situations of scientific debate [2,3] . He assures mediator's role in the groups of students, to help to orientate activity by reformulations, to recalls of task, to partial syntheses and to allowing the move forward exchanges.

This paper proposes a study of an informal approach for teaching the Solar System astronomy, using electronic resources and mixed generically learning methods. The role of the teacher was reduced to a long distance documentation selector and at a mediator between divergent approaches of different groups or different interpretation of astronomy notions. The methodology used was characteristically to the On-line Enriched (Driver) Model from E-learning, where the learning process is largely delivered on-line, with only rare periodically physical contact with a teacher.

## II. The Informal Method Of Teaching/Learning

The informal learning is a very old method of teaching and learning that involve the direct implication of the scholars or students in the formation process, adapting the knowledge acquisition to the individual capacity of information acquisition and understanding. This method was largely employed in the pre-industrial age of European Universities, in the flexible relation between the ancient Masters and their Scholars.

By opposition, the formal learning deals with strictly defined objectives, a learning program and a non-subjective evaluation procedure. Unexpectedly, the informal method can produces rapid results in the case of natural sciences teaching, where the direct contact of students with the nature's phenomena and an individual interpretation can lift up the interest and the attention of them.

In the case of Astronomy, the formal teaching method is affected by the barrier of mathematical formulation and the computational aspects of space investigation. In contrast with the formalised manuals, the huge quantities of not-structured astronomical information covered by Internet and the almost permanent breaking news about the recent advances in astronomy research can maintain a high level of the students' curiosity and interest.

In this context, a didactical informal approach to the learning of some modern notions in the Solar System astronomy was tested on a group of students. We combined an informal approach of basic notions in Astronomy, approach that include a formalization of the studied problems with a continuous feed-back inside the testes group of students, an extended individual documentary research, based on the virtual lab principle, and an final analysis of the results of this investigation.

The methodology used was characteristically to the On-line Enriched (Driver) Model from E-learning ([4]), where the learning process is largely delivered on-line, with only rare periodically physical contact with a teacher. The result of this approach are described bellow..

## III. The Didactical Experiment

### *A. The experimental methodology*

The didactical project tokens three weeks, the last week mainly concerning the edition and realization of the final student's project on the solar system. Each sequence proposes situations to endow the student with resolution tools adapted to the research work, and situations specific to the sciences.

The work is for students as part of a multidisciplinary project, finalizing the tasks of an Internet project production by creating an e-site on the solar system. It is accompanied by a space exploration game in the form of questions to go from one planet to another, the answers can be found in the Web resources.

The learning unit was broken down into five sequences to progressively address more complex situations involving more data. The following table restates the logic of the proposed situations and their articulation with respect to the intended scientific notion.

The study of Solar System representations showed a diversity of opinions based on poorly understood knowledge. To pass to a scientific knowledge, it is necessary that this one is problematized, founded in reason. When it comes to science at school, you have to think about scientific debate and argumentation. For this, each didactic situation is organized in three stages.

1. The formalisation of problem: Every situation leans on an initial question which points out the position of problem but does not allow solving it without hiring a debate on criteria allowing determining resolution. It is therefore a question of constructing research criteria in small groups to spot arguments and to justify a resolution.

2. Documentary research: A collective debate allows then to confront the propositions of different groups to develop a common issue and found a shared reason. The problematic framework directs research and allows a selection of relevant information in the available data.

3. The proposal of the solutions: The sharing of research results gives rise to a second debate in small groups to formalize a proposal. A final collective debate then leads to a confrontation of the proposals and to the development of a reasoned solution, i.e. to a knowledge shared by the class.

The didactical experiment involved different small groups of students and have the final purpose to learn them how to elaborate an astronomy lesson planning adapted to the understanding of scholars,

### *B. The steps of the experiment*

The experiment begun with a list of chosen basically problems in positional astronomy, adapted to the understanding of main astronomic notions and facts at the scholars level. The students implied in the experiment were asked first to explain the nature of the studied problem at different levels of formalisation, next to propose solutions to the problem, using any bibliographical reference their can found and finally to confront theirs solutions in a collective debate about the correctitude, the efficiency and the adaptability of the solutions to the scholars level of understanding. The relation with the teacher was driven generally on-line, using the facilities of Skype.

