EUDOXOS

# Implementation Guide

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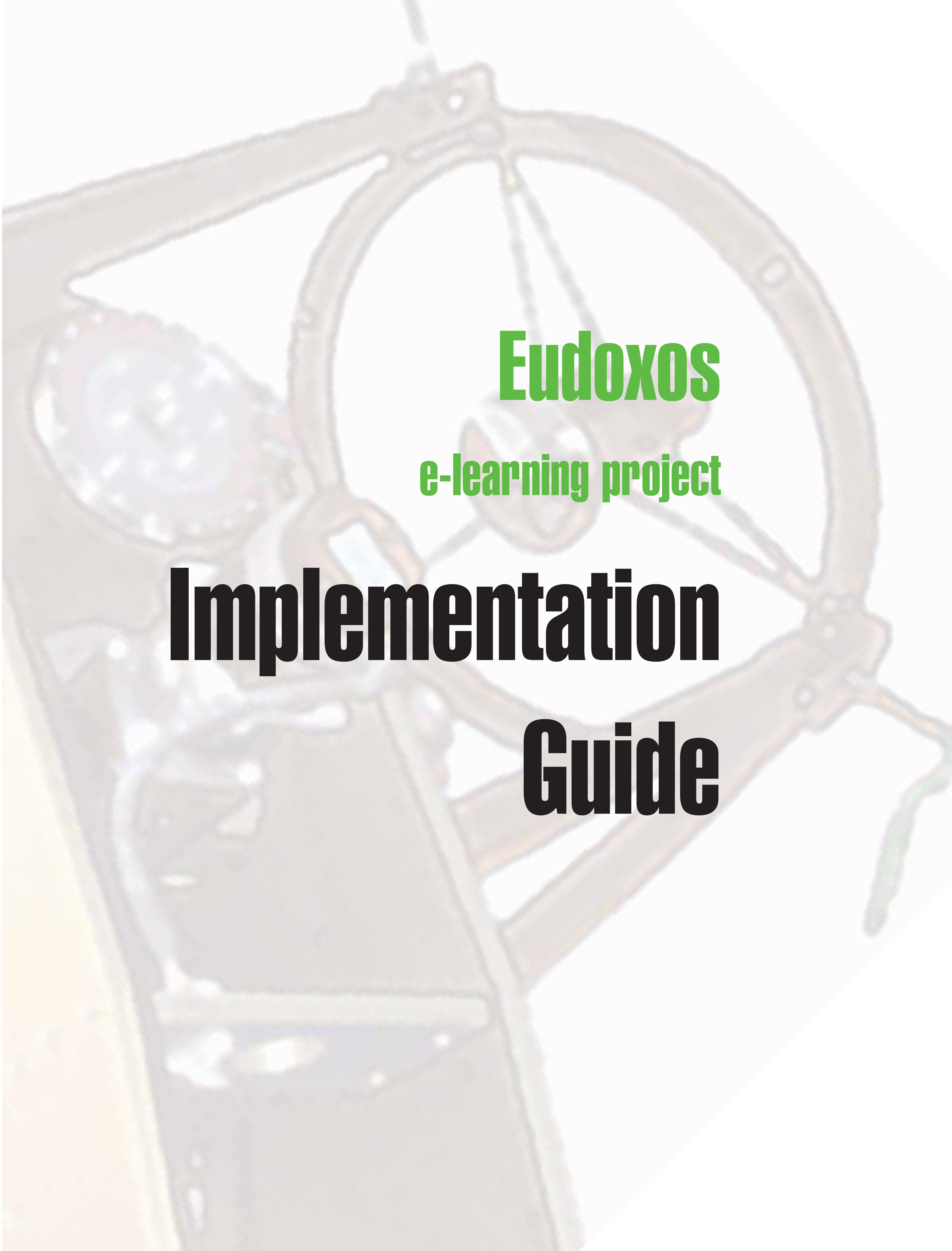

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## e-learning project

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# Contents

# For the teacher

The Eudoxos e-learning project focuses on the educational use of the remotely controlled telescopes of the National Observatory for Education “Eudoxos” (NOE Eudoxos) on mount Ainos of the island of Kefallinia, Greece. The aim of this Implementation Guide is to support the teachers involved in the project to implement the proposed activities in the school science curriculum of secondary education of all participating countries. The Implementation Guide aims also to help both students and teachers go beyond cliches in the fields where they can make the most valuable contributions. To assure maximal usability of the new tools, optimal adaptation to the local environments and realistic evaluation of the pedagogical effects, the Eudoxos e-learning project uses a heavily user-centered approach.

In the framework of the project a user-friendly **web based educational environment is developed** allowing the Andreas Michalitsianos (TAM) and Apollon (HTA) telescopes to be operated via queue based scheduling (TAM, HTA) or in real time (HTA), by high school students and their teachers. The web based educational software gives the opportunity to students across Europe to control the telescopes and perform observations. The development of the educational environment is the outcome of the collaborative effort of scientists, pedagogical and software experts, teachers and students. Additionally, the partnership has upgraded the observatory with a software component that allows the students to observe on-line the sun during the day. The capability of controlling the TAM on-line also exists but it is discouraged as highly technical.

The Eudoxos project adopted a heavily user-centered approach in the development of the User Interface. In order to achieve this goal the project's implementation involved **two cycles of school-centered work** in real school environments. For the first cycle an adapted curriculum was developed around a solid educational framework that captures the main learning objectives of the project (analysing observations of the sun, the moon, galaxies, nebulae, variable stars, eclipsing binaries), while during the second the students and teachers of the participating schools had the chance to design and perform their own projects by creative use of the telescopes (determination of the orbital elements of asteroids (minor planets in the solar system and other ambitious projects and experiments) carrying out their own direct astronomical observations. The project was implemented initially in schools in Greece, Italy, Spain and Austria, while during the second cycle of school centered work more schools were allowed to access the network from any European country.

The project's evolution relied in parallel **on the further development of the observatory** (upgrade of its technical base and improvement of the access to it through the development of a new highly user-friendly user interface, in order to be used for educational purposes) and **the design and development of a new pedagogical framework for the introduction of the scientific inquiry in science teaching at school level**. Another but different framework for similar purposes has been developed for Greek schools and funded by the Greek Ministry of Education (Solomos et al 1999, 2001).

The pedagogical framework includes the necessary adjustments to the normal school curriculum, teachers' training (on-line seminars and workshop) and support, development of lesson plans for the project's implementation in the classroom and development of educational material (conventional and electronic). The classroom activities are based mainly on observations with the TAM and HTA telescopes of the NOE Eudoxos, however, input with information from other larger aperture ground based or space telescopes including the Hubble space telescope or special astronomical instruments located on earth or in space, is also used to enhance the validity of the scientific ideas and the educational value of the project.

During the implementation of the school-centered activities teachers and students are provided with the needed pedagogical and technical support through the project's web site, which also serve as the starting point for discussions on the project's aspects.

The **Implementation Guide** consists of four main chapters which include all the necessary information for the project's implementation. The **First Chapter** describes the pedagogical framework of the project setting its implementations parameters. The **Second Chapter** includes the technical description of the NOE Eudoxos telescopes and the Users' Interface. The **Third Chapter** describes the lesson plans which help the teachers during the implementation of the project in the school environment. The **Fourth Chapter** describes the evaluation methodology of the project providing specific information and guidelines for the teachers.

# Introduction

The **Eudoxos e-learing project** aims at using the possibilities the Internet offers in order to transform the classroom into a research laboratory. The project studies the applicability of the emerging technology in the school sector and provides a platform that allows the students to use the TAM and HTA telescopes of the Eudoxos National Observatory for Education and Research (Greece) in the framework of their school curriculum. The Eudoxos project aims at demonstrating in practice how e-learning can improve and enrich the quality of the learning and teaching process in science and technology and thus should constitute an element of a new educational environment.

The **main aim** for the Eudoxos project is to take advantage of the popularity of the subject of Astronomy and the attraction of a idea of using directly first rate scientific instruments, in particular high grade networked telescopes of a real research observatory, to teach students scientific concepts and ideas of a multidisciplinary nature spanning areas of mathematics, statistics, chemistry, physics etc. and, of cource, astronomy, astrophysics and cosmology.

The **objectives** of the project were:

- **The development of a pedagogical framework that allows for successful application of advanced technology in science teaching:** The project developed an innovative educational approach, which guides students through actual the learning process in science, by using real-time astronomical observations as possible subjects of both formal and informal scientific investigation.

- **The enhancement of a constructionist approach in science teaching:** Usually pre-designed experiments are used in science teaching. In the framework of the project, students acquire the skills to use the telescopes to set up their own experiments and observations, which they conduct autonomously. In this way the procedure of scientific inquiry is fully realised: formulation of hypothesis, experiment design, selection of time and sky area, implementation, analysis of data, verification or rejection of hypothesis, evaluation and generalisation are the steps that allow for a deeper understanding of the scientific method. The partnership believes that the proposed approach acts as a qualitative upgrade to everyday teaching for several reasons:

  **Motivation of students:** Students are more likely to feel a sense of personal investment in a scientific investigation as they actively participate in the research procedure and add their own ideas to their observations.

  **Developing critical attitude:** Too often students accept the readings of scientific instruments without question. When students get involved in the project's activities they appreciate the power and limitations of an experiment and, as a result, they develop a healthy scepticism about the readings and acquire a more subtle understanding of the nature of scientific information and knowledge.

**Making connections to underlying concepts:** In the framework of the project's application to the school communities, students are asked to design their own projects. During this procedure students figure out what things to measure and how to measure them. In the process they develop a deeper understanding of the scientific concepts underlying the investigation.

**Understanding the relationship between science and technology:** Students participating in the project gain hands-on experience in the ways that technology and engineering can both serve and inspire scientific investigation and vice versa.

- **The development of new learning tools and educational environments:** The Eudoxos e-learning project gives the opportunity to use remotely controlled telescopes in a real-time, hands-on, interactive environment to students around Europe. It enables the students to increase their knowledge of astronomy, astrophysics, mathematics and other science subjects; improve their computer literacy; and strengthens their critical thinking skills. A **User friendly Interface** has been developed to be an adding tool that bridges science teaching and technology. This software educational tool supports teachers and students in a new learning environment and is at the same time compatible with graphics and analysis software components, so students can easily investigate trends and patterns of the data they collect by using the telescope.

- **The development of a concrete evaluation scheme of the educational and technological aspects:** Evaluation of both aspects of the project (technology and pedagogy) is done according to well-defined methodologies. The aim is to develop a better theoretical framework on how different types of tools and instruments support different types of thinking, reasoning and understanding. The evaluation of the didactic approach will be performed on three aspects: evaluation of student's learning, evaluation of the underlying pedagogical framework and ethnographical evaluation.

**Project's Innovation**

Although the Eudoxos e-learning project is using front-end technological devices, the aim is not to test this technology but to focus on the results and changes on the qualitative upgrade that it can produce in the teaching procedure. The Eudoxos challenges the most difficult objective of **the development of a better understanding of the opportunities, which are associated with e-learning methods, contents and resources and their impact in education in terms of organisation and management.** The partnership believes that the new systems and educational tools have to start from the user. They have to be so transparent that the user can understand them and be in control of what she or he is doing.

Recent studies normally describe science lessons by means of negative indicators. Students behave passively and their learning outcome is mostly not seen as a basis for the acquisition of new knowledge and for further activities in the area [Baumert et al, 1997]. Students seem to be far away from skills proposed by "scientific literacy" to become reasonable and responsible acting citizens [Fischer, 1993] meaning in short they are far away from presenting, discussing and criticising science related topics of society. The Eudoxos project contributes in changing the present situation by implementing the following innovations:

- **Teaching science through the use of an advanced scientific instrument**

  The new technology offers to the participating students and teachers a unique possibility to use advanced scientific instruments remotely. The students are able to observe the sun, the planets, the stars, the galaxies on line. In this way their classroom is transformed into a scientific laboratory. The partnership believes that students can come to view the astronomical observations as a craft that rewards dedication and precision but simultaneously encourages a spirit of creativity, exuberance, humour, stylishness and personal expression. On the other hand, students, through their personal engagement, will develop a sense of responsibility concerning the careful preparation of their experiment and the success or failure of it.

- **Reinforcing interdisciplinary approaches**
  The main link usually missing in the learning process is that students do not learn sufficiently through experience but through a systematic model based approach, which should be the culmination of learning efforts and not the initiation. A particularly disturbing phenomenon, that is common knowledge among educators, is that students fail to see the interconnections between closely linked phenomena or fail to understand the links of their knowledge to everyday applications. Therefore, in recent years, there is a clear focus on interdisciplinary education. This approach supports that educational experiences should be authentic and encourage students to become active learners, discover and construct knowledge. Authentic educational experiences are those that reflect real life, which is multifaceted rather than divided into neat subject-matter packages. The Educational context of Eudoxos e-learning is not transmitted in a theoretical way but rather in a biomatic way in the form of a real life experience. Observing the sky and using a telescope is a highly interdisciplinary subject and its implications give topics for discussion in Astronomy, Cosmology, Physics, Chemistry, Mathematics and Mechanics, clearly expanding the learning resources for students. Additionally, teachers are faced with a real challenge. Having specialised in an academic discipline may cause frustration to them when it comes to creating interdisciplinary, cross-curricular activities. Such activities demand considerable knowledge in many areas, something they may lack. Collaboration with their colleagues may help them overcome this challenge, develop positive attitudes to interdisciplinary learning and gradually adopt it and make it part of their teaching practice.

- **Promoting behaviour and process oriented learning**
  After the familiarization of the students with the use of the robotic telescopes of NOE Eudoxos, projects are assigned to them. They are let free to approach the phenomena and the astronomical objects (sun, planets, stars etc) they want to study. The students are requested to develop real problem solving practices, letting themselves free to handle situations and study them. By using the telescope and the user interface to compose their own scientific inquiring strategy, the partnership expects students to be able to engage in more meaningful and motivating science-inquiry activities. In this way these assigned projects promote creativity through new forms of content combining highly visual and interactive media with the use of innovative ways of design, delivery, access and navigation. The versatility of the tool and results is one of the most compelling factors of the project. The students are encouraged to present and further develop their results in settings that go beyond the school boundaries. Finally, the partnership believes that at the end of the project students will not see the advanced electronic equipment like the telescope and other similar measuring devices as black boxes, but as something that can "take it apart and built it again".

# Chapter 1
# The Pedagogical Framework of the Eudoxos Project

## 1.1 The project background

One of the main goals of the Eudoxos e-learning project is to study the applicability of the existing and emerging technologies in the school sector. This will be tested by providing a platform that will allow learners to navigate remotely controlled telescopes in the framework of their normal school curriculum. Aim is to demonstrate in practical terms how e-learning can improve and enrich the quality of the learning and teaching process in science and technology.

In this chapter it is intended to design and develop a pedagogical framework for the introduction of the scientific inquiry in science teaching at school level. This framework will contribute to the implementation of the necessary adjustments to the normal school curriculum, to the teachers training (on-line seminars and workshop) and support, to the development of lesson plans for the project's implementation in the classroom and to the development of educational material (conventional and electronic).

Within this given context the pedagogical approach consists of providing an adequate frame for improving teaching and learning in school education. Lesson plans and methods can be enhanced and adapted according to the national curricula of each participating country. However, as a second step it needs to be kept in mind that technologies provide new educational potentials which are still not sufficiently reflected in school curricula. Besides improvements to be achieved with the given technologies new pedagogical (constructionist) approaches for science teaching are supported as well which allow learner-centred approaches to be implemented such as project-based or problem-based learning (setting up own experiments and performing observations etc.). As consequence national curricula will need to be adapted as well taking into account the new possibilities given by the integration of the remote control of the NOE Eudoxos telescopes. Taking into account the cultural differences in European school education (curricula, pedagogy and learning approaches) this task will need to be performed at a national level in each partner country.

As a consequence there cannot be a common pedagogical approach applied by all project partners in all countries. Due to the diversity of schools, their curricula, users (including age of learners), lessons, missions and needs - any kind if pedagogical suggestion needs to be adapted to the local contexts and cultural background. Namely different school subjects and classes (age groups) involved make it impossible to formulate one singular pedagogical approach. However, examples of the application of the proposed lesson plans in the local context of the Ellinogermaniki Agogi School, Greece, can be found in this guide. They can serve as a reference for the adaptation to local school contexts.

Project benefits are given to a wider audience as well. Next to teachers and pupils of the participating school bodies, European school education in general will be a potential beneficiary of the project outcomes. This will need to be reflected in the follow-up of the project and dissemination activities. Furthermore informal learning potentials for the European public will be kept in mind as well as during the design process of the Internet-based electronic environment.

There are various aspects of how information technology is used in education: as a platform for the development and delivery of products for teaching and learning and as a tool for the organisation of the learning contents and resources as well. This covers relevant aspects about environments **and** courses which cannot be analysed separately due to their inter-dependency. The question arises as to whether open and flexible learning environments built on information technology, as provided by the Eudoxos project, will lead us to qualitatively better, more effective and more efficient education and how these new educational models have to be brought about. This will be analysed during the project. The evaluation shall provide new insights into practises and adequate approaches for the remote telescope application in school education.

However, instructional methods and the quality of courses in traditional and virtual settings can hardly be compared, since it is the whole setting of the educational activities which must be considered too.

## 1.2 Principles for Teaching and Learning in different types of learning environments

Taking a closer look on the courses internationally given we observe that in practical teaching situations the methodology used in computer-assisted instruction is moving more and more into ICT-assisted knowledge construction, distributed expertise and collaborative learning. Hyper- and multimedia-based sources of knowledge have replaced in many cases traditional study books with electronic resources. ICT and networking can make the learning environment more open in terms of knowledge acquisition in all phases of education.

The enhancement of teaching and learning with real learning settings such as provided by the Eudoxos project is accomplished by the implementation of a variety of pedagogical functions. We refer to pedagogical functions as being the practical activities and methods in the learning environment that make learning possible.

When teaching and learning is supported by virtual tools it should be kept in mind that there is already a pedagogical concept incorporated within this environment determining the scale of pedagogical functions made available for the courses. Speaking in the context of the Internet: first it is the technology itself determining the range of possibilities (e.g. dominance of texts due to bandwidth restrictions). Then it is the environment based on the functionality of the technology, containing a certain design with a set of tools, functions, bars, fixed hierarchies and positions - again with some kind of pedagogical limitations provided at the final stage of the pedagogical design of courses. The variety of pedagogical functions is then reduced to the tools which are offered by the pre-defined and standardised environment.
However, the Eudoxos User Interface, applies an open approach which allows an adaptation to the pedagogical needs in the local context.

Wilson [Wilson, 1996] has described the relationship between the ideas of knowledge and the consequences for the nature of the learning environment (author's comments in parentheses):

| Metaphor about knowledge, knowing | Consequence for the learning environment |
|---|---|
| Knowledge is a quantity or packet of content waiting to be transmitted | Products that can be distributed via different methods, media. (Electronic self-study materials) |
| Knowledge is a cognitive state as reflected in a person's schema and procedural skills. | Combination of teaching strategies, goals and means to change the schemes of thought in the individual. (Teaching programme) |
| Knowledge is a person's meanings constructed in interaction with one's environment | The pupil acting and working in an environment with plenty of resources and stimuli. (Collection of tools and resources) |
| Knowledge is enculturation or adoption of a group's ways of seeing and acting. | Participation in the everyday life and activities of the community. (Collaborative working environment; can also include the above-mentioned items) |

***Table 1**: Relationship between the ideas of knowledge and the nature of the learning environment (Wilson, 1996)*

By analysing the concepts of environments and courses where information is provided on the Internet, all the mentioned types of learning environment can be found. Information and communication technology (ICT) is therefore not prone to support one particular type of learning environments. On the contrary, in the design of ICT-based educational innovations, the technology will have to be introduced in such a way as to create and support the learning environment desired. However, in practice we notice that the integration of virtual learning tools can be a result of a pragmatical decision at the institution too. This can also be used as a step for introducing the evolutionary transition from traditional teaching environments towards settings related to ideas of social constructivism. The evolution of learning environment is a complicated process, where institutions cultural and historical situation with practical arrangements is often the critical factor, not the learning theory [Bourdieu & Passeron, 1977].

As a consequence of this shift towards a student-centered approach the building of "learning communities" and "collaboration" play a crucial issue in instructional design of (social constructivist) learning environments.

We have mentioned the idea that learning is an active process. [John Dewey, 1916] foreshadowed the idea of active learning when he made his case that an individual learns by doing, by engaging in authentic tasks. Learning being an active process has also been elaborated on by Bruner [Bruner, 1966, Bruner, 1986, Bruner, 1990]. Central to this idea is the concept that learning is a process where students explore and discover connections in order to construct new ideas and create meaning. Learning occurs when the learner interacts with the content, materials, and others in the learning environment.

Exploring this experience of teaching in an online web based environment needs to include discussion about the interactive nature of learning as well as the cooperative responsibilities that are implied by the use (and nature) of technology. The interplay between the learner and the instructional content is also a critical component of student learning. A recap and discussion follow as well as an outline of how this interplay defines the evolving responsibility of the teachers in this environment.

Working with ICT in classroom education poses many barriers. The environment needs to be able to support the learner in ways that are encouraging, provide familiarity and security for the learner. The learner also needs to be productive in the environment and therefore needs to have tools at her/his disposal that will help her/him accomplish her/his tasks. Organising group work is not only a pedagogical measure that supports good learning, it is also a necessity since it is the cornerstone of establishing the student teacher relationship and defines the interaction among participants.

In their study about the evaluation of environments [Britain and Liber, 1999] define two crucial issues for the work with Virtual Learning environments (VLE):

- VLEs should provide opportunities to improve the quality and variety of teaching and learning that are not being achieved using current methods.

- VLEs should reduce the administrative burden on teachers, thus allowing them to manage their work load more efficiently and to be able to give more time to individual students' educational needs.

Considering these requirements it becomes obvious that the approach for analysing the process must reflect various other aspects too than just the discussion of pedagogical techniques within Virtual Learning Environments.

During the stage of planning, development and while courses are running it needs to be stated that there are also a lot of other aspects important to be considered in this discussion about pedagogical techniques. Teaching with support of ICT also means a lot or organisational aspects to consider. This point even increases dynamically in inter-cultural settings and even more when the benefits of technologies are even applied in the context of collaboration between local, regional, national or international collaboration. So, being a "good" teacher in the Eudoxos context means as well being a good organiser and designer of information, communication, didactical implementation and media integration. In an optimal way the course concept varies according to cultures integrated, available infrastructure concerning technology and networks. This demonstrates too, that teaching becomes a complex process during several stages to a higher degree than it is known from traditional educational situations.

## 1.3 Teaching and Learning with support of ICT

Some general pedagogical principles are mentioned by Chickering and Gamson [Chickering and Gamson,1987]:

- Good practice encourages student-faculty contact
- Good practice encourages co-operation among students
- Good practice encourages active learning
- Good practice gives prompt feedback
- Good practice emphasises time on task
- Good practice communicates high expectations
- Good practice respects diverse talents and ways of learning.

These principles were implemented in concepts of many educational institutions worldwide, mainly for undergraduate education. Technological examples for these principles are:

| **Seven Principles** | **Seven technological examples** |
|---|---|
| 1. Encouraging student-faculty contact | Interactions among the students and professors can be increased thanks to the E-mail, the videoconference, the Visio conference, IP telephone, etc. Interactions can be now synchronous or asynchronous between student and faculty. |
| 2. Encouraging cooperation among students | Cooperation among students can be favoured by information and communication technologies (ICT). This cooperation can sometimes express itself by virtual teams. Teamwork can be done at a distance without the participants seeing each other. |
| 3. Encouraging active learning | Dynamic learning of a subject can be made by employing computer tools, simulating complex problems or simply browsing through databases or making use of search engines. |
| 4. Giving prompt feedback | E-mail and other communication tools can provide rapid feedback. Intelligent authoring agents can also help in following the progress of a student. They offer the opportunity of identifying the strengths and weaknesses of a learner in a particular domain. |
| 5. Emphasizing time on task | Many consider that ICT accelerate learning process and encourages effective use of time. |
| 6. Communicating high expectations | Creating a website, working with students from other countries through virtual teams; displaying assignments through a site can be sources of motivation and excellence. |
| 7. Respecting diverse talents and ways of learning | Many believe that learning technologies allow students to work at their own pace. Furthermore, these technologies can now supply visual, textual, hearing and tactile supports. |

***Table 2:*** *Seven principles and seven examples*
(http://www.erudium.polymtl.ca/html-eng/education/education4c.php)

Concerning the pedagogical design of courses [Cunningham, Duffy, & Knuth, 1993] listed several principles which are imbedded as well in the pedagogical approach in the Eudoxos project:

- Provide experience with the knowledge construction process,
- Provide experience in and appreciation for multiple perspectives,
- Embed learning in realistic and relevant contexts,
- Encourage ownership and voice in the learning process,
- Embed learning in social experience,
- Encourage the use of multiple modes of representation
- Encourage self-awareness of the knowledge construction process.

The listing becomes more instructionally designed focused and concrete when taking a look at Xiadong et al [Xiadong et al, 1995] presentation of a typical instruction design process:

- Identify objectives (e.g., what do you want students to be able to do when they have completed the instruction?)
- Assess students' prior knowledge and skills (e.g., determine whether the target students have the prerequisites to benefit from the instruction)
- Specify the content to be taught (e.g., what content skills should be taught to students?)
- Identify instructional strategies (e.g., what instructional methods should be used?)
- Develop instruction (e.g., a learner's manual, instruction materials, tests, and an instructor's guide)
- Test, evaluate, and revise (e.g. how should students be evaluated to determine the degree to which students have meet the performance objectives?).

Although the 'transparency' of the technology is one of the most important goals in the learning environment, special technical tutoring might become necessary in open learning environments as well in order to avoid student frustrations. It can help learners to get to know the technical equipment and software used, thus 'taking charge' of the tools in their learning environment. As a result of technical developments, it is possible to include a range of functions in the same user interface. Learning environments built on Web-based technology, for instance, only require students to use a single application, a Web browser. Students need to have only minimum knowledge of information technology. Tutors can use an increased range of alternative channels to provide efficient tutoring (telephone, e-mail, tutorials, etc.) either at a distance or in a face-to-face context.

As it was pointed out before the role of the teacher is changing to a large extent. Within the context of new educational paradigms the new functions can be characterised by the shift from acting as a content provider and "transmitter" towards a mentor guiding and supporting learners through the process of knowledge acquisition.

Within the Eudoxos e-learning project environment learning can be largely directed by the learners themselves. Therefore the meaning of mentoring and tutoring, a system for supporting learning and study guidance, gets special emphasis. Tutoring can mean support related to the learning process, study contents, tasks or technical problems. According to Daloz [Daloz,1990] effective mentorship is akin to "guiding the student on a journey at the end of which the student is a different and more accomplished person. In a formal learning situation, mentoring functions can be understood as variously providing support, challenge and vision". Tools for providing both tutoring and mentoring should therefore be adaptable for each purpose in Virtual Learning Environments.

Especially in constructivist learning environments tutoring in terms of "moderation" gets special emphases. This is the case when communication concepts are implemented including support for interactive processes like group works to be done collaboratively by learners. There are a lot of "open questions" for online teaching which are still being widely discussed with the scientific community in the field of computer-mediated communication (CMC) as how and to what extent moderation must take place in settings where learners work collaboratively on the assessment of contents.

# 1.4 The Eudoxos e-learning concept

The Eudoxos approach cross cuts the traditional boundary between the classroom, home, scientific laboratories and research institutions as distinct learning environments. It involves the users (students, teachers) in extended episodes of playful learning. Specific elements to focus on here include motivating learning, demonstrating application, and scaffold practice. Learning enhanced to be fun can be more effective [Quinn, 2003]. According to Lepper and Gordova [Lepper and Gordova, 1992] learning embedded in a motivating setting (like an observatory) improves learning outcomes. One implication of this model is that students should be assigned activities that reflect the application of the content knowledge as it is practiced outside the classroom. The goal is to induce the learner into a "culture of practice" which makes the knowledge meaningful. Another implication is that the feedback ideally should be intrinsically embedded into the context in which the activity is performed. A further implication is to have the learning challenge carefully balanced to keep it within a "zone" that matches the learner's ability. What we see is that elements that contribute to effective learning environments include a thematically meaningful story ("situating" the application of the knowledge), relevant and rapid feedback, and a carefully managed level of challenge. The working hypothesis of the Eudoxos partnership is that a major expansion of education, which is called Autonomy Oriented Education [Aviram, 1993], can be built around the notions of autonomy and a sense of belonging. Autonomy is composed of authenticity and self-direction. By authenticity we mean the individual's ability to be aware of her/his feelings, aspirations, her/his characteristic style of activity and learning and her/his various talents - and to adopt them. Self-direction is based on the individual's ability to think and act rationally, on her/his adequate level of literacy and on an adequate measure of emotional maturity. Belonging is grasped as being based on the individual's conception of herself/himself as belonging to a social group (and thereafter to a culture) to which she/he is committed.

Within this general framework the new technology application supports the pedagogical method of autonomous self-directing learning and allows for a self-directed acquisition of skills to meet users individual communication and learning needs. The self-learning method will be supported by elements of entertainment (play and learn) in order to enhance learning by using the new communication technologies to transfer the magic of an observatory in the classroom. A learner support is realized through the possibility of connecting to an on-line manual that acts as an on-line tutor. The on-line tutor serves as the guide to the students work. Methodological it is based on the learning scenarios and the lesson plans that are developed in order to support the project's application.

It is important to point out, that with the given technology scientific inquiry can be fully implemented. Formulation of hypothesis, experiment design, realization of the experiment, analysis of measured data (images), verification or rejection of hypothesis, evaluation and generalisation are the steps that allow for a deeper understanding of the science concepts and the scientific methodology.

According to the project idea the approach acts as a qualitative upgrade to everyday teaching for several reasons:

- Motivation: Students are more likely to feel a sense of personal investment in a scientific investigation as they actively participate in the research procedure and will add their own aesthetic touches to their observations.
- Extending the experimentation possibilities: The sky observations can serve as spurs to the imagination, promoting students to see all sorts of daily activities as possible subjects of scientific investigation. The proposed procedure is freed from the pressing time limitation of the teaching hour.
- Developing critical capacity: Too often students accept the readings of scientific instruments without question. When students get involved in the proposed activities they should as a result develop a healthy scepticism about the readings and a more subtle understanding of the nature of the scientific information and knowledge.

- Making connections to underlying concepts: In the framework of the project's application to the school communities, students are asked to design their own projects. During this procedure students can figure out what things to measure and how to measure them. In the process they develop a deeper understanding of the scientific concepts underlying the investigation.
- Understanding the relationship between science and technology: Students participating to the project gain firsthand experience in the ways that technology can both serve and inspire scientific investigation.

## 1.5 The Eudoxos Pedagogical Approach

In addition to contributing to the overall aims of the Eudoxos project as detailed in the programme specification the following pedagogical aims have been followed:

1. Enabled participants to navigate the NOE Eudoxos telescopes by applying the electronic tools provided by the Internet ("Eudoxos User Interface")
2. Enabled participants to make self-directed observations of the sky and relating to the modules as supplied within by the project (Moon, Saturn, Sun, Asteroids)
3. Enabled participants to develop knowledge of the content area, rules and formula for mathematical calculation, underlying concepts and principles & the ability to interpret these with in their own learning context of school projects or subjects taught
4. Provided participants with first hand experience of involvement in active and collaborative learning online.

Learning outcomes and assessment strategies are explained in the following section relating to the lesson plans.

There is a set of tools, techniques and "tricks" which can be learned for application in such pedagogical setting as proposed by the project. Nevertheless this must be taught to the staff concerned to avoid any repetition of same mistakes, same explorations and even in order to improve the applied methods in detail. Therefore, teacher training is seen as a crucial issue in the Eudoxos project. An effective training was offered to the teachers of the participating schools. The training included the teachers' workshop, where the user-interface was presented, and a series of on-line seminars through the Internet. The workshop was performed before the final determination of the user-interface's parameters, therefore giving the opportunity to the teachers to provide input for its final development. The pedagogical approach was optimised after the first phase of the implementation of the project and during the second phase according to the students' and teachers' input.

Closely related to these issues of teaching and learning is the point of evaluation which must take place in order to determine the success of the project and the application of the provided tools. Economic factors (cost for staff and technology) have to be assessed as well as pedagogic (quality of teaching, outcomes). Evaluation activities consist of validation of the knowledge as well as the assessment of the students. According to a constructivist approach, it is essential to involve students in the validation process of the information produced on the course. This will lead to more critical and reflective discussions [Gokhale, 1995] of the course contents and can make meta-cognition possible in students' learning processes. Special discussion forums for debates and criticism and collective commenting of the writings are good tools for assessment of students in the open learning environment.

# Chapter 2
# Technical description of the Eudoxos Project

## Introduction

The first section of this chapter presents the technical description of the NOE Eudoxos telescopes and the second section provides the Guide for the User Interface

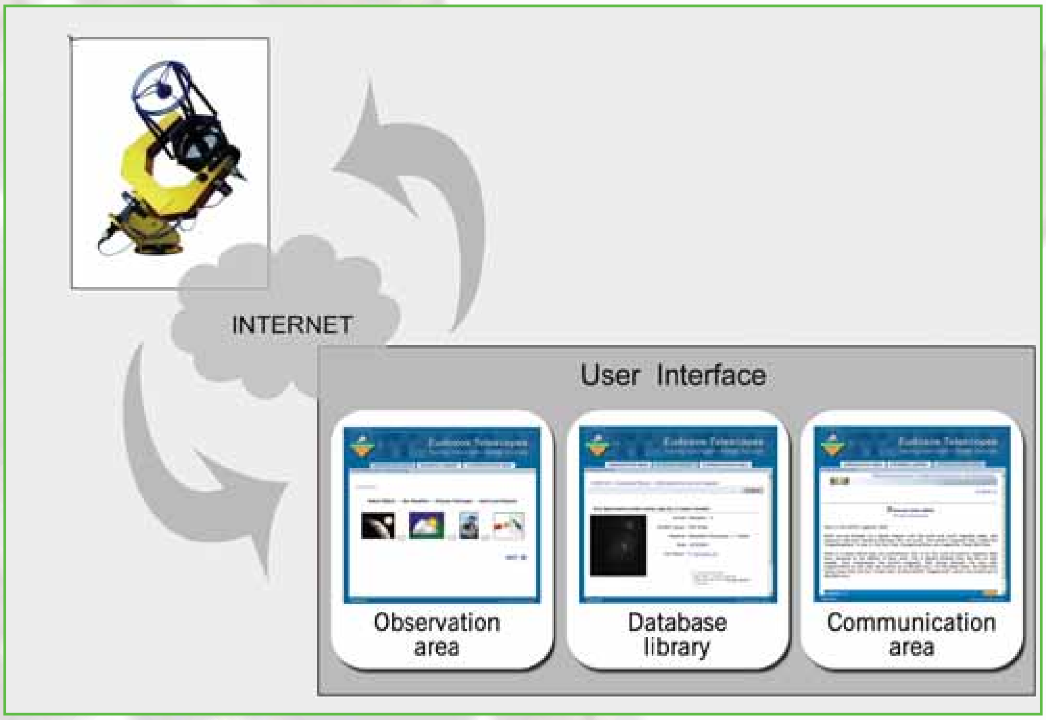



***Figure 2.1:*** *The web based User Interface allows anyone with Internet access to use the Eudoxos Robotic Telescopes*

# 2.1 The NOE Eudoxos Telescopes

***Figure 2.2:***
*The National Observatory of Education Eudoxos*

The present project users' infrastructure is offered by the National Observatory of Education (NOE) Eudoxos. NOE Eudoxos is an innovative robotic observatory complex capable to support effective teaching as well as serious research, in astronomy and related fields. Among its main tasks was the realization and gaining of experience on the "tele-laboratory" concept. The creation of the NOE Eudoxos (Solomos et al, 1999) and the development of a curriculum dedicated for use by Greek schools (Solomos et al, 2001) were founded by the Greek Ministry of Education and Prefecture of Kefallonia and Ithaki, Greece (scientific coordinator N. Solomos)

***Figure 2.3:***
*The TAM on location (Ainos mountain, Kefallonia Island,Greece)*

**The Andreas Michalitsianos Telescope**
In 1999, the National Observatory of Education (NOE) "Eudoxos" initiated the construction of an innovative robotic observatory complex capable to support remote teaching and scientific research in astronomy and related fields. Among its main tasks was the realization and gaining of experience on the "tele-laboraty" concept, applied for the first time in Greece under the auspices of the Ministry of Education.

The facility is located 16 km SE of Argostoli, Kefallonia Island, Greece at a plateau 600m below the peak of mount Ainos (height 1628m). It is housed in a former military communications base of the Hellenic Air Force, a 30.000 $m^2$ area, donated to the "Eudoxos" establishment.

Eudoxos Observatory's first instrument, the Andreas Michalitsianos telescope (TAM) is a 60cm Cassegrain type remotely controlled robotic telescope. It is a fully autonomous computerized instrument with automated enclosure, meteorological sensors, and a large format imaging CCD camera with photometric filters interchanged via filter wheel.