As title of example, there are presented below some of the investigated subjects

1. Exotic objects of the Solar System: the Comets and the Dwarf Planets: Statement: Beginning from 2006, the International Astronomical Union (IAU) introduced a new kind of celestial body: the dwarf planets

*Question*: Identifies the dwarf planets in the Solar system, exteriors to the orbit of Neptune, and their positions.

2. The small objects of the Solar System: the Asteroids. Statement: It is well known that the asteroids of the Solar System, majority of them orbiting the Sun between Mars and Jupiter, have different orbit that the planets and different velocities compared with the almost constant velocity of a main planet; there is a risk that some asteroids produce some catastrophically impacts with the Earth in the future.

   *Question*: How depends the velocity of an asteroid on his distance to the Sun.

3. Extra-solar planets. Statement In the last decade of years, the astronomers detected and reordered few hundred of new planets, orbiting other stars that the Sun, using in general indirect photometric methods.

   *Question*: What kind of extra-solar planets were discovered and by witch methods.

We will discuss detailed in the next of the paper just the approach to the first question.

The formalization step leads to the official definition of a dwarf planets: A dwarf planet, since the new definition of the International Astronomical Union in August 2006, is a celestial body orbiting the Sun that has sufficient mass for its gravity outweighs the forces of cohesion of the solid body and the maintain hydrostatic equilibrium (in an almost spherical form), which is not a satellite, but which did not clean up in its orbital neighborhood [5]. So the student must identify using a bibliographical research what body in the Solar System can be identified as a planet and to eliminate the main planets Mercury, Venus, Earth (Terra), Mars, Jupiter, Saturn and Neptune.


Fig. 1 The exterior dwarf planets

The second step of the research put the students in a face–to face debate purposing the validity of the information available in Internet. According to IAU, seven bodies have access to the status of dwarf planet Ceres, Pluto, Eris, Makemake, Haumea, Sedna and Quaoar. The status of Charon, currently considered a satellite of Pluto, is uncertain. Pluto and Charon orbit around a point in space rather than inside Pluto, forming a binary dwarf planetary system. A number of other candidates have been observed: Orcus, Varuna, Ixion, 2015 RR245. The sharing of research results rise to a second debate in small groups to formalize a response to the question.

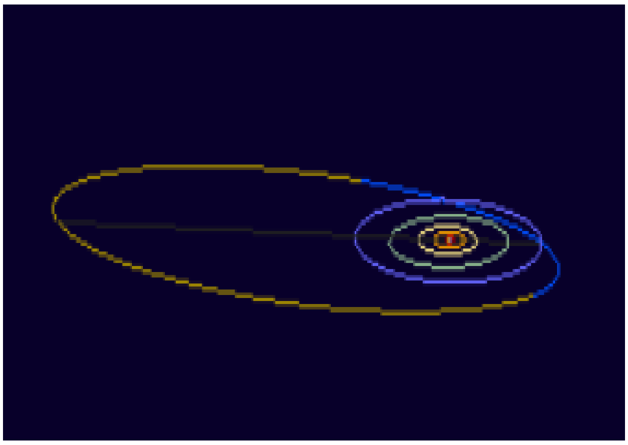
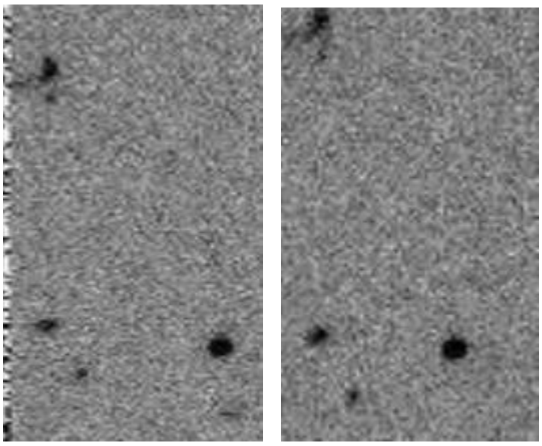


Fig 2. The 2015 RR245 dwarf planet: (a) sketch of its orbit, reported to the orbits of Neptune (all blue).



a. b.