All equipment is completely controlled by two central computers which communicate via a local ISP to the participating secondary schools and institutions. An innovative automated telescope control and analysis software system controls the entire installation which is backup-powered by emergency generators.

| **Andreas Michalitsianos Technical Data** | | | |
|---|---|---|---|
| Optics | Aperture 0.62 m<br>Focal ratios: f/10, f/6.3 | Imaging f Photometry | 512 x 512 CCD Camera |
| Field of View | ~30 arcmin (uncorrected)<br>~50 arcmin (corrected) | Field of View (narrow) | 7 x 7 arcmin |
| Accuracy of pointing | <10 arcsec ±2 arcsec RMS | (wide) | |
| Theoretical pointing accuracy | <0.27 arcsec | angular resolution | |
| Tracking accuracy | 2" in 20 min | | |
| Access Speed | 10 deg/sec | | |
| Control | Local, remote, autonomous | | |
| Operating System | Linux | | |

The Andreas Michalitsianos Telescope was constructed by TORUS Technologies USA according to the specifications set by the "Eudoxos" collaboration (Solomos et al, 1999; Solomos et al, 2001). It is a computer-controlled classical Cassegrain telescope system designed for serious research. The optics, mechanical construction, and control system are of the highest-quality. The tracking, pointing accuracy, and precision of this telescope system are extraordinary, making them ideal for CCD imaging, search programs requiring high repeatability, remote operation, automated operation, and other demanding applications. The Andreas Michalitsianos Telescope control system supports observations through internet and is governed by ΛETAM an evolved version of "TALON", one of the most sophisticated and powerful control systems designed for ASTs (Automatic Small Telescopes).

A Web-based interface allows anyone with internet access to select, observe, and retrieve their own astronomical images.

***Figure 2.4a:***
*The TAM inside its cylidrical dome*

Who was A. Michalitsianos?

The Telescope was named "Andreas Michalitsianos" to honour the memory of Andreas Michalitsianos (1947-1997) the eminent Cephalonian Astrophysicist and Director of the Laboratory for Astronomy & Solar Physics of NASA, not only symbolically -for his early contact with robotic astronomy at Kitt Peak (in the-70s)- but for his profound scientific originality, experimental skills and steep rise in astronomy since the age of 16, which offers a unique bright paradigm to the younger generation.

**The Apollon Solar Telescope of the Eudoxos Observatory**

The Apollon Solar Telescope (HTA) was named after the Greek God Apollon who, according to Greek Mythology, was responsible for the advent of the day carrying the sun with his chariot in the heavens.

It is a two element telescope. It consists of a 15cm diameter achromatic refractor (f/8) equipped with a 1/10000 solar filter which provides large magnification and is used for observing localized solar features. This optical tube is parallelized with a 300mm focal length smaller telescope which provides larger field of view and can cover the whole sun. Both telescopes work with the same computer controlled mount and both use a CCD camera as the detector. The apparatus is located inside a fibre-glass dome and is operated remotely through special software.


***Figure 2.4b:***
*Picture of the Apollon telescope*

# 2.2 The Eudoxos User Interface

## The Eudoxos Observation Area


**Figure 2.5:** *The Eudoxos User Interfaces' Main Menu*

### Location

In this section of the User Interface geographical details of Eudoxos observatories are presented. The user (student, teacher or researcher) can select the mouse sensitive areas of the presented Image-maps in order to see the real geographical location of the "Andreas Michalitsianos" telescope.

The aim of this section of the User Interface is for the user to understand that although the real telescope is situated hundreds or thousands kilometers away from him, he can operate it using modern remote control communication and networking technologies.

The user activating the mouse sensitive parts of the Image-maps is gradually guided through Europe, Greece, island of Kefallonia, mount Ainos to the TAM or HTA telescopes. For TAM these steps lead to the following Figures:


**Figure 2.6:** *Eudoxos' telescopes geographical location*

The user returns to the home page using the button **OBSERVATION AREA** from the User Interfaces' main menu.

## Getting Started

This section of the User Interface provides eight easy steps to becoming an active Telescope User. This quick guide should get you started in the right direction.


***Figure 2.12:***
*The Eudoxos User Interfaces' Quick Guide*

**1. Create a User Account**

Follow the link Remote observer's code and fill in the form to receive your User account (by NOE Eudoxos), which entitles you to use the robotic telescope facilities of the NOE Eudoxos.

**2. Select an Object to Observe**

You have to select an object you want to observe. It is important to consider the rules currently in effect for what the telescope is allowed or not to observe. For example it is forbidden to use the TAM to observe the sun and in most cases the moon and very bright planets. In these cases the Apollon telescope should be used.

**3. Check the Weather**

Next you have to visit the weather forecast for Kefallonia Island. Notice that the day of forecast is the running day and the time is 21:00 local time. This can give you an idea of the posibility that your observation request will be executed within reasonable time.

**4. Choose Telescope**

You have to choose the appropriate telescope for your observation. You must know that the Andreas Michalitsianos Telescope is a nights' observations telescope and the Apollon Telescope is a Solar Telescope for observing the sun during the day and also the very bright planets in the night.

**5. Fill in the Submission Form**

On the Eudoxos User Interface follow the instructions, pick an object to observe on the Sky map and then fill in the Submission Form. There is extensive online help for filling in the form. Particular attention should be paid to the determination of the exposure time for each "shot" of the CCD camera.

### 6. Submitting the Observing Proposal

Make sure that you have correctly filled in all the (required or optional) fields and then submit you proposal to Eudoxos Observatory. In a few minutes you will have a confirmation via email from Eudoxos Observatory.

### 7. Patiently Wait

Your proposal is entered in the telescope observing queue and will be scheduled for execution after optimization of all requests received by a special software. General statistics on the scheduler's queue processing activities can be found on the Eudoxos Database Library.

*(more details at: http://knidos.snd.edu.gr)*

### 8. Download your Data

Follow the link Eudoxos Database Library and download your astronomical images for further processing. In the proposed lessons you can learn how to analyze astronomical photometric data taken with a CCD camera.

*(more details at: http://knidos.snd.edu.gr)*

From there what you do with the data you get is up to you. But you must know that you can find proposed On Line Lesson Plans for your practice.

## Go Observing

With **Go Observing** button from the main menu of the User Interface the user (student, teacher or researcher) can make a web-based astronomical observation.

## The Scientific Methodology section

In this section the main steps of an astronomical observation involving imaging of a small part of the sky with the telescope/camera combination are presented.


***Figure 2.13:*** *The main steps of the Scientific Methology*

**Next button**
This button leads to the next section.

## The Sky Map section

In this section of the Interface the user can observe a simulated view of the sky in real time, choose his object of interest and find out the celestial coordinates of that astronomical object. These are the absolute parameters for the effective pointing of the telescope to that particular object.


***Figure 2.14:*** *Sky map above the Eudoxos observatory*

### Observation Date and Time

In these text boxes the user sets the date and time of the observation (if it is necessary).


***Figure 2.15:*** *Setting date and time of the observation*

**Attention:** During the setting of the date and time of the observation the user should take into account that the local time in Kefallonia Island is **UTC + 2hours** from November to March and **UTC + 3hours** from April to October. Please note that by choosing to impose the time of observation, the user risks that his observation will be canceled if the weather does not permit the observation at the specified time.

### Update button

After setting the date and time (if required) the user should press the **Update** button. The simulated celestial sphere in the screen is then updated to that date. For solar systems objects the positions of which are continuously changing on the celestial sphere, their coordinates (RA, Dec) are variable. Their current (or future) celestial coordinates are then presented in a relevant table (see Fig. 2.16) if the user "click" in the object of interest. The user should fill in the relevant coordinates in the text boxes named **Right Ascension** (RA) and **Declination** (DEC)**.** These angles (RA and DEC) are needed to determine the position of the projection of the object on the celestial sphere and they are needed by the telescope to aim to that object.


***Figure 2.16:*** *Table of celestial coordinates*

**Right Ascension Field**

This text box is filled by the user from the table above regarding the astronomical object to be observed (i.e. Saturn, see Fig. 2.17). The **Right Ascension** coordinate format is **00:00:00** (i.e.: 6h5m6s ⇨ 06:05:06).


***Figure 2.17:*** *Right Ascension and Declination*

**Declination Field**

This text box is filled by the user from the table above regarding the astronomical object to be observed (i.e. Saturn, see Fig. 2.17). The **Declination** coordinate format is **±00:00:00** (i.e.: +22° 37.0' ⇨ +22:37:00).


***Figure 2.18:*** *Appearance of astronomical object*

**Attention:** The selected astronomical object should be visible from Kefallonia during the specific date and time of the requested observation. This is indicated with the sign **Up** (“up in the sky” meaning above the local horizon) in the last column of the coordinates table (see Fig. 2.18).

**Next button**

This button leads to the next section.

## The Weather section

In this section of the User Interface the user can check the actual (at present) and foreseen (in the near future) weather conditions in the area of the telescope (Kefallonia Island, Greece).


***Figure 2.19:*** *Weather map*

**Weather link choice**
This web link leads to additional Web pages about weather forecasts and satellite images.

**Next button**
This button leads to the next section.

## The Telescopes section

In this section of the User Interface the user can select the telescope for the astronomical observation.


***Figure 2.20:*** *Choice of telescope*

**Telescope 1 (Andreas Michalitsianos) choice**
With this telescope only **night** observations of far away objects or asteroids are possible.

**Telescope 2 (Apollon) choice**
With this telescope only **day** observations are possible (sun observations) and bright night objects (moon, planets).

**Next button**
This button leads to the next section.

## The Submission section

In this section of the Interface the user fills in the text boxes of the submission form.

**Schools field**
From this pull down menu the user selects the school requesting the observation.

**Student Group field**
From this pull down menu the user selects the Group (according to the teacher's guidelines).

**Password field**
In this text box the user fills in the password of the relevant Student Group (the password is provided by the teacher, after consultation with the NOE Eudoxos administration, *http://knidos.snd.edu.gr*).

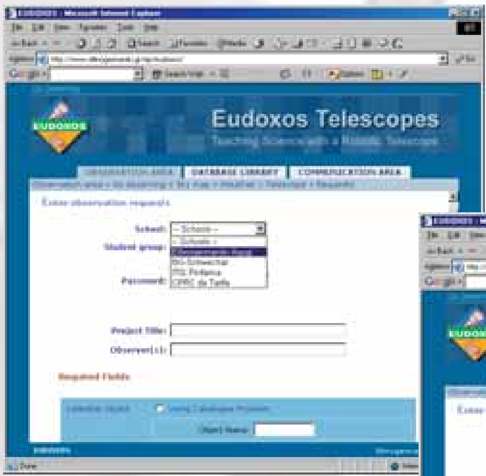



***Figure 2.21:*** *School selection*


***Figure 2.22***
*Students' Group selection*


***Figure 2.23:*** *Password field*


**Project Title field**
In this text box the user fills in the title of the requested astronomical observation.

***Figure 2.24:*** *Project Title field*

**Observer's field**
In this text box the user(s) fills her/his full name(s).

**Object Name field**
In this text box the user fills in the name of the astronomical object to be observed.

**Attention:** If the user fills in this field the Interface **ignores** the previously entered information of the requested observation (celestial coordinates, date and time) and schedules the observation of the astronomical object the soonest possible (in accordance to the general timetable of the already requested observations).
If the user wants to keep the previously entered information of the requested observation (celestial coordinates, date and time), the **Object Name** text box **should remain empty.**

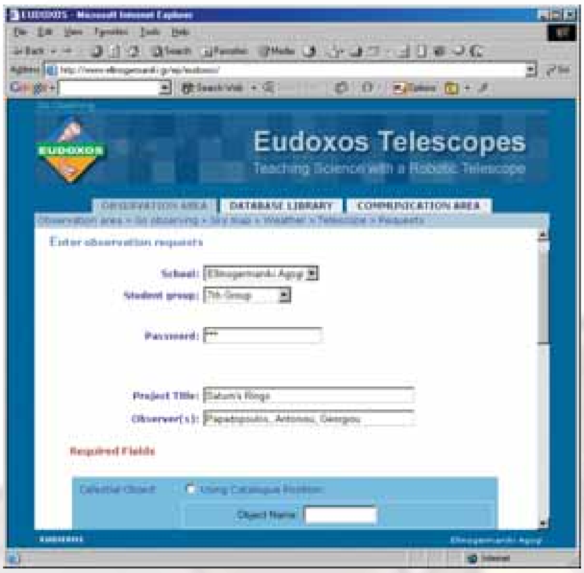



***Figure 2.25:*** *Observers' names field*

**Right Ascension, Declination and Epoch fields**
In these text boxes the celestial coordinates have been automatically entered from the previous section Sky Map.

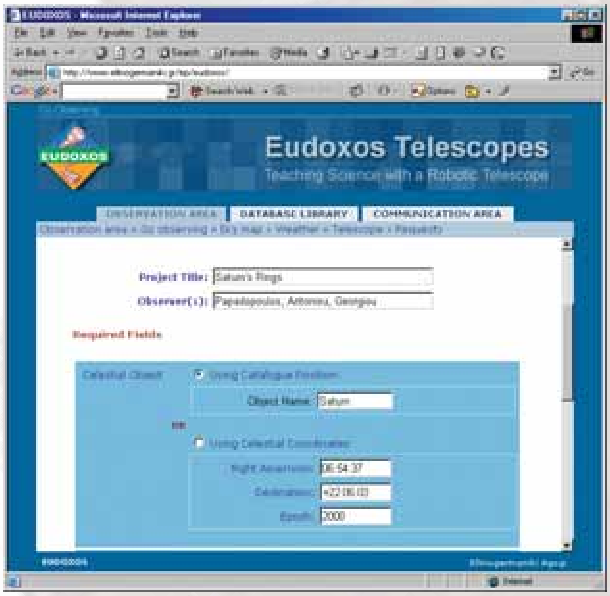



***Figure 2.26:*** *Object Name field*

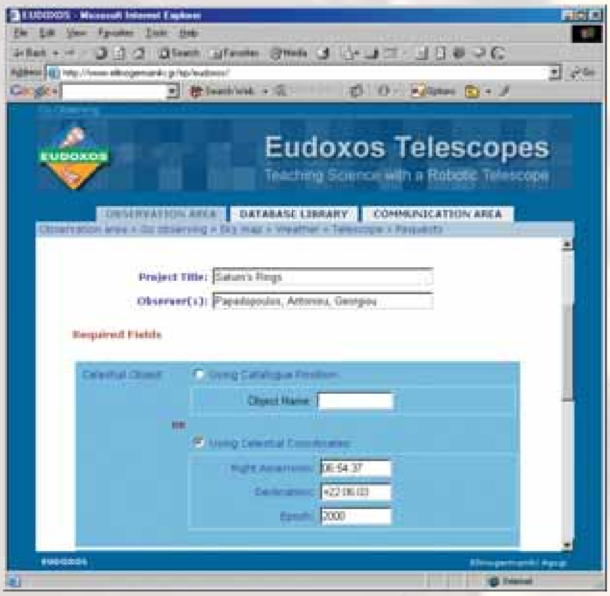



***Figure 2.27:*** *Celestial Coordinates and Epoch*

**Filters and Duration fields**
In the section Filters the user can choose the suitable filter(s) for the requested observation according to the relevant guidelines.

In the sections **Duration** the user should enter the appropriate exposure time. The duration is in minutes (i.e. 0.01). For the right exposure time determination the user can see the relevant theory.
*(see Appendix A.3)*

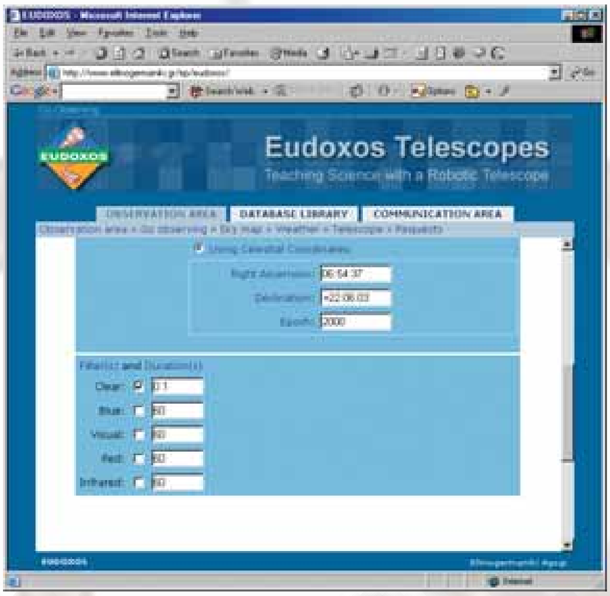



***Figure 2.28:*** *Filters and Duration*

**Date field**
On mouse click on the icon the user can enter the Date of the requested astronomical observation.

**Start Time field**
In this field the user enters the exact local time (referring to the place where the telescope is situated) of the requested astronomical observation. The local time (for Kefallinia) is **UTC + 2hours** from November to March and **UTC + 3hours** from April to October.

**Attention:** If the user requests an astronomical observation using celestial coordinates then the Date (and Start Time if it is a solar system object) fields is compulsory.

If the user has filled the Object Name text box then the fields **Date** and **Start Time** are not compulsory.


***Figure 2.29:*** *Date*


***Figure 2.30:*** *Start Time*

**Repeat Count field**
From this pull down menu the user can select the number of sequential observations with the same general settings as the requested observation to be executed immediately after the end of previous one.

### Delay field

From this pull down menu the user can select the time interval between sequential observations with the same general settings as the requested observation. This field determines the delay from the end of a previous observation to the beginning (start time) of the next.

**Attention:** If the user wants to make repeated observations then the fields **Object Name, Date,** (**Start Time** for objects with variable position in the celestial sphere)**, Repeat Count** and **Delay** are **obligatory.**

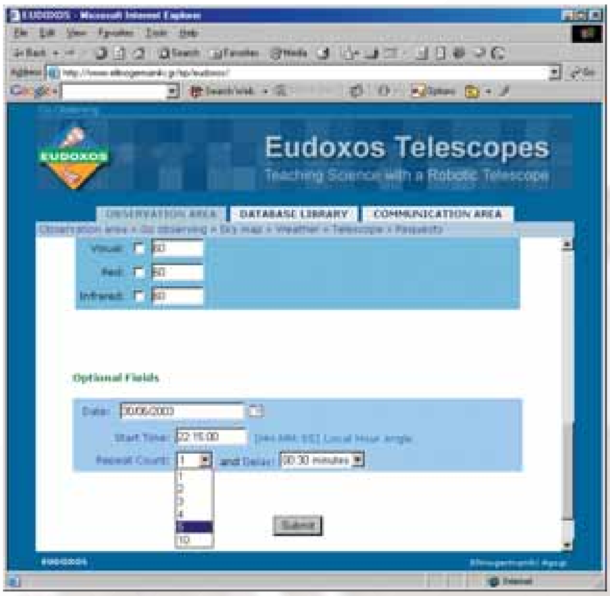



***Figure 2.31:*** *Repeat Count*

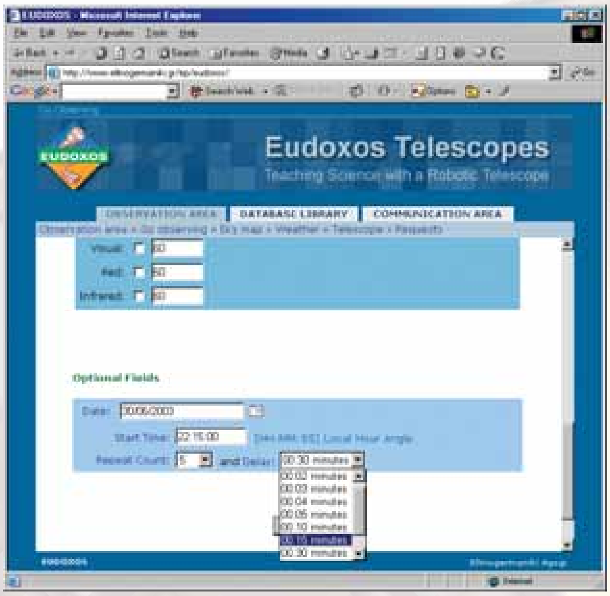



***Figure 2.32:*** *Delay*

### Submission button

With the Submission button the complete form with all the necessary information about the requested observation is submitted to the Eudoxos Observatory in Kefallinia over the networks and will be scheduled for inclusions in a night's program of operations.

# The Eudoxos Database Library

In this section of the Interface the user can have access to all the requests that are stored. In the same section the images taken by the telescopes are presented. These images are stored in JPEG and FITS format. Explanatory info is presented for each image.

### Pending requests

Within choice the user can have access to all the pending requests.

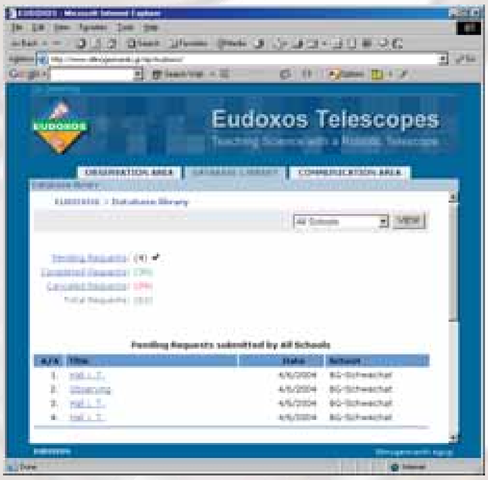



***Figure 2.33:*** *Pending requests*

### Completed requests

Within choice the user can have access to all the completed requests.


***Figure 2.34:*** *Completed requests*

### Canceled requests

Within choice the user can have access to all the canceled requests.

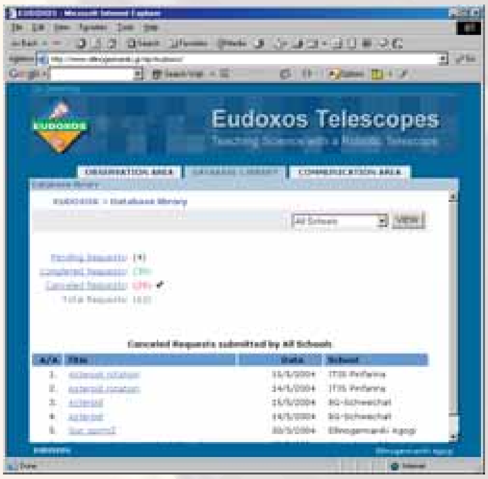



***Figure 2.35:*** *Canceled requests*

The user can select (School's menu - View) to view images from one or all participating schools. The user can also select directly an image by clicking on it's title.

***Figure 2.36:*** *Schools' menu*

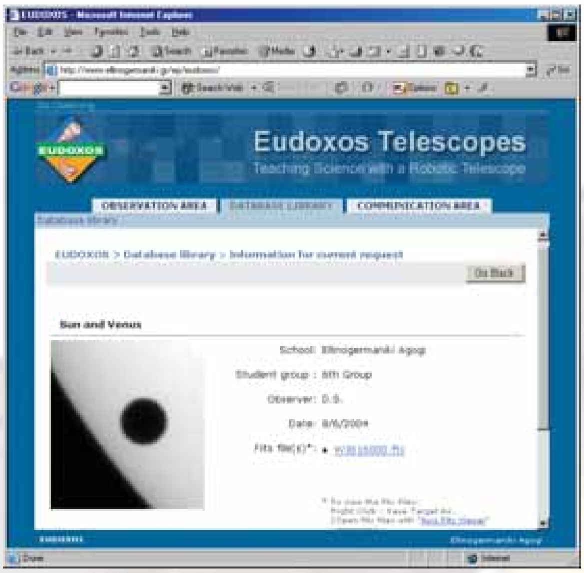


***Figure 2.37:*** *Image's info*

**Image's information**

In this section the user can be informed about the **School, Student Group, Observers** and **Date** that requested an astronomical observation.

The user can also download and save an image in FITS format (right mouse click, Save target as…)

**Avis Fits Viewer button**

This button allows from the user to download the **Avis Fits Viewer** software. This software is suitable for astronomical images processing.

**Go back button**

This button leads to the **Database Library** section.

# The Eudoxos Communication Area

This section of the User Interface presents the communication area with which the users (teachers and students) will communicate and exchange experiences, materials, information, proposals, lesson plans and their work.


***Figure 2.38:*** *Communication area*

### Question of the month

In this section of the User Interface the question of the month is presented. The user can answer the question using the button **reply it**.


***Figure 2.39:*** *Question of the month*

### Student's Discussion Forum

In this section students can enter opinions, proposals and interesting texts that complement the lesson plans. The user can **post a message** using the button post message or can answer using the button **reply it**.


***Figure 2.40:*** *Student's Discussion Forum*

### Teacher's Discussion Forum

In this section teachers can make comments about collaboration with teachers from the other participating schools of the project. The user can post a message using the button **post message** or can answer using the button **reply it**.


***Figure 2.41:*** *Teacher's Discussion Forum*

### Ask the Astronomer

In this section the users can communicate with the astronomers of the project.


***Figure 2.42:*** *Ask the Astronomer*

# Chapter 3
# Lesson Plans

## 3.1 The Design of the Learning Processes

In the framework of the Eudoxos project a series of lesson plans has been developed to be implemented in classroom during the first two cycles of the school-centered work. The lesson plans are in accordance with the science curriculum of the participating schools and are designed to utilize the experimental capabilities of the robotic telescopes. The aim is to implement these lesson scenarios for the familiarization of the students with the idea of scientific investigation in order to reach the last stage of the work in the school environment. At the final cycle of the school-centered work students and teachers will have the opportunity to design and perform their own scenarios for observations.

A specialized structure for the Eudoxos lesson plans have been developed for the needs of the project. Each lesson plan consists of two main parts; the first part of the lesson plan gives general information concerning the lesson. It is based on the curriculum and provides details for the implementation in classroom. In this part information about the time duration, vocabulary, the tools and the materials necessary for the observation are given.

The educational aims of the each lesson activity are specified and categorized in general and more specific didactical objectives. Finally the usual student's misconceptions on the teaching subject are presented to teachers in order for them to be prepared and plan an effective teaching session.

The second part of the lesson plans provides information about the pure educational phase of the lesson. This is the part where ideas to stimulate students are proposed and the observational activities are described. Discussion, observation and analysis of the data are proposed as well, while the expected conclusions that should be the outcome of the lesson are listed. In order to assist consolidation, a series of exercises and questions and further activities are proposed.

Four lesson plans have been developed so far, namely:

1. Measuring the size of Saturn's Rings
2. Measuring the height of the Lunar Craters
3. Measurement of the Solar Rotation
4. Determination of Asteroids Rotation Periods

# 3.2 General Structure of the Lesson Plans

**I. General Information**

Duration

Vocabulary

Tools and Materials

Aims and Objectives

Student's Misconceptions

**II. Educational Phase**

Stimulation

Experimental Activities

Observation - Discussion

Consolidation

# 3.2.1 Measuring the size of Saturn's Rings

**I. General Information**

This lesson plan provides information and material concerning observational (experimental) study of Saturn's rings using the Andreas Michalitsianos Robotic Telescope or preferably the Apollon telescope. Specific observational and experimental activities are presented and several questions, exercises and tasks are proposed to assist consolidation of acquired knowledge.

**Duration:**

Classroom lesson : 1x45 min
Observational Activities : 2x45 min

**Vocabulary:**

Saturn, Saturn rings, satellites, Cassini division

**Tools and Materials:**

Andreas Michalitsianos Telescope (TAM) or Apollon telescope, PC with internet connection, Paper sheet, Pencil, Ruler

**Aims and Objectives:**

The students should:

- be able to plan and carry out astronomical observations
- be able to understand the exact correspondence between lengths in the focal plane of the telescope and angles in the sky.
- be able to compute the maximum angle in the sky from which the incoming light is focussed within the area of one picture at the detector.
- be able to use compute the size of Saturn's ring
- be able to understand the scientific methodology

**II. Educational Phase**

**Stimulation:**

1x45 min

***Figure 3.1:*** *The Saturn's Rings*

Presentation of selected photos and/or videos of the Saturn's rings

- Short discussion on the Saturn's atmosphere
- Draw up a list on the blackboard with the proposed methods of measuring of the size of Saturn's rings
- Explain the optics behind the operation of the telescope
- Explain the concept of focussing a parallel light beam by a lens or mirror
- Explain why the position of the focus in the focal plane (where the CCD is located) determines the direction of the (point-like) astronomical source in the sky (along which the light is coming to us)

**Experimental Activities:**

First phase (1x45 min)

The students using the Eudoxos User Interface must:

- select the Andreas Michalitsianos Robotic Telescope or the Apollon telescope
- check the meteorological status for the site of the Kefallinia Island

- determine a reasonable exposure time
  *(see: http://knidos.snd.edu.gr/telescope/E-Exposur.html)*
- fill in the Saturn name or the celestial coordinates of the Saturn (and the corresponding time) and submit their request(s)

Second phase (1x45 min)

The students using the Eudoxos user interface must:
- study and understand the method employed to measure sizes
- determine the actual distance of Saturn from Earth at observation time
- take the Saturn's images from the Database Library
- estimate the size of Saturn's ring using the proposed image-processing software *(using the "sky map" tool or "cart du ciel" tool)*

**Observation - Discussion:**
Discussion of the theoretical issues arising from the observational (experimental) activities
This is facilitated with the assistance of the website's theory tutorial and links
- Theory and observation (experiment) comparison
- Comparison with the Galileo's anagram
- Short discussion on the satellite system of Saturn.

**Consolidation:**
Questions, exercises and tasks aiming at consolidation of the acquired knowledge

**Exercises:**
- Attempt to measure the size of the Cassini division, problems, comments
- Measure the Saturn's radius
- Measure the diameter of other planets
- Discuss the factors determining the accuracy of the method

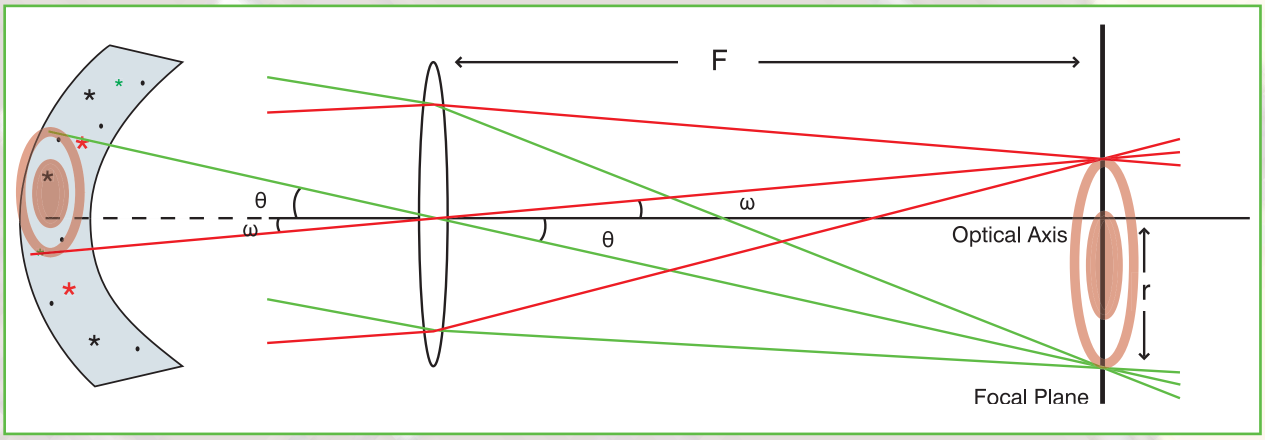



***Figure 3.2:*** *Measuring the size of Saturn's Rings*

# 3.2.2 Measuring the height of the Lunar Craters

**I. General Information**

This lesson plan provides information and material concerning observational (experimental) study of the lunar craters using the Andreas Michalitsianos Robotic Telescope or preferably the Apollon Telescope with a Lunar camera. Specific observational and experimental activities are presented and several questions, exercises and tasks are proposed to assist consolidation of acquired knowledge.

**Duration:**

Classroom lesson : 1x45 min
Observational Activities : 2x45 min

**Vocabulary:**

Lunar craters, Meteorites, Solar ray, Shadow, Moon radius, Moon phases

**Tools and Materials:**

Apollon or Andreas Michalitsianos Telescope, PC with internet connection, Paper sheet, Pencil, Ruler

**Aims and Objectives:**

The students should:

- be able to prepare and make astronomical observations
- be able to use celestial coordinates
- be able to measure the moon radius and the lunar craters radius
- be able to estimate the height of the lunar craters
- be able to understand the scientific methodology

**Student's Misconceptions:**

Shape of the earth, day-night cycle, phases of the moon

**II. Educational Phase**

**Stimulation:**

1x45 min

- Presentation of selected photos and/or videos of the Moon's surface
- Short discussion on the Moon's surface and crater formation mechanisms
- Draw up a list on the blackboard with the proposed methods of measuring of the height of the lunar craters

***Figure 3.3:*** *The Shape of the Moon*

**Experimental Activities:**

First phase (1x45 min)

The students using the Eudoxos User Interface must:

- select the Apollon or Andreas Michalitsianos Telescope (Lunar camera)
- check the meteorological status for the site of the Kefallonia Island
- fill in the celestial coordinates of the Moon and the proper time of observation or (better) just select the moon and submit their request(s)

Second phase (1x45 min)

The students using the Eudoxos User Interface must:

- take the Moon's image from the Database Library
- study and understand the analysis method followed in the theory
- estimate the height of the lunar craters using the proposed software for the analysis of the image(s)

**Observation - Discussion:**
Discussion of the theoretical issues arising from the observational (experimental) activities
This is facilitated with the assistance of the website's theory tutorial and links

- Theory and observation (experiment) comparison
- Comparison with the Eratosthenes experiment, observe similarities and differences

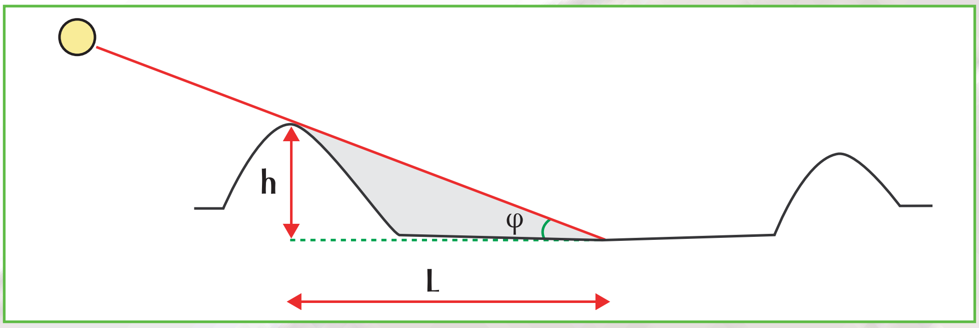



***Figure 3.4:*** *Estimating the height of a crater*

**Consolidation:**
Questions, exercises and tasks aiming at consolidation of the acquired knowledge

**Exercises:**

- Estimate the height of a tree measuring the shadow of the tree
- Make craters by throwing small marbles on flour.

# 3.2.3 Measurement of the Solar Rotation

**I. General Information**

This lesson plan provides information and material concerning an observational (experimental) study of the solar surface in order to find characteristic features (solar spots) whose apparent motion is due to Solar Rotation. By taken sequential images of the solar surface, using the Apollon Robotic Telescope (HTA), and estimating the display of the spots, the solar rotation can be detected. Then by converting that displacement to an angle (using the spherical grid) the sun period of rotation can be measured. Specific observational and experimental activities are presented and several questions, exercises and tasks are proposed to assist consolidation of acquired knowledge.

**Duration:**

Classroom lesson : 1x45 min
Observational Activities : 2x45 min

**Vocabulary:**

Sunspots, rotation orbit, differential rotation, solid body, period, gravity

**Tools and Materials:**

Apollon Solar Telescope, PC with Internet connection, Paper printout, Pencil, “Spherical” grid

**Aims and Objectives:**

The students should:

- be able to compare and contrast the differences between orbital and circular motion
- learn safety rules for observing the Sun
- understand that the apparent motion of the solar spots accross the solar disk is an indication of rotation
- be able to acquire an appreciation for basic astronomy and astrophysics through the exposure in such topics as these embedded in this lesson

**Student's Misconceptions:**

Day-night cycle, seasons, geocentric system, sun nature

**II. Educational Phase**

**Stimulation:**

1x45 min

- Presentation of selected photos and/or videos of the Sun
- Presentation of the first solar telescopes
- Short discussion on the Sun's surface (photosphere) - origin of solar light emission - origin of dark spots
- Draw up a list on the blackboard with various proposed methods of measuring of the solar rotation period

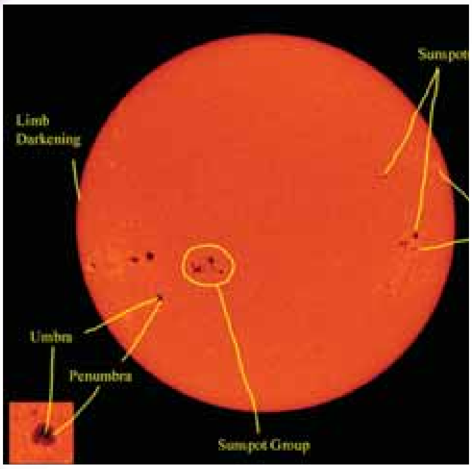



***Figure 3.5:*** *The Solar activity*

**Experimental Activities:**
First phase (1x45 min)

The students using the Eudoxos user interface should:
- select the Apollon Telescope, select the "Sun" as object of interest in the observing request form
- check the meteorological status for the site of the Kefallinia Island
- fill in the celestial coordinates of the Sun and the time and submit their request(s)
- decide the number of exposures to be ordered

Second phase (1x45 min)

The students using the Eudoxos user interface must:
- take the Sun's images from the Gallery, display and print them using the proposed image-processing software
- estimate the Solar Rotation Period by measuring the angular displacement of a certain spot in a given time interval (with the aid of the "spherical grid")

**Observation - Discussion:**
Discussion of the theoretical issues arising from the observational (experimental) activities
This is facilitated with the assistance of the website's theory tutorial and links
- Theory and observation (experiment) comparison
- Short discussion on the center of the universe in ancient times Ptolemaic versus Aristarchian / Copernican system

**Consolidation:**
Questions, exercises and tasks aiming at consolidation of the acquired knowledge (Refer to the relevant Worksheet)

**Exercises:**
- Make a solar telescope using simple materials (like pinhole on a box)
- Make the daily solar orbit using a simple solar telescope to center the sun and measure its angular height from the horizon and azimuth of the telescope from the local meridian, at different times

**Questions:**
1. How the stars evolve?
2. Approximately how long is the main sequence lifetime of the sun?
3. Why do sunspots appear dark?