Fig 3. (a - b) Two different positions of 2015 RR245 (bottom- right) observed with the telescope of Mauna Kea. (source: https://www.minorplanetcenter.ne)

A correct identification of the position of a dwarf planet supposes knowledge of his orbital parameters, accessible at the Minor Planet Centre [6], eventually the sketch of his orbit. For this purpose, the student where asked to learn, using the Internet in small group, how to use the main database of all MPC objects (dwarf planets, asteroids, comets) , the graphical facilities of the MPC and the signification of main parameters that describe an (almost) elliptical orbit around the Sun. This part of the experiment assured the passage from Observational astronomy to the concepts of Computational astronomy (astrometric coordinates, mathematical characterisation of an orbit, graphical representation methods)

Some of the dwarf planets have a very eccentrically orbit, as in the case of 2015 RR245 (see Fig. 2). Discovered at Mauna Kea, 2015 RR245 is one of the strangest objects in the Solar System. To explain the form of its orbit, some knowledge of the analytical geometry of elliptic curves were necessary (major and minor semi-axis, eccentricity, perihelion, aphelion, and others). The students passed this step with the help of the teacher.

TABLE 1. EXAMPLE OF THE ORBITAL ELEMENTS FOR 2015 RR245 DWARF PLANET

| | | | |
|---|---|---|---|
| epoch | 2016-07-31.0 | semimajor axis (AU) | 81.4415225 |
| epoch JD | 2457600.5 | mean anomaly (°) | 322.65132 |
| perihelion date | 2092-10-30.96626 | mean daily motion (°/day) | 0.00134100 |
| perihelion JD | 2485451.46626 | aphelion distance (AU) | 129.192 |
| argument of perihelion (°) | 261.38034 | period (years) | 735 |
| ascending node (°) | 211.68362 | P-vector [x] | -0.38722704 |
| inclination (°) | 7.57471 | P-vector [y] | 0.88925229 |
| eccentricity | 0.5863222 | P-vector [z] | 0.24348632 |
| perihelion distance (AU) | 33.6905492 | Q-vector [x] | -0.91938117 |
| Tisserand w.r.t. Jupiter | 6.4 | Q-vector [y] | -0.35259387 |
| ΔV w.r.t. Earth (km/sec) | 10.7 | Q-vector [z] | -0.17440132 |
| | | absolute magnitude | 3.7 |

In the Table1 we present a synthesis of computational elements that characterise completely the orbit of a Solar System body. Understanding the signification of each parameter in order to compare the orbits of different dwarf planets was the most difficult part of this step.

Each of the steps described below required an adjustment of the understanding of the students, from the correct definition of a problem and a fair documentary research, until the adaptation of the answers to the scientific language and scientific requirements. The students were forced to learn independently from the teacher and to constantly adjust their research and their knowledge to the feed-back of the other members of the team.

The finality of the experiment was to insert the students directly into some hot topics of astronomical research, both in the framework of Observational astronomy (images analysis) and the Computational astronomy (the orbital parameter determination), starting only with the basically knowledge derived from astronomy popularisation sites.

*C The results of this approach*

The finality of the experiment was to insert the students directly into some hot topics of astronomical research, starting only with the basically knowledge derived from astronomy popularisation sites and studying in small interactive autonomous groups. The role of the teacher was reduced to a long distance documentation selector and at a mediator between divergent approaches of different groups or different interpretation of astronomy notions.

Students were also asked to develop, on the basis of the stages of the experimental learning approach described below, some lessons planning for teaching these subjects at high school classes. The topic has generated numerous discussions about the classroom understanding of mathematical aspects of the Astronomy, the motivation of pupils for sky observation and the choosing of the best teaching strategies in classroom.

Most students participating in this didactical experiment sustaind that the documentary research and discovery method as modern teaching methods are useful in learnong the modern astronomy.

## IV. CONCLUSIONS

The presented work attempts to expose the strong interweaving between technology, didactic and scientific aspects of an informal formative situation focused on the astronomy learning. It also tries to account for the dynamic processes that are designed to train the future teachers on three levels of perception of fenomenas, to allow them a more custom conversion between the popularization aspect of space sciences and the rigurous aproach of astronomy.

The generical method of learning used in the didactical experiment described in the third section, combining a directioned formalization and documetation with a version of discovery method of learning, having constant corrections from inside the students group, proved to be a very fast informal method of teaching the scholars about natural phenomenas and natural sciencies.

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