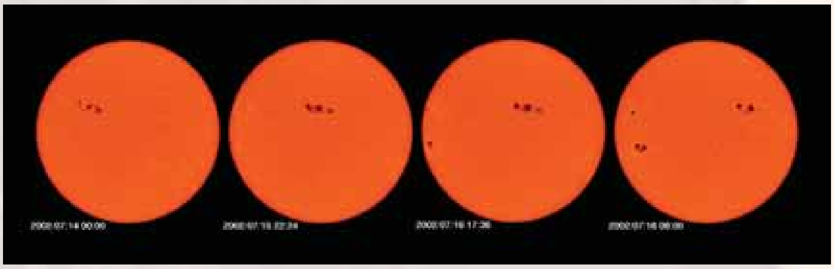


***Figure 3.6:***
*Observing the sunspots during a five days time*

# 3.2.4 Determination of Asteroids Rotation Periods

**I. General Information**

This lesson plan provides information and material concerning observational (experimental) study of the Asteroids rotation period, using the Andreas Michalitsianos Robotic Telescope. Specific observational and experimental activities are presented and several questions, exercises and tasks are proposed to assist consolidation of acquired knowledge.

**Duration:**

Classroom lesson : 1x45 min
Observational Activities : 2x45 min

**Vocabulary:**

Order and names of the planets, asteroid belt, position of the asteroid belt, light curve, solid bodies, rotation, period, reflectivity

**Tools and Materials:**

Andreas Michalitsianos Telescope, PC with internet connection, Paper sheet, Pencil, Ruler

**Aims and Objectives:**

The students should:

- be able to understand the origin of the constant rotation of an asteroid along its axis (conservation of angular momentum)
- be able to understand the origin of the asteroid motion around the sun (Newton's universal attraction law)
- be able to recognize a periodicity within a set of data
- be able to compare and contrast the differences between orbital rotation and self rotation
- be able to make astronomical imaging observations and extract Photometric data from their CCD frames
- be able to learn how to complete and apply the method of finding the period by plotting the asteroid light curve
- be able to understand the scientific methodology

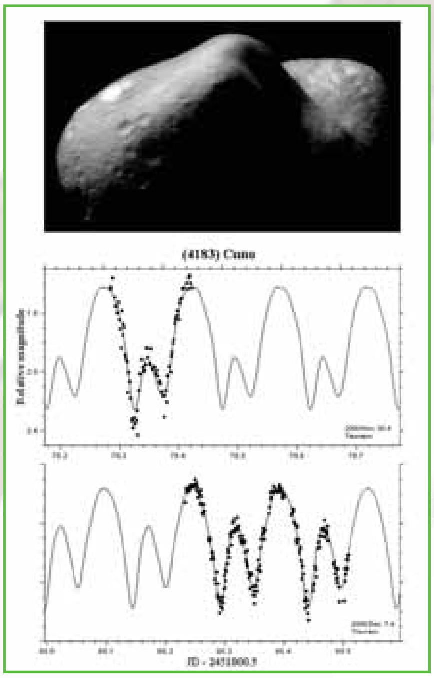



***Figure 3.7:*** *The asteroid 433 Eros and the photometric light curves from asteroid 4183 Cuno*

**Student's Misconceptions:**

Composite motion, angular velocity

**II. Educational Phase**
**Stimulation:**

1x45 min

- Presentation of selected photos and/or videos of Asteroids
- Short discussion on the Asteroids' surface and the reflection of the incident sun light
- Short discussion on the Asteroids' self rotation and the relative positions of Earth, Sun and Asteroids. Also on the path of light from sun to earth through the asteroid.
- Draw up a list on the blackboard with the proposed methods of measuring of the Asteroids rotation period

**Experimental Activities:**
First phase (1x45 min)

The students using the Eudoxos user interface must:
- decide which asteroid to observe
- find the coordinates of the object at a known (future) time using "cart du ciel" software
- select the Andreas Michalitsianos Telescope
- check the meteorological status for the site of the Kefallonia Island
- fill in the celestial coordinates of the selected Asteroids the appropriate times and the number of sequential CCD frames desired and submit their request(s)

Second phase (1x45 min)

The students using the Eudoxos user interface must:
- collect the Asteroids' images from the Database Library
- display each CCD frame using the proposed image-processing software
- extract photometric information (brightness measurements) of the asteroid for each frame
- plot the asteroid light curve
- estimate the asteroids rotation period

**Observation - Discussion:**
Discussion of the theoretical issues arising from the observational (experimental) activities
This is facilitated with the assistance of the website's theory tutorial and links
- Theory and observation (experiment) comparison
- Comparison with the orbital period and the period of the self rotation
- Discussion on the origin of the asteroid belt
- what determines of brightness difference between the maximum and minimum of the light curve?

**Consolidation:**
Questions, exercises and tasks aiming at consolidation of the acquired knowledge

**Exercises:**
- Determine the two maxima (or minima) on asteroids light curve.
- Estimate the Asteroids rotation angular speed. What other data are needed?
- How the light curve would look like, if the surface was a perfect sphere?

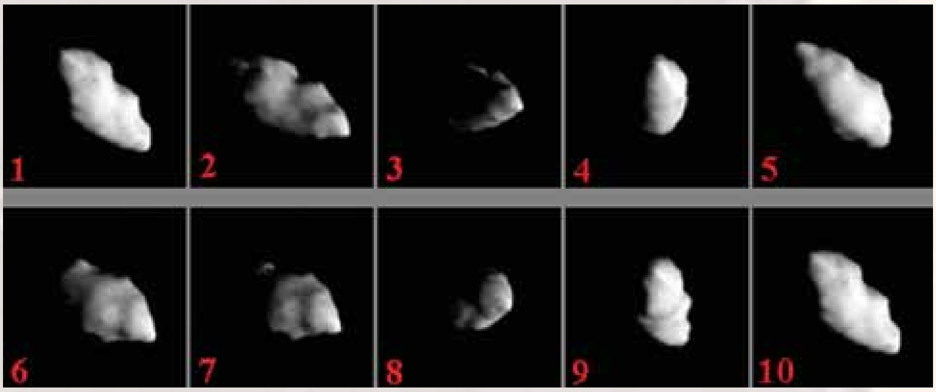



***Figure 3.8:*** *A sequence of views from Earth of asteroid Geographos that demonstrates how the cross-section varies with time.*

# Chapter 4
# Evaluation of the Eudoxos Project

## 4.1 Framework of the Evaluation

**Teaching for Understanding: What is really most important in education?**
Educational research describes teaching as a complex activity which is characteristically simultaneous, multidimensional and unpredictable [Darling-Hammond, 2001]. In the classroom contradictory objectives and multiple tasks are negotiated at a very fast rate; changes are continually made, and obstacles or unforeseen opportunities appear. Every hour and every day teachers have to reflect on and take decisions to create a safe environment and encourage learning, pressurised by the need for academic performance and the need to satisfy each individual student and the demands of the group. Realities such as these contradict the bureaucratic view of teaching as a task directed at a limited number of aims and simple, predetermined objectives; organised into a sequence of activities and uniform lessons for all the students in a particular class, or in different classes or countries.

Therefore, any teaching plan that does not take into account the complexity of these schools is not consistent with reality and does not respond to the necessities, interests and situations that arise in every educational situation:

> "*Probably, whenever we bring together 25 to 30 people of the same age, whatever age that might be, we find major differences in development, levels of knowledge, types of personality, expectations, interests, etc. and, precisely because of that, one of the most significant characteristics of teaching is that of having to create a "complex" and "diverse" environment; and therefore one of the conditions that any teaching strategy should meet, if it wants to be effective, is the ability to adapt itself to this complexity and diversity*" *[Porlan, R., 1996]..*

It is absolutely necessary to adapt every project, plan, activity, etc., to the real situation in each context. There are various pieces of research [Good and Brophy, 1997] highlighting that the best teaching is that which is adapted to each situation, to the educational aims and planned outcomes, to the students and the lessons.

There is no point in an educational approach based on the transmission of knowledge (teachers give academic lectures or use textbooks, students memorise content). On the contrary, the process of teaching and learning must go hand in hand with the social construction of knowledge on the part of the students. The following table lays out the main aspects that define the two major theoretical approaches to the process of teaching and learning: Transmission of Information versus Social Construction of Knowledge:

TEACHING AND LEARNING AS TRANSMISSION OF INFORMATION VERSUS SOCIAL CONSTRUCTION OF KNOWLEDGE
[Good and Brophy, 1997]

| Transmission View | Social Construction View |
|---|---|
| Knowledge as fixed body of information transmitted from teacher or text to students. Texts or teacher as authoritative source of expert knowledge to which students refer. | Knowledge as developing interpretations co-constructed through discussion. Authority for constructed knowledge resides in the arguments and evidence cited in its support by students as well as by texts or teacher; everyone has expertise to contribute. |
| Teacher is responsible for managing students' learning by providing information and leading students through activities and assignments.<br>Teacher explains, checks for understanding, and judges correctness of students/ responses. | Teacher and students share responsibility for initiating and guiding learning efforts.<br>Teacher acts as a discussion leader who poses questions, seeks clarifications, promotes dialogue, helps group recognize areas of consensus and of continuing disagreement. |
| Students memorize or replicate what has been explained or modelled. | Students strive to make sense of new input by relating it to their prior knowledge and by collaborating in dialogue with others to co-construct shared understandings. |
| Discourse emphasizes drill and recitation in response to convergent questions; focus is on eliciting correct answers. | Discourse emphasizes reflective discussion of networks of connected knowledge; questions are more divergent but designed to develop understanding of the powerful ideas that anchor these networks; focus is on eliciting students' thinking. |
| Activities emphasize replication of models or applications that require the following of step-by-step algorithms.<br>Students work mostly alone, practising what has been transmitted to them in order to prepare them to compete for rewards by reproducing it on demand. | Activities emphasize application to authentic issues and problems that require higher-order thinking.<br>Students collaborate by acting as a learning community that constructs shared understandings through sustained dialogue. |

“As educators, we want students not just to retain information but to develop deep understandings and reflect thoughtfully about what they are learning. We want them to become scientific inquirers, critical thinkers, systematic problem-solvers, and value-based decision makers. If these lofty goals are to be accomplished, we need to teach with emphasis on higher-order thinking about the implications of what is learned". [Good and Brophy, 1997].

A curriculum that is consistent with the Social Construction of Knowledge approach has to be open and flexible to make it possible for all students to learn and has to respect different learning rates.

Taking into account that we have just outlined, we propose that Eudoxos Project is approached as a Telecollaborative Curriculum Project (TCP) [Angulo, F, 2003]. A TCP is a project for students in which understanding, knowledge construction and collaborative learning are promoted.

Understanding is the ability to think and act flexibly with what one knows. Understanding can be appreciated (appraisal) and developed via the performance of understanding: activities and practice that give students the opportunity to understand and learn.

Knowledge construction means that the students have to use arguments and evidence, ask and answer questions, it promotes dialogue, emphasizes reflective discussion, etc.

Collaborative learning means tele-working with other groups of students or partners sharing experiences, ideas, results, doubts, etc.

The TCP must:

- Be flexible in terms of the structure to be adapted to countries and schools
- Be a learning tool that motivates and challenges the students
- Be a pedagogical tool for the teachers
- Focus on the students' work and collaboration
- Focus on the process much more than on the "results"
- Combine information from the Net, information from other sources and field research information
- Subordinate the technology to the pedagogical material

TCPs are not teaching plans with pre-specified learning objectives.

**Evaluation and Assessment: Why is Testing not the best way to evaluate the Project?**

Evaluation in education can be understood in two distinct ways: with a broad view of the concept or with a narrow view. In Anglo-Saxon countries a distinction is usually made between *evaluation and assessment.* These terms correspond to the two views of evaluation [Angulo, 1995].

*Evaluation or broad view* refers to the process through which we come to know and evaluate the quality of "the service" (or the project) and the role of the various components in delivering the service.

*Assessment or narrow view* refers to the process through which we establish "quality" only by means of the impact of "the service" on individuals or groups of individuals, restricting the understanding of quality of educational service to its effect on students. In addition, the narrow view of evaluation underlies some everyday words such as "exams" and "tests", and other more technical ones such as public exams, educational quality indicators, performance measurement, testing systems, etc.

Within the *narrow view of evaluation* (assessment) there is a general and commonly-used concept: "tests". Tests represent the essence of scientific measurement in psychology and education, the followers of this narrow view of evaluation wrongly believe and defend the fact that its use shows up students' learning clearly and thoroughly, which allows discrimination between students on the basis of merit.

However, in all of this, various things are usually forgotten:

Firstly, it is forgotten that a test is a measurement tool that collects very specific information about an individual or group of individuals. But it is not the only tool that we have at our disposition. It could be that we limit ourselves to the narrow view (assessment) with tests being the fundamental tools, but not even in this case are they the only ones. If on the other hand we feel more inclined towards the *broad view*, tests are one of the many tools that we can use and are not even the most important.

Secondly, tests as tools are only a sample or selection of questions or situations (called items) taken from one area of content or interest" [Madaus, 1988]. The psychometrician has to make sure that it is representative of the field in general. In technical terms this is called the validity of the test.

However, tests can only tell us whether the student has answered correctly or incorrectly, without showing the underlying causes of these answers (correct and incorrect). That is to say, tests do not help us understand the educational reasons why the marks are high or low, nor how to solve or improve the problems or difficulties that may be detected [Berlak 1992; Broadfoot 1983, 1984; Broadfoot, Murphy and Torrance 1990; Gipps, 1994].

This tool is regarded as being certain, thorough and scientific, in the sense that it allows mental states, intelligence, learning or certain characteristics of social interaction [Berlak 1992 & Madaus 1988a].

However, this characterisation is questionable for various reasons:

- It is clear that tests measure those meanings, concepts, experiences that society believe to be valuable, standardized and homogenous without taking into account that learning, achievement, attainment, are concepts that take on different historical, social and political meanings; and therefore, are not universal, unchanging truths.

- The psychometric approach has held a fragmented view of learning and knowledge practically since the beginning, but it has been particularly influenced by the area of conductive psychology (since the 1950s). This fragmentation can be seen in the tests in the separation between the cognitive, affective and connective areas and in their decontextualisation. Decontextualised teaching lacks meaning for the students, distorting and obscuring the richness and complexity of the learning process.

  "*The importance of the content does not lie in facts and routine skills, but in the understanding of concepts and relationships, that is what gives meaning and usefulness to facts and skills*" *[Darling-Hammond, 2001].*

By putting evaluation and tests on the same level we limit the amount we can capitalise on the significance, richness and complexity of the former. Therefore, deciding about the future of an individual or group of individuals, about the performance or professionalism of a teacher, about the state or quality of a system, about teaching and learning experiences, or the future direction of education policy, basing ourselves on the marks obtained in certain tests, however numerous they may be, is a questionable and educationally-and politically-irresponsible exercise.

We can conclude that the adoption of the narrow view of evaluation or the technique of tests as the theoretical framework for the evaluation of a project (of some innovative teaching and learning experiments), seriously mars the knowledge about and perception of the quality of such a project, reducing the process to pure information collection using tools which are technically and educationally limited.

In this case, it seems to be assumed that quality depends purely on the "results" measured in student performance. This implies that the quality of teaching and the quality of the educational centres is determined by the success rates of the students.

Finally, it is important to add here that evaluation methods have a decisive influence on teaching. For example, the use of standardised tests, as often happens in the United States [Darling-Hammond, 2001], has a powerful influence when it comes to determining what to teach, how to teach, what the students study, how they study and also what they learn. The use of this method of evaluation results in a classroom emphasis on memorisation of isolated facts and vocabulary, to guarantee that the students pass their exams.

But, as a consequence, they never develop the ability to use the knowledge and skills in new situations, connect ideas from different subjects or fields, etc. That is to say, they have not arrived at the development of understanding: the knowledge they have acquired is inert, it cannot be remembered, transformed or applied in a significant way to new situations or problems.

On the other hand, when the evaluation methods take a global view of the whole process of teaching and learning and concentrate on understanding what goes on in the classroom, (and do not check what the students know about the content laid-out in the curriculum), more enriching and dynamic educational processes are allowed to develop. The aim of this form of evaluation is the analysis of educational practice, to later be able to take steps towards improvement. This approach encourages active learning (projects, discussions, research, etc.,) that allows students to develop complex thought processes. They will be capable of remembering and applying what they have learnt, and make connections between what they already know and new content by relating it to their experience.

**Global, Qualitative Evaluation: What do we want to evaluate and how?**

The evaluation that we suggest is concerned with analysing the influence of the various components of the teaching and learning process (curriculum, methodology, organisation of the centre or of the classroom, teachers and students) in educational quality.

Evaluation processes are converted into research processes in the classroom. This research should be based on the following principles [Porlan and Martin, 1996]:

a) Research done by students: as a way of creating rules, attitudes, skills and knowledge in the classroom.

b) Research done by teachers: as a way of adopting reflective practices and continuing professional development.

c) Curricula which are open and experimental as a way of establishing the correct balance between the planning and evaluation of teaching.

The Eudoxos Project (Learning Science with a Robotic Telescope, TSRT) is within the framework of the e-Learning Plan of the European Union, and is designed to be an **innovative** project. The innovation, in this case, is the achievement of learning about natural sciences through the use of a telescope via the Internet and the promotion of telecollaborative learning.
The value of a new innovation does not depend on the quantity that the students learn, but on more factors: the design of the innovation, its implementation, consideration of the contexts (schools) in which it will be applied, the understanding of the innovation by the agents, etc. An innovation therefore includes everything.

**Authentic Assessment as the basis of Student Evaluation**

The broad view of evaluation demands that the most important aspect of the evaluation is student learning. With this in mind, and as an alternative to Testing, some years ago the concept of Authentic Assessment [Torrance, 1995] was added to the field of learning evaluation. Authentic Assessment means that students are exposed to tasks which are designed to confront them with situations which are more practical, realistic, and challenging than those offered by traditional tests [Torrance, 1995].

There are two basic elements that define the kind of tasks which are included in the Authentic Assessment approach: the production of knowledge and disciplined investigation:

*Production of knowledge* means that students have to produce, more than reproduce, knowledge and express it in different forms: speeches, performances, compositions, problem-solving, etc.

*Disciplined investigation* assumes the use of previous knowledge (substantive or conceptual and procedural), deep understanding (of a problem or situation) and the integration of knowledge (interpretation of information, formulation of ideas and comments which require the re-organisation, synthesis and coherent re-structuring of knowledge in a different way).

With regard to the specific evaluation strategies and tools, authentic assessment highlights the following:

- The strategies and tools used in global, qualitative evaluation should be sensitive to social and educational phenomena, the ethos of the school and the needs of those directly involved.

- Tools and strategies should not artificially separate the cognitive, affective, connective, interactive and situational aspects of learning.

- They should also allow the various social groups involved to freely express their opinions, criticisms, uncertainties and problems.

- Instead of forcing teaching to adapt itself to the structural and technical requirements of certain forms of evaluation, as happened with tests (to be precise, tests of criteria and minimum competence), evaluation must be subordinate to the natural complexity of learning, school-based knowledge, the process of teaching and the curriculum. (Angulo, 1995: 216).

## 4.2 The main aim of the Evaluation

The main aim of the evaluation of the project is to **understand the processes of change** that take place in the various participating schools, caused by the use of the Internet-run telescope and within the lesson plan framework.

## 4.3 Procedural Principles

During the Evaluation, those that play an important role in the teaching and learning process in the classroom must actively participate, ie, the teachers and students must be involved. They are the most appropriate to provide information and evaluate the implementation of the project; given that they are directly involved. Their opinions, comments, recommendations, difficulties encountered, etc., with respect to the implementation of the lessons and the use of the telescope, can be a rich source of information in trying to understand the processes of change in each different context.

In order to provide a contrast with the information and evaluation given by students and teachers, the external evaluators will analyse from outside what is going on inside classrooms. This triangle of information from different sources gives internal validity and coherence to the evaluation process.

**a. Role of teachers in the evaluation process**

Teachers take on a fundamental role in the evaluation of the project, given that they constitute the link between two different levels in its realisation: the design and its application in the classroom (direct work with the students). Their privileged position in this respect is fundamental to inform, analyse and evaluate all the details of the implementation of the project. Their contributions must be the most honest, thorough and systematic possible. They are the real centre of the whole project, in its implementation, as well as its evaluation.

Their role in the evaluation process should be connected with the following tasks or responsibilities:

- Guarantee the appropriate use and application of the tools for the collection and analysis of information in their schools.
- Transmit the philosophy of the evaluation to the students: tell them about their role in the project and in the evaluation, make them participate in the whole process; explain to them how to input appropriate and useful information for the evaluation of the project.
- Coordinate the use of evaluation tools in the classroom to allow the expression of shared opinions and comments in order to produce conclusions and summaries.
- Keep in contact with the coordinators of the project, and inform them about problematic, relevant, curious and interesting aspects, so that they can consider them throughout the process.
- Keep in contact with the external evaluators: inform them about doubts that arise about the evaluation process, share with them the process of using the practical guides to the evaluation tools, give opinions and comment on significant situations with respect to the various aspects of the project (application of the lesson plans in the classroom, contextualised difficulties, use of the program to use the telescope, etc.)

**b. Role of students in the evaluation process**

It is of primary importance that students make the contents of the project and the use of the program to use the telescope their own, and because of that they are the most appropriate to comment about the extent to which this happens, what steps they take and what difficulties they encounter. It is important that they main tain an open relationship with the teacher, and they comment freely about the most representative and difficult incidents. More precisely, students should actively participate in the collection of information; using the strategies that we propose (Students' Portfolios and Inter-School Collaboration Journals).The collection of information will have to be the result of systematic, thorough work. Similarly, the comments made must be very honest.

**c. Role of the physics experts**
For the consortium, it is important to know the results of the use of the framework and the e-tool designed for the project. One of the areas in which some members are really interested is ascertaining the influence that the specially-designed educational programme and the programme that allows images collected by the telescope to be viewed via the Internet have on student knowledge. They want to know the way in which the project affects the knowledge the students acquire about astronomy, physics etc. To investigate this, it would be necessary to create evaluation instruments directly related to the subject matter that would allow the amount of learning achieved by students to be gauged. We must therefore count on the active collaboration of the physics experts that form part of our project.

This evaluation will be sent to UCA in the form of a report written by the experts. This quantitative data will be used by the L.A.C.E. research group as data which is complementary to the qualitative documentation, thereby enriching the evaluation process.

**d. Role of the external evaluators**
The team from the University of Cadiz have taken on this role of external evaluators. Their responsibilities during the implementation of the project should be the following:

- Monitor the process, maintaining contact with the various parties (teachers, students, coordinators).

- Advise the teachers of the four schools in the development and use of the tools designed to carry out the evaluation with the intention of making the greatest possible use of the information registered.

- Carry out on-line interviews with teachers to get further information, if necessary.

- Produce a Final Report on the Evaluation of the Project, using the information submitted by each school and that registered personally during the process.

## 4.4 Evaluation Strategies and Tools

The evaluation strategies and tools that we propose match the characteristics required by global, qualitative evaluation. Fundamentally, the teachers and students will be responsible for registering and analysing the information for the evaluation. The tools we propose for them are the following:

a. Teachers' Diaries

b. Students' Portfolios

# 4.5 Teachers' Diaries

**Introduction**

The model of education which is in harmony with the concept of evaluation, as previously defined, demands a central role for those who are at the centre of the teaching and learning process: teachers and students.

- We consider that social reality is extraordinarily complex and rich.

- This complexity is reflected in the teaching and learning processes started in the classroom.
  We understand that these processes, because of their complexity, have to be tackled with a critical and social eye that allows them to be understood and improved.

- We believe in human development and learning, brought about via a continuous process of construction and investigation.

Teaching goes further than more formal, academic explanation of the content by the teacher. And students, from our point of view, are not obliged to memorise and reproduce such content. The model of education that we believe to be relevant and significant is that in which students and teachers reflect on their daily work in order to improve it.

The teacher becomes a fundamental **mediator** between educational theory and practice. The teacher analyses, interprets and takes decisions about the teaching and learning process. The teacher is an active agent of everything that happens in the classroom taking on a role as regulator and controller of educational events.

The teacher diagnoses problems, formulates hypotheses and experiments, evaluates these hypotheses, chooses and selects materials, designs the activities, etc. She or he is, definitely, a **researcher** in the classroom.

The teacher has to develop a strategy that allows her or him to carry out a systematic, critical and significant analysis of the events that take place in the classroom. The Teacher's Diary will be, without a doubt, one of the most relevant and useful tools that the teacher will have to achieve this objective.

**The Teacher's Diary**

The Teacher's Diary is a tool for the collection and analysis of information that allows the teacher to analyse thoroughly and systematically what happens in her or his classroom. It allows also reflecting on the teaching and learning processes put into action in class and carry out a critical analysis of her or his daily work. The ideas, contributions and views that a teacher could collect with a tool like this Teacher's Diary seem to us to be extremely valuable. The evaluation that the teachers can make of the day to day implementation of the project will be of great use in judging the impact of the Eudoxos Project

**How to produce the Teacher's Diary**

The purpose of the Teacher's Diary from L.A.C.E.-UCA's point of the view is that of an evaluation tool with which teachers will become aware of the things that happen in the classroom when integrating the teaching and learning process with the lessons and the telescope that the Eudoxos Project proposes. Teachers will develop this tool in three main phases related to each of the phases of the implementation of the Framework and of the Telescope.

1st Part : Before the implementation of the Project.
2nd Part : During the implementation of the Project.
3rd Part : After the implementation of the Project

**1st Part: Before the implementation of the Project**
It is important that teachers give their initial points of view about the Project before putting the lessons and on line work into practice. This initial evaluation will allow us to discover how the process of implementation of the project changes preconceptions, previously-held ideas about learning possibilities etc. All of these ideas will help us to better understand the influence of the project in each school.

**2nd Part: During the implementation of the Project.**
This phase of evaluation by the teachers will be of vital importance. When the lessons start to be used in class, it will be fundamental to try to collect information about the teaching and learning process that is being undertaken, the reactions of the students to the content, etc.

**3rd Part: After the implementation of the Project**
When the work has finished, it will be necessary for teachers to analyse in a general way all the work done. It will be important to have an evaluation of all that has gone on to gauge the influence of the project, taking into account how far that project has met original expectations, the most important aspects during its implementation, etc.

**TEACHERS' DIARIES**
**1st Part: Before the Implementation of the Project**
We propose that you undertake an initial evaluation of the project. You can do it via the following questions which will point you in the right direction:

- What do you think of the project in general? What educational possibilities do you think this e-learning can offer your school?
- Offer your opinion of the educational planning of the project: What do you think of it? What do you expect from it?
- Give an opinion about the aspects of educational innovation that this project can contribute to your daily work in particular and your school in general.
- What educational expectations do you have with regard to the framework and the use of the telescope? How do you think that this project can encourage the learning of science by your students? And your professional development?
- What would you add to the project bearing in mind your teaching needs and in those of your school? What would you take out or change?
- Others...

**2nd Part: During the Implementation of the Project**
Below we propose some categories that will help you collect all the information possible about the things that happen in the classroom during the implementation of the project. We suggest, to facilitate the process of evaluation that you are going to undertake, that you do this work every time that you going to do activities related to the project. That way you can evaluate your work and the teaching and learning process in a practical and systematic way.

<u>Lesson Planning</u>
This first category of analysis will help you analyse your intentions and create a design in accordance with the objectives that you plan to develop during each class. You can respond to these questions, making a note of your comments.

- What do you intend to achieve in this lesson, taking into account students' previous knowledge?
- How will you adapt the lesson to the particular characteristics of your students?
- How will you select and organise the content to be worked on? Give your point of view about how adapt-

able the lesson plan is to the particular characteristics of your school.
- What activities will you undertake to achieve the objectives you have set for this lesson? Describe them briefly and say what resources are necessary to carry them out.
- What teaching methodology will you use to work on the content with your students?
- How will you organise your classroom to carry out these activities? How will you organise the time?

Access to and Use of the User Interface
When you have to put certain lessons into practice, you will have to prepare technical resources and materials like images from the telescope with specific coordinates, specific information from the project web page, etc. We propose:

- Fluidity of information on the web page
- General functioning of the program
- Quality and effectiveness of the documents and images from the telescope
- Possible communication difficulties
- Quality of the assessment of the professionals
- Others…

The Lesson Plan in Practice
In this section you should make a note of all the relevant events that happen in class once you put the lesson plan into practice. This is about describing the classroom dynamics via systematic and detailed accounts of what happens in the classroom. This exercise might appear very complicated at first, especially in relation to the separation between description, interpretation and the spontaneous evaluation of processes but this difficulty will be overcome once you acquire the critical ability to be able to differentiate between spontaneous description and calm, systematic, rational analysis.

The situations collected in your description will allow you to discover problematic aspects that you will be able to resolve on a daily basis when analysing what you have written, accepting the complexity of the teaching and learning process, encouraging improvement via reflection on your daily work.
We propose some areas for consideration that will help you produce this description.

- How did the lesson develop? Do you think your methodology was appropriate? Briefly describe how the class was, what was the general dynamic? etc.

- Describe how you undertook the activities in class: how did you present them, how did the students react, what results were you able to see, have the students learnt anything from them? Highlight possible difficulties, curious aspects, incidents etc.

- Do you think the students understood the content? How did they feel?

- Was your space and time management appropriate?, Describe those aspects related to the management of time and space (the allocation of students to computers, the time dedicated to each activity, etc)

- Describe the reaction of your students to the User Interface. Recount how the work on the computer went, how the Internet worked, what implications working with this "virtual" telescope had for you and your students?

- Think about how far you have achieved the objectives you set for this lesson: In practice did the User Interface give the results you expected?

- Describe the most significant psycho-social processes: your relationships with your students, relationships between them, negotiation processes, reactions, level of participation and implication, etc.

- Lastly, it would be very interesting for you to reflect on your feelings, needs, and impressions, beliefs in terms of the implementation of the lessons and the use of the e-tools in your classes.

You can accompany your description with photos of the class, your students working, of the organisation of the classroom and the computers, etc. Photos can sometimes offer direct, clear, rich information about the processes that take place in the classroom, and allow the reader to understand what went on there.

This kind of information will be very interesting for our research group. The pictures will allow coming closer with the reality of each class. It would be interesting that the main figure of the photos could voice comments about the situations that the pictures showed

Analysis of the information collected

In the previous section we proposed a description of the most relevant classroom events. This description, although thorough and true to reality, needs close examination which will allow an understanding of what really went on in the classroom. Critical reflection on those things entered in your diary will be required in order to analyse those things that took place when working with a telescope via the Internet.

You can organise the information however you want to. We will show you a way of structuring your analysis that could be useful, but it will be you that decides how to organise your ideas in order to get the most out of them: it will be this reflection that allows you to take reasoned and coherent decisions that will improve the teaching and learning process.

a. Conceptions of your teaching work: Evaluate your work as a teacher in this class: your teaching methodology, your relationship with the students, your way of approaching work with the computers and User Interface, the quality of the activities, etc. Suggest what you would change to improve your teaching.

b. Aspects with regard to students: Reflect on the learning process that your students have been through in the class. Analyse what aspects might require changes in order to improve their learning. Reflect on how they felt working with the telescope and the advantages and disadvantages of this way of learning physics on-line.

c. Analysis of the content and the User Interface: Evaluate how the content arrived at the students, think about to what extent their previous ideas about the material have been changed and enriched. Reflect on the organisation and sequencing of the content that they worked on. Make a note of contributions. Highlight how the telescope and web page were used, analysing the positive and negative influences on learning. Evaluate the reaction of students to this new way of learning physics. Note what you would change to improve the following classes.

d. Reflection on the classroom climate: It is important that you analyse the psycho-social dynamic of the classroom. Evaluate the relationships that you have established with your students, the way they have worked together, the possible conflicts and the solutions we can plan to resolve them, etc.

**3rd Part: After the Implementation of the Project**

Lastly, to cover everything that goes on in the classroom throughout the project, it will be fundamental that the teacher goes back to their initial ideas, thoughts, and expectations (collected in the first part of the Teacher's Diary). This review will allow them to see if their expectations have been met and therefore it will help us to understand the influence of the project in each school.

We will be able to discover the ability of the User Interface to improve the learning of astronomy in particular and of sciences in general, evaluate the contribution of this project to innovation in education, etc.

We propose the following suggestions and questions to help you carry out this evaluation exercise:

- Offer your general opinion about the implementation of the project in your school.
- Has this e-learning lived up to the educational expectations that you had of it? Evaluate the educational value of the User Interface and Lesson Plans.
- What do you think about the implementation of the Lesson Plan in your classroom? What did it bring you as a teacher?
- Explain the positive aspects for student learning that participation in this project has brought. Analyse how they have worked with the content, what abilities they have developed through working with the Internet, their motivation level when using the telescope, etc.
- Highlight the advantages and disadvantages that the Eudoxos Project has for the teaching of science.

Note the educational and technical difficulties that you experienced. You can make recommendations, aspects that you would improve, etc.

# 4.6 Students' Portfolios

**Reason for and usefulness of the Portfolios: Evaluation through files of work.**
Students that learn content by understanding it, do not only learn the content itself, but also appreciate the reason for learning it and retain it so that they can use it again when necessary. The *Student's Portfolio* constitutes a fundamental tool with which each student monitors their learning process systematically and thoroughly and becomes aware of the usefulness of the content they are working on. It will help (or try to help) students to develop the ability to evaluate their own learning process and work. Similarly, their opinions with respect to the multiple elements that form part of the whole (content, activities, methodology, way of working, space and time management) will take on a considerable importance in the global evaluation of the teaching and learning process of the group. In addition, teachers will have a rich source of information about where the student was at the beginning, what steps they have taken, what processes they have followed, where they have arrived, what aspects have interested them most, what difficulties they have found, etc.

**Physical Characteristics of the Portfolios: How they should be created and used.**
A *Portfolio* is a file in which each student keeps a record of the activities undertaken within the framework of the project. The portfolios for the Eudoxos Project are divided into three main parts, which correspond to the three main phases of implementing the project in the classroom:

1st Part: Before the Implementation of the Project
2nd Part: During the Implementation of the Project
3rd Part: After the Implementation of the Project

Students should respond to the questions posed (in the first and third parts) and collect, during the implementation phase, materials used in class activities (texts, images, notes, etc.), activities done and reflections on the knowledge acquired, strategies, ways of working (with the Internet, in groups, individually, etc.), interests, feelings that the activity provoked, difficulties experienced, solutions for the difficulties, etc.

As we indicated before, for the UCA research, pictures would be very interesting and additional information. The students could make photos about their different daily schools life: working with the e-tool in the computer, the teachers' explanations of any activities, etc. Each student could express their ideas in relation to the situations represented in their photos.

**STUDENTS' PORTFOLIOS**
**1st Part: Before the Implementation of the Project**
Answer the following questions, either one by one or by writing a general summary of your answers to all of them. You can use pictures, drawings, texts, personal comments, etc.

- What do you think of the project?
- What do you think about its presentation?
- What information do you have about the Eudoxos Project?
- What possibilities do you think the project offers you?
- At the moment, what do you know about the activities you are going to do?
- How would you like the activities to be?
- What would you like to learn with the framework of this project?
- What attracts you most about the project?
- What do you expect of the project?
- What would you add to the project bearing in mind your needs as a student?

**2nd Part: During the Implementation of the Project**
For each of the sessions or teaching units (each one of the lesson plans) that you work on in class, you will have to collect the following information:

- Put together the materials (texts, pictures, personal notes taken, etc) that you use in each session.

- Collect together the activities that you do (things you produce: drawings, sketches, essays, Internet searches; problems set in class and solved; group activities, etc). It is important to indicate how you have done them, e.g. individually, in a group, exchanging opinions with students in other European schools via the Internet.

- At the end of each session or each lesson it is important that you make a retrospective schedule of the timing of the activities in class, i.e., that you write in your own words the process that you have followed during the session. For example: teacher's explanation, undertake the activities proposed by the teacher, use of the Internet to view the selected planet, etc.

- It is also important that you collect information about the step by step development of each session, those moments in which you get lost, you do not understand why you are doing that particular activity, you think it would be better to change the order of the activities, or also, if you would have removed one of them because it did not have any significance for you.

- Also when you finish each session or each lesson it is very important that you register your personal comments, your evaluation, the difficulties that you experienced, the aspects that you would change, those that you would remove and add. It is vital that you are completely honest in these comments, and even better that you are explaining and back up your opinions.

- To give you an idea of where to start, you could answer the following questions: What did you think of the activity? Was it interesting? Where did you have difficulty? How did you work: individually or in a group? What would you change? How would you like to continue?

**3rd Part: After the Implementation of the Project**
**General Evaluation of the Whole Process**
Reread the expectations that you wrote down at the beginning of the project, and answer some of the following questions:

- Have your expectations been met?
- Why? Why not?
- What aspects would you change?
- What would you improve?
- What did you like most and least?
- What can you say you learnt?
- What do you think of the project in general?
- What material did you think was the most interesting?
- What material did you think was the most boring or complicated?
- Did you have difficulty using the telescope via the Internet?
- How did you feel when you were working with your classmates?
- How did you feel when you were working with young people from other countries?

## 4.7 Inter-School Collaboration Journals

Another tool that we propose for the collection and analysis of data is the *Inter-School Collaboration Journal.*

Collaboration between different European schools, within the framework of this e-Learning project, means an innovation in education (added to the innovation contributed by the use of a telescope managed via the Internet to teach science). This collaboration will be grounded in the communication and exchange of experiences, materials, comments and opinions, between the different European schools participating (teachers and students) using space on the Internet, for communication, debate, and collaboration between countries. To this end, we propose that an *Eudoxos Collaboration Forum* be set up on the Internet that can be accessed via the Project website. During the process of implementation of the project in the classroom, the forum will remain open to allow teachers and students to exchange views, proposals, recommendations, materials or interesting texts that complement the lesson plans, students' work, difficulties found in trying to solve problems, etc. In addition to encouraging student learning and teacher development, it will be an extraordinarily rich source of information for the evaluation of the project.

The *Inter-School Collaboration Journal* is intended to be a tool with which teachers and students can register events, situations, experiences, opinions, exchanges of information, materials and work produced, help with problem-solving, etc., related to the process of collaboration between the educational centres. This will take place on line (in the Eudoxos Collaboration Forum), and the Inter-School Collaboration Journal will allow participants to note down the most significant aspects of this collaboration.

Each school will use a journal or file in which they will note down these comments about the collaboration. The Journal will consist of two sections: one for teachers and the other for students:

- In the Teachers' Section teachers can make comments about collaboration with teachers from the other participating schools and the coordinators of the project.

- In the *Students*' *Section*, students can enter feelings, opinions, relevant or strange situations with regard to collaboration with students from the other European schools.

## 4.8 Phases of the Evaluation and Timing

The following table shows a schedule for the phases of the evaluation of the project and their respective timings.

<table>
<tr><th colspan="3">PHASES OF THE EVALUATION OF THE PROJECT</th></tr>
<tr><td colspan="3">1st Phase: Exchange detailed information about the participants.<br>March 2003.</td></tr>
<tr><td rowspan="2">2nd Phase: Evaluation during the process of Implementation of the project.<br><br>April, May and June 2003<br><br>October, November, December 2003 and January 2004</td><td rowspan="2">Use of the Evaluation tools:<br><br>Teachers' Diaries<br>Students' Portfolios<br>Inter-School Collaboration Journals</td><td>Analysis of the process of preparation:<br>Lessons<br>Technical aspects<br>( User Interface )</td></tr>
<tr><td>Analysis of the implementation process.</td></tr>
<tr><td>3rd Phase: Production of SummaryDocuments<br><br>January and February 2004</td><td colspan="2">Each school produces:<br><br>Summary of Teachers' Diaries<br>Summary of Students' Portfolios<br>Summary of the Inter-School Collaboration Journal<br>Conclusions/Recommendations.<br><br>To be translated into English.</td></tr>
<tr><td>4th Phase: Production of the Final Report<br><br>February and March 2004.</td><td colspan="2">UCA will take responsibility for the production of this report.</td></tr>
</table>

**1st Phase: Exchange detailed information about the Participants**
When you try to integrate educational projects in particular schools, and evaluate the impact of these on each one, it is necessary to know something about these centres. Each school is unique: it is in its own particular context, with rich, diverse, complex socio-cultural realities and different people. It will be possible to discover the influence of the Eudoxos Project on each school, when the particular characteristics of each centre and the people that run it are known.

For this reason, we believe it is necessary that the participants in the project in each school write a Report that will allow us to understand the particular context in which the project will be undertaken: only then will be it possible to understand the influence of Eudoxos on the teaching and learning process in each classroom.

The report should include clear and direct information about those at the centre of the project (students and teachers), in a way that anyone unconnected with the centre could get an overall idea of the characteristics and peculiarities of that centre. It would be fundamental for the report to include the answers to three main questions:

Who are we?
Where are we?
What do we do?

Below we offer you some categories of analysis which will point you in the right direction in the production of the report. However, you should feel completely free to highlight those aspects which you believe to be the most unique and idiosyncratic with regards to your school.

**WHO ARE WE AND WHERE ARE WE?**
**GENERAL CHARACTERISTICS OF THE CENTRE**

- Brief presentation
- Analysis of the immediate environment (characteristics of the population, where the centre is located, etc.)
- Socio-cultural and economic characteristics of the school
- Organisational structure of the centre
- Educational aims
- Pedagogical principles

**WHAT DO WE DO?**
**TEACHING STYLE ETC OF THE STAFF INVOLVED IN THE PROJECT**

- Methodology
- Most frequent activities
- Structure of lessons
- Space and time management of classes
- Resources used (laboratories, computers, access to the Internet, etc.)
- Evaluation

**CHARACTERISTICS OF THE STUDENTS INVOLVED IN THE PROJECT**

- Number of students
- Age
- Level of previous knowledge related to the content included in the project
- Learning styles that usually operate: rote-learning, collaborative learning, research projects, problem solving, individual work vs. team work, etc.
- Familiarity with the use of computers and the Internet in the school as a learning resource.

We propose that, to complement the report, you include photos of the centre , of the classrooms, of diverse everyday educational situations when students interact with teachers, students' ways of working, resources used in activities, spatial organisation of classrooms, work dynamics, etc. When producing the report it would be useful to describe and analyse the situations that have been photographed.

This report should be translated into English and will be fundamental in the overall evaluation process. It will constitute a basic reference document when producing the final report. If the external evaluators need any further information, this report will be complemented by on line interviews using open questions to focus on points that remain unclear or have not been answered.

**2nd Phase: Evaluation during the process of Implementation of the project**

At the same time as the implementation of the project in the classroom, the collection and analysis of information for the evaluation will take place. To do this the proposed tools will be used: Teachers' Diaries, Students' Portfolios, and Inter-School Collaboration Journals.

It is important that a good flow of communication is maintained between the coordinators, the external evaluators and the participants in the schools (teachers and students). The University of Cadiz will supervise this whole process, noting information which may be relevant to the final report.

**3rd Phase: Production of Summary Documents**

In this phase, each school will analyse the information collected by each one of the evaluation tools (Diaries, Portfolios and Collaboration Journal), and produce a summary of each one. Each school will produce the following documents:

Summary of the Teachers' Diaries
Summary of the Students' Portfolios

The Summary of the Teachers' Diaries should include those aspects which the teacher considers fundamental to the understanding of the process that has gone on in the classroom. Similarly, it is important that recommendations are made.

The Summary of the Students' Portfolios must be a document in which the teachers and students include the most significant materials, student work, general sequence of activities, opinions, suggestions, etc. The selection of this material must be carried out by both the teachers and students.

The summaries from each school (12 summaries in total) will be translated into English, and will constitute the basic source of documentary evidence for the production of the Final Report by UCA.

**4th Phase: Final Report**

UCA will produce a final report using the information obtained from the summaries and the notes made throughout the whole process (fora, meetings,) etc.

We propose that each participating school receives a copy of the Evaluation plan (once the draft has been agreed) in English and that the worksheets to carry out the contextualisation and the evaluation tools (Teachers' Diaries, Students' Portfolios and Inter-School Collaboration Journal) are translated into the languages of the four participating schools (Greek, German, Italian and Spanish).

## COMMENTS WITH RESPECT TO THE WORK PLAN

WP.5, covering Evaluation, has undergone significant changes in this Evaluation proposal. The Evaluation timetable would therefore be structured in the following manner:

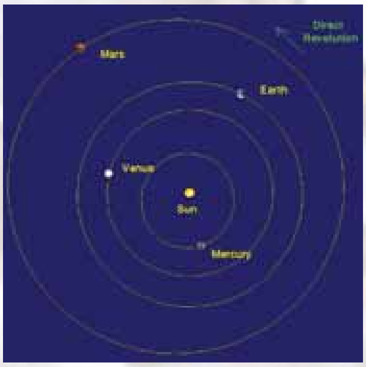
| WORKPLAN OF THE PROJECT | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WP | ACTIVITY | 2003 | | | 2003 | | | | | | | | | | | | 2004 | | |
| WP5 | Evaluation | O | N | D | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M |
| 5.1 | Development of the research plan | ■ | ■ | ■ | | | | | | | | | | | | | | | |
| 5.2 | Draft Evaluation proposal | | | | ■ | ■ | | | | | | | | | | | | | |
| 5.3 | Exchange detailed information about the participants (1st Phase) | | | | | | ■ | | | | | | | | | | | | |
| 5.4 | Evaluation during Implementation (2nd Phase) | | | | | | | ■ | ■ | ■ | | | | ■ | ■ | ■ | | | |
| 5.5 | Summaries (3rd Phase) | | | | | | | | | | | | | | | | ■ | ■ | |
| 5.6 | Final Report (4th Phase) | | | | | | | | | | | | | | | | | ■ | ■ |

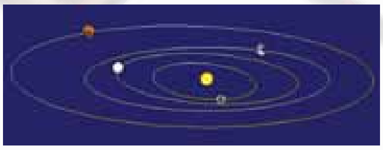
# Appendix

## A.1 The Solar System

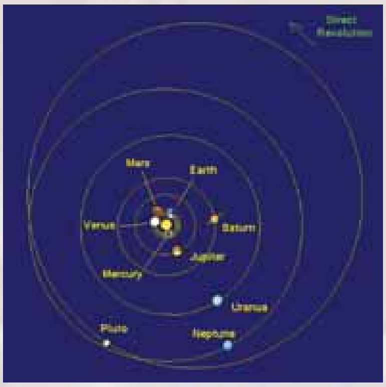
The solar system consists of the Sun; **the nine planets, over 100 satellites** of the planets, a large number of small bodies (the **comets** and **asteroids**), and the interplanetary medium (There are also many more planetary satellites that have been discovered but not yet officially named).

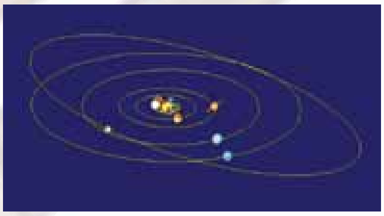
The **inner** solar system contains the **Sun, Mercury, Venus, Earth** and **Mars:**



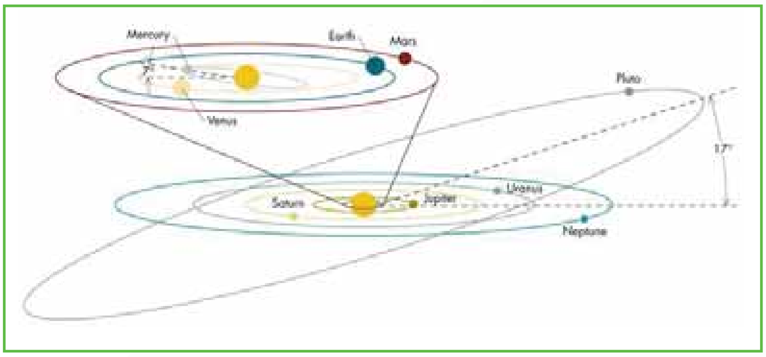
The planets of the **outer** solar system are **Jupiter, Saturn, Uranus, Neptune** and **Pluto:**



**The orbits of the planets**

The **orbits** of the planets are **ellipses** with the Sun at one focus, though all except Mercury and Pluto are very nearly circular. The orbits of the planets are all more or less in the same plane (called the **ecliptic** and defined by the plane of the Earth's orbit). The ecliptic is inclined only 7 degrees from the plane of the Sun's equator. Pluto's orbit deviates the most from the plane of the ecliptic with an inclination of 17 degrees.

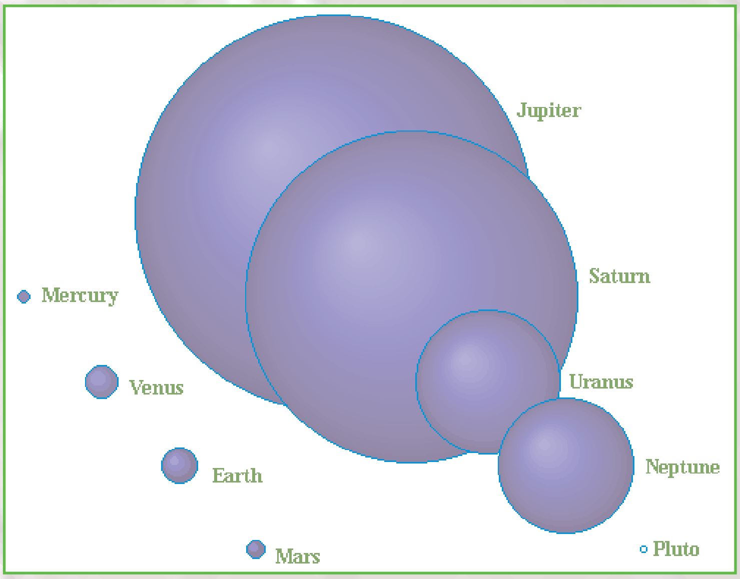


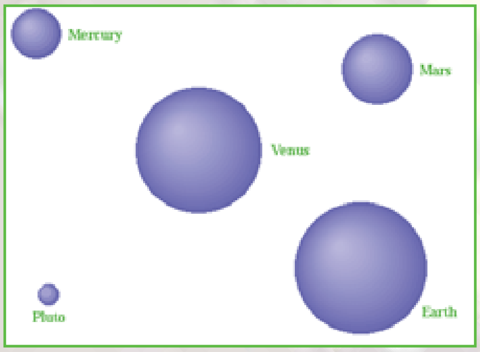

The above diagrams show the relative sizes of the orbits of the nine planets.

**The relative sizes of the planets**

One way to help visualize the relative sizes in the solar system is to imagine a model in which it is reduced in size by a factor of a billion (109). Then the Earth is about 1.3 cm in diameter (the size of a grape). The Moon orbits about a foot (~30.5 cm) away. The Sun is 1.5 meters in diameter (about the height of a man) and 150 meters (about a city block) from the Earth. Jupiter is 15 cm in diameter (the size of a large grapefruit) and 5 blocks away from the Sun. Saturn (the size of an orange) is 10 blocks away; Uranus and Neptune (lemons) are 20 and 30 blocks away. A human on this scale is the size of an atom; the nearest star would be over 40000 km away.

The following composite shows the nine planets with approximately correct relative **sizes.**




Traditionally, the solar system has been divided into **planets** (the big bodies orbiting the Sun), their **satellites** (moons, variously sized objects orbiting the planets), **asteroids** (small dense objects orbiting the Sun) and **comets** (small icy objects with highly eccentric orbits). Unfortunately, the solar system has been found to be more complicated than this would suggest:

- there are several moons larger than Pluto and two larger than Mercury;
- there are several small moons that are probably captured asteroids;
- the Earth/Moon and Pluto/Charon systems are sometimes considered "double planets".

**Classification of the planets**

The nine bodies conventionally referred to as planets are often further classified in several ways:

- By size:
    - **Small** planets: Mercury, Venus, Earth, Mars and Pluto
      The small planets have diameters less than 13000 km
    - **Giant** planets: Jupiter, Saturn, Uranus and Neptune
      The giant planets have diameters greater than 48000 km
    - Mercury and Pluto are sometimes referred to as **lesser** planets (not to be confused with **minor planets** which is the official term for asteroids)
    - The giant planets are sometimes also referred to as **gas giants**
- By position relative to the Sun:
    - **Inner** planets: Mercury, Venus, Earth and Mars
    - **Outer** planets: Jupiter, Saturn, Uranus, Neptune and Pluto
    - The asteroid belt between Mars and Jupiter forms the boundary between the inner solar system and the outer solar system
- By position relative to Earth:
    - **Inferior** planets: Mercury and Venus
      Closer to the Sun than Earth
      The inferior planets show phases like the Moon's when viewed from Earth
    - **Earth**
    - **Superior** planets: Mars thru Pluto
      Farther from the Sun than Earth
      The superior planets always appear full or nearly so

**Statistical information for the Solar System**

The Sun contains 99.85% of all the matter in the Solar System. The planets, which condensed out of the same disk of material that formed the Sun, contain only 0.135% of the mass of the solar system. Jupiter contains more than twice the matter of all the other planets combined. Satellites of the planets, comets, asteroids, meteoroids, and the interplanetary medium constitute the remaining 0.015%. The following table is a list of the mass distribution within our Solar System.

- Sun: 99.85%
- Planets: 0.135%
- Comets: 0.01%
- Satellites: 0.00005%
- Minor Planets: 0.0000002%
- Meteoroids: 0.0000001%
- Interplanetary Medium: 0.0000001% ?

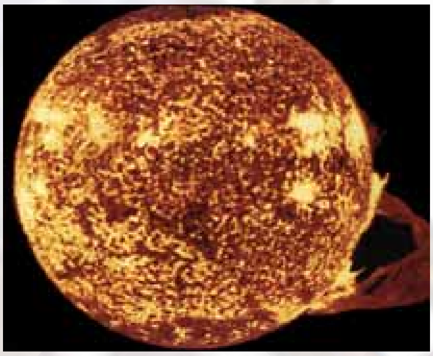
| Name | Distance (au) | Radius (Earth's) | Mass (Earth's) | Rotation (Earth's) | # Moons | Obliquity | Density ($g/cm^3$) |
|---|---|---|---|---|---|---|---|
| Sun | 0 | 109 | 332.800 | 25-36 | 9 | --- | 1.410 |
| Mercury | 0.39 | 0.38 | 0.05 | 58.8 | 0 | 0.1° | 5.43 |
| Venus | 0.72 | 0.95 | 0.89 | 244 | 0 | 177.4° | 5.25 |
| Earth | 1.0 | 1.00 | 1.00 | 1.00 | 1 | 23.45° | 5.52 |
| Mars | 1.5 | 0.53 | 0.11 | 1.029 | 2 | 25.19° | 3.95 |
| Jupiter | 5.2 | 11 | 3.18 | 0.411 | 16 | 3.12° | 1.33 |
| Saturn | 9.5 | 9 | 95 | 0.428 | 18 | 26.73° | 0.69 |
| Uranus | 19.2 | 4 | 17 | 0.748 | 15 | 97.86° | 1.29 |
| Neptune | 30.1 | 4 | 17 | 0.802 | 8 | 29.56° | 1.64 |
| Pluto | 39.5 | 0.18 | 0.002 | 0.267 | 1 | 119.6° | 2.03 |

| Name | Magnitude | Radius (km) | Mass (kg) |
|---|---|---|---|
| Sun | -26.8 | 697000 | $1.99 \times 10^{30}$ |
| Moon | -12.7 | 1738 | $7.35 \times 10^{22}$ |
| Venus | -4.4 | 6052 | $4.87 \times 10^{24}$ |
| Jupiter | -2.7 | 71492 | $1.90 \times 10^{27}$ |
| Mars | -2.0 | 3398 | $6.42 \times 10^{23}$ |
| Mercury | -1.9 | 2439 | $3.30 \times 10^{23}$ |
| Saturn | -0.7 | 60268 | $5.69 \times 10^{26}$ |
| Uranus | 5.5 | 25559 | $8.69 \times 10^{25}$ |

| Name | Magnitude | Maximum Elevation (degrees) | Observing Time (hours) |
|---|---|---|---|
| 522 Helga | ~14.4 | ~40 (mid-May) | 5½ |
| 699 Hela | 13.5~15.0 | ~30 (mid-May) | 6 |
| 841 Arabella | ~15.5 | ~30 (spring) | 9 |
| 1250 Galanthus | ~15.6 | 12 (1-15 June) | ??? |
| 1368 Numidia | 14.0~15.0 | ~35 (mid-April) | 4 |
| 1727 Mette | 15.0~16.0 | ~85 (end of March) | 10 |
| 4979 Otawara | 15.4~16.0 | ~29(1-10 June) | ??? |

# Images

Milky Way



Sun

Mercury

Venus

Earth

Mars

Jupiter

Saturn

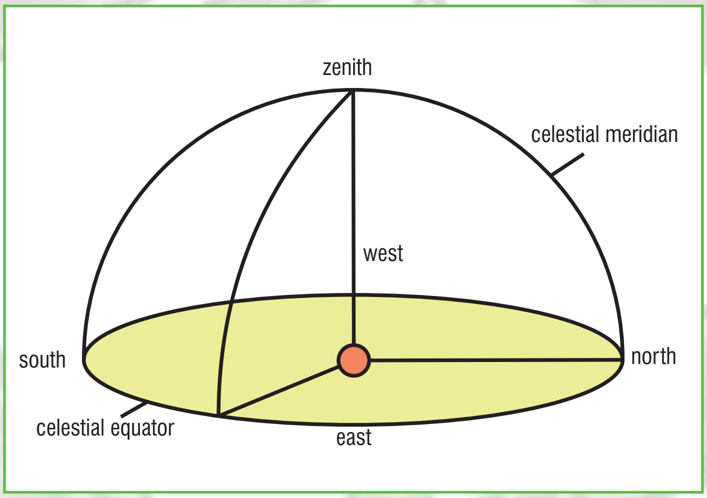
Uranus

Neptune

Pluto

# A.2 Celestial Coordinates

**Celestial Sphere:** The celestial sphere is an imaginary shell of infinite radius, centered on the observer. This concept is useful for determining positions in the sky.




**Zenith:** This is the point in the sky directly above the observer.

**Celestial Poles:** As the Earth rotates, the sky appears to rotate around two points in the sky, one aligned with the geographic North Pole, and the other aligned with the geographic South Pole. These two points are the north celestial pole and the south celestial pole. The north celestial pole can be seen in the Northern Hemisphere, and currently is very close to the star Polaris.

**Celestial Equator:** This is a great circle on the celestial sphere that is in the same plane as the Earth's equator. It is 90 degrees from each celestial pole, so it is directly halfway in between them. To a person standing on the Earth's equator, the celestial equator would appear to pass through their zenith.

**Celestial Meridian:** This is a great circle passing through the celestial poles and the observer's zenith.
Ecliptic: The path of the sun in the sky.

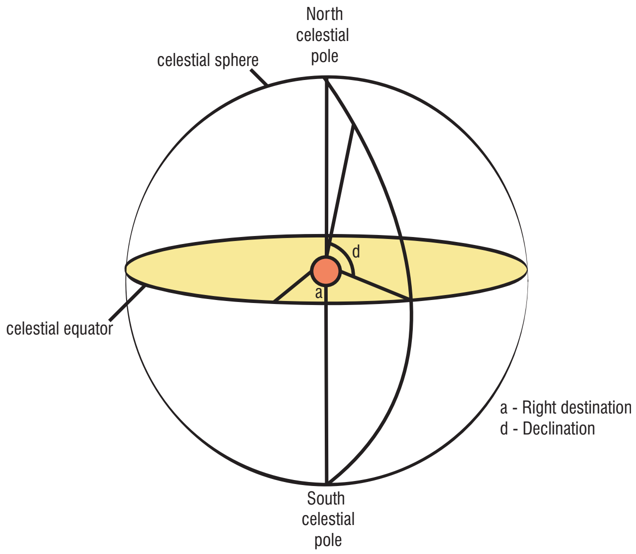
**Vernal Equinox:** This is one of the two points on the celestial sphere where the celestial equator and the ecliptic intersect. The vernal equinox marks the first day of spring. The autumnal equinox is the other point, and it marks the first day of autumn.

**Summer Solstice:** This is the northernmost excursion of the Sun along the ecliptic. The summer solstice is the longest day of the year. The southernmost excursion is the winter solstice.

**Hour Circle:** A great circle on the celestial sphere running north and south through the celestial poles.

**Hour Angle:** This is measured westward along the celestial equator from the local celestial meridian to an object's hour circle. 15 degrees in arc units equals 1 hour in time units, because it takes an object one hour to apparently move 15 degrees across the sky.

**Equator System:** This is a coordinate system attached to the celestial sphere itself, using right ascension and declination to notate the positions of celestial objects.




**Right Ascension:** The arc distance measured eastward along the celestial equator from the vernal equinox to the hour circle of the star; comparable to longitude.

**Declination:** The arc distance from celestial equator either north or south to the star, along the hour circle given by right ascension; comparable to latitude.

**Epoch:** This is the time frame for which the object's coordinates are valid. The star's apparent coordinates change with time, because of precession and proper motion, so it is necessary to know the time for which the given coordinates are precise.

**Sidereal Day:** This is the time required for the Earth to make a complete rotation with respect to the vernal equinox. This is slightly shorter than a solar day, which is the period of the Earth's rotation with respect to the Sun. The local day begins (00h 00m 00s) when the vernal equinox is on the celestial meridian. The sidereal day is 23 hours, 56 minutes, and 4.1 seconds long.

**Sidereal Time:** Official sidereal time is the day beginning at the hour angle of the vernal equinox. Star positions are given using this sidereal time. The position of a star with respect to the observer's meridian is then related to the sidereal time.

**Ephemeris Time:** A time system based on dynamics, and which, unlike the other time systems, has an invariable rate. The beginning of ephemeris time (0 days, 12 hours) was near the beginning of 1900 when the Sun's longitude was 279 degrees 41 minutes 48.04 seconds. The ephemeris second, ephemeris day, etc. are defined at having specific, unchanging lengths.

# A.3 Exposure Times for imaging observations

A short tutorial on imaging observations: With the 0.62m "Andrew Michalitsianos Telescope" (TAM), (as we do with any other telescope), we collect light from various objects and entities in the Universe. This light has been coded with and thus conveys, most of the available information about the physical properties of its source. The light collected by the telescope is subsequently processed by auxiliary optical systems to reveal some of the information it contains, and eventually arrives to a sensor producing a Signal. In all experiments of the EUDOXOS Basic Curriculum, the sensor used to detect the celestial light from the source of our interest, is a CCD. The CCD (Charge Coupled Device) is a two dimensional array (or 'mosaic') of small detectors (photosensitive pixels) on which the optical system re-directs the light collected by the telescope, in the following manner: Any distant celestial source (like stars which are located at infinity) produces a parallel beam of light which is made to converge on a localized area in the CCD containing a few pixels. The position of this area on the CCD mosaic can be deterministicaly related with the direction of the source in the sky. By reading and adding together the signal (charge) created in each of those pixels [because of the interaction of the incoming light with the pixel material (Si crystal)] we get a number (called "ADU") which in first approximation is proportional to the true brightness of the source.

Exposure is the amount of time we permit the light from the targeted astronomical object, to impinge on our detector, the CCD. CCDs, like photographic films, are integrating sensors. This means that as more light continue to fall on the sensor, new signal continues to be produced, which is added to whatever amount had been produced in the past.

Note that the process of detection of light is for simplicity a two-stage one (see the animation, http://knidos.snd.edu.gr/telescope/E-Exposur.html):

1$^{st}$ Stage: we let the pixels of the CCD to be exposed to the celestial light ("EXPOSE")
2$^{nd}$ Stage: we read the recorded signal in the exposed pixels (grey ones) ("READOUT")

With photographic film the signal that has been built on the sensor is permanent and there is no way to force the latter back to its original condition -i.e. when no light had fallen on it (this is why for every photograph we shoot we need to use a new piece of film). However with CCDs the recorded image is stored on the CCD chip electronically and can be erased very easily, so that the same CCD can be used over and over again.

As outlined above, the main property of an integrating sensor is that it will build more and more signal with time, as more and more light falls on it. This allows such sensors to detect faint light sources provided they are illuminated for a prolonged time (exposure). The concept is reminiscent of photography, when bright light illuminates the scene e.g. on a sunny day, then one needs to expose the film for a very short time interval (usually one uses the fastest shutter speed on the camera maybe something like 1/1000s). However when the scene is not very well illuminated e.g. on the afternoon, one would need to make much longer exposures (slow speeds like 1/15s), else the photograph will turn out to be dark and noisy, or even, there might be no image recorded at all! The same principle applies also to CCDs. Thus we need to expose long enough to record a good signal. The above consideration is translated to the following rule: short exposures are enough for bright objects and longer ones are necessary for fainter ones, and the fainter the object the longer the exposure that is needed.

On the other hand both film and CCD will reach saturation at some point. This means that no more signal can be effectively stored on the sensor, and therefore any additional signal produced is lost forever! Thus, the sensor has reached its brightest "white" level possible and any additional signal (from light) is simply clipped to "white" on the final image. For example, this is what happens when some part of a scene is overexposed on a photograph, and everything there turns out to be a featureless white. The same phenomenon can happen with a CCD, but with CCDs there is also the phenomenon of "blooming", i.e. when too much charge is stored on a pixel, it can start bleeding up and down contaminating the neighboring pixels! This obviously destroys the information stored in other pixels and must be avoided.

Furthermore, as it becomes clear from the above discussion, the observer must carefully determine the proper exposure time to get the best results. With astronomical objects, since most are inherently faint, it's true that the longer the exposure the better, provided -of course- we are away from saturation. However, it is always desirable to use as short exposures as possible, for many reasons: Among other things (like better time-sampling of any brightness variations of the source), we can optimally exploit the telescope time available (reduce the time engagement of the telescope to achieve a certain photometric measurement), and also avoid problems with the telescope tracking (possible enlogation of point source images spreading light in such a way which is difficult to be handled in the subsequent analysis of the CCD frame by software), or even random events like wind bursts which could shake the telescope and ruin the image!

This raises the question: what is the shortest exposure I can use on an object to get a good result? The answer to this probably varies depending on the type of observation we want to do. The most usual is the making of some photometric measurement on stars of interest within the image. This implies an experimental prerequisite: we need these stars to have a good signal-to-noise ratio (S/N), i.e. we need to have a Signal (=response of the detector to the light from the source/object) that is well above the Noise background (= responses of the detector system, not due to the light from the observed source/object), in order to make precise measurements. A rule of thumb is to have S/N=100, or something like that, which would eventually lead to a precision in the measurement of brightness of the order of 0.01mag (surpassing the requirements of most observational exercises of the Educational Curriculum of EUDOXOS).

According to the discussion above, to get a S/N ratio of that order, we need to expose the CCD for an appropriate period of time. Recall that our Signal is increased with exposure time, as more and more signal (charge) is built (accumulated) on the sensor. However, the superposed result of the presence of several noise sources (producing unwanted "signals"), ) is increased as well and the increase of S/N is usually not linear with exposure time. Using a first approximation we can (in most cases -time intervals) assume a square root relation:

$$S/N \propto \sqrt{T} \xrightarrow{S \propto T} S/N \propto \sqrt{S}$$

and the Pogson law (relating brightness measurements (S) to the traditional “magnitude” system (m)) of:

$$m_1 - m_0 = -2.5 log(s_1/S_0)$$

From the above relations we can deduce a conclusion: to increase the signal-to-noise ratio by a factor of 10 we would need to increase the exposure time (i.e. increase the signal) by a factor of 100! Or, equivalently, we could state that with a certain exposure time two stars (=point sources) would have to have a 5mag difference in brightness for their S/N ratio to differ by a factor of 10.

**Example Exercise**

*Given that on a CCD image taken with 4sec exposure time, a 14.5mag star exhibits S/N=200, what is the minimum exposure that we need to use in order to make photometry on a 17.0mag star?*

***Solution:***

Since we want to make precise photometry it would be desirable to have a S/N=100 at least. Therefore we need to find out how much we have to increase the exposure time in order to obtain this S/N ratio.

Since the 14.5mag star has S/N=200 at 4sec exposure, a 17.0mag is 10 times less bright (17mag-14.5mag=2.5mag or S1/So=1/10), and therefore would have a signal-to-noise of:

$$S/N = \frac{200}{\sqrt{10}} = 63.2$$

but we need S/N=100, i.e a factor of 100/63.2=1.58 improvement on S/N. Therefore we should increase the exposure time by the square of that factor, ie:

$$t = 4sec \cdot (\frac{100}{63.2})^2 = 10sec$$

Here is a useful table to help you make reasonable decisions on the determination of Exposure Times. Use it to eliminate the possibility of submitting inappropriate Observing Request which will return scientifically useless images and sacrifice valuable telescope time resources:

TABLE: Recommended Exposure Times for Eudoxos' Telescope "Andreas Michalitsianos"

| Object Brightness (mag) | Exposure Time (seconds) |
|---|---|
| 12 | 2 |
| 14 | 5 |
| 16 | 15 |
| 18 | 60 |
| 19 | 120 |

# References

Angulo Rasco, J. F. (1995) La evaluacion del sistema educativo: algunas respuestas criticas al porque y al como, en Volver a pensar la educacion (Vol.II), Congreso Internacional de Didactica. Madrid: Morata.

Angulo Rasco, J. F. (2003) Tellecolaborative Curriculum Project. Propuesta de Grupo LACE para MOFTAL Minerva Project.

Aviram A. (1993). International Review of Education 39, p. 419-433

Baumert, J., Lehmann, R., Lehrke, M., Schmitz, B., Clausen, M., Hosenfeld, I., Koller, O. & Neubrand, J. (1997). TIMSS - Mathematisch-naturwissenschaftlicher Unterricht im internationalen Vergleich, Opladen: Leske + Budrich.

Berlak, H. (1992) "The need for a New Science of Assessment", en H. Berlak, F. M. Newmann, E. Adams, D.A. Archbald, y cols. (Comp.) (1992) Toward a New Science of Educational Testing Assessment. Albany, N. Y. State University of New York; pags.1-21.

Bourdieu, B. & Passeron, J-C. (1977). Reproduction in Education, Society and Culture. London: Sage.

Britain, S. & Liber, O. (1999). A Framework for Pedagogical Evaluation of Virtual Learning Environments. JTAP reports. http://www.jtap.ac.uk/reports/htm/jtap-041.html.

Broadfoot, P. (1983) "Evaluation and the Social Order in Advanced Industrial Societies: the Eductional Dilemma" International Review of Applied psychology, Vol. 32: 307-325.

Broadfoot, P. (1986) "Assessment Policy and Inequality: The United kigdom Experience" British Journal of sociology of Education, Vol. 7, N? 2: 205-224.

Broadfoot, P. (Comp.) (1984) Selection, Certification & Control. Social Issues in Educational Assessment. London. The Falmer Press.

Broadfoot, P., Murphy, R. y Torrance, H. (Comp.) (1990) Changing Educational Assessment. International Perspectives and Trends. London. Routledge.

Bruner, J. (1966). Toward a theory of instruction. Cambridge, Mass: Belknap Press.

Bruner, J. (1986). Actual Minds, Possible Worlds. Cambridge, Mass.: Harvard University Press.

Bruner, J. (1990). Acts of Meaning. Cambridge, Mass: Harvard University Press.

Chickering, Gamson, Z., & Barsi, (1987) Seven Principles for Good Practice in Undergraduate Education.: American Association for Higher Education.

Cunningham, D., Duffy, T.M. & Knuth, R. (1993). Textbooks of the future. In C. McKnight (Ed.), Hypertext: A psychological perspective. London: Ellis Horwood Publishing.

Daloz, I.A. (1986). Effective Teaching and Mentoring. Josey-Bass publishers.

Darling-Hammond, L. (2001) El derecho de aprender. Crear buenas escuelas para todos. Barcelona: Ariel.

Dewey, J. (1916). Democracy and education. New York: The Free Press.

Fischer, H. E. (1993). Framework for conducting empirical observations of learning processes. Science Education, 77(2), 131-151.

Gipps, C. (1994) Beyond Testing. Toward a theory of educational assessment. The Falmer Press. London.

Gokhale, A. A. (1995). Collaborative learning enhances critical thinking. Journal of Technology Education, 7(1), http://scholar.lib.vt.edu/ejournals/JTE/jte-v7n1/gokhale.jte-v7n1.html

Good, T. L. and Brophy, J. E. (1997) Looking in classrooms. United States: Longman.

Gould, S.J. (1984) La falsa medida del hombre. Barcelona: Antoni Bosch.

House, E.R. (1980) Evaluating with validity. London: Sage.

Kushner, S. (2000) Personalizing Evaluation. London: Sage.

Lepper, M.R. and Cordova, D.I. A desire to be taught: Instructional Consequences of Intrinsic Motivation, Motivation and Emotion, 16(3), 187-208, 1992

MacDonald, B.(1987) Evaluation and the control of education, en Murphy , R. And Torrance, H. (Eds.) Issues and Methods in Evaluation. London: Paul Chapman.

Madaus, G. F. (1988a) "The distortion of teaching and Testing: high-stakes Testing and Instruction", Peabody Journal of Education, Vol. 65, n? 3, pags. 29-46.

Madaus, G. F. (1988b) The Influence of Testing on the Curriculum, en TANNER, L. N. (Comp.) (1988a) Chicago. 87th Yearbook of the National Society for the Study of Education. The NSSE: 83-121.

Norris, N. (1990) Understanding Educational Evaluation. London: Kogan Page.

Porlan, R. y Martin, J. (1996) El diario del profesor. Un recurso para la investigacion en el aula. Sevilla: Diada.

Quinn, C.N., Engaging Learning, ITFORUM paper, www.tech1.coe.uga.edu/itforum/paper18/paper18.html

Wilson, B. G. (1996). What is a constructivist learning environment? In: B. G. Wilson (ed),. Constructivist Learning Environments. Case Studies in Instructional Design. Englewood Cliffs, New Jersey: Educational

Solomos et al (1999), Eudoxos Project Proposal, SEPPE No 19, Greek Pedagogical Institute.

Solomos et al (2001), Eudoxos Project Final Report, SEPPE No 19, Greek Pedagogical Institute.

Xiaodong et al (1995). Instructional design and development of learning communities: An invitation to a dia-logue. In: B. G. Wilson (ed),. Constructivist Learning Environments. Case Studies in Instructional Design. Englewood Cliffs, New Jersey: Educational, p.203-222.

http://learnweb.harvard.edu/alps/tfu/info1b.cfm (ALPS Teaching for Understanding: A Deeper Look at Understanding).

The Nine Planets, http://www.nineplanets.org

Views of the Solar, http://www.solarviews.com

## RECOMMENDED READING ABOUT EVALUATION:

MacDonald, B. (1987) Evaluation and the control of education, in Murphy, R and Torrance, H (Eds) *Issues and Methods in Evaluation*, London: Paul Chapman

House, E.R. (1980) *Evaluating with Validity* London: Sage

Norris, N. (1990) *Understanding Educational Evaluation* London: Kogan Page

Kushner, S (2000) *Personalising Evaluation* London: Sage

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