The Role of Astronomy in Society and Culture
Proceedings IAU Symposium No. 260, 2009
D. Valls-Gabaud & A. Boksenberg, eds.

doi:10.1017/S1743921311003103

"Astrophysique sur Mesure", E-learning in Astronomy and Astrophysics

Benoît Mosser, Audrey Delsanti[1], Damien Guillaume[2], Christian Balança[3] and Chantal Balkowski[4]

[1]LESIA, Observatoire de Paris,
CNRS, Université Pierre et Marie Curie, Université Denis Diderot, Observatoire de Paris,
92195 Meudon cedex, France
email: benoit.mosser@obspm.fr, email: audrey.delsanti@obspm.fr

[2]UFE, Observatoire de Paris, 92195 Meudon cedex, France
email: damien.guillaume@obspm.fr

[3]LERMA, Observatoire de Paris, 92195 Meudon cedex, France
email: christian.balanca@obspm.fr

[4]GEPI, Observatoire de Paris, 92195 Meudon cedex, France
email: chantal.balkowski@obspm.fr

Abstract. "Astrophysique sur Mesure" (astrophysics made-to-measure) is a set of e-learning programmes started 4 years ago at the Paris Observatory. In order to deliver attractive and efficient programmes, we have added many multimedia tools to usual lectures: animations, Java applets. The programmes are presented on two different platforms. The first one offers the content of all the lectures in free access. A second platform with restricted access is provided to registered students taking part in the e-learning program and benefiting from the help of tutors. The development of these programs helps to increase the sphere of influence of astronomy taught at the Paris Observatory, hence to increase the presence of astronomy in various degree courses. Instead of teaching classical astronomy lectures to a happy few, we can bring astronomy and astrophysics to a wider audience.

Keywords. E-learning, tutoring, xml editor JAXE

1. Introduction

Since 2001, the Paris Observatory has developed a large e-learning program. We explain in this paper why and how we managed its development. The context of teaching at the Observatory helps to define the reasons that lead us to promote e-learning. The Paris Observatory has the status of a "Grand Établissement", which means that it is equivalent to a small University (about 40 FTE faculty members). Courses are delivered from the primary school level to the graduate level. At the primary school level, our actions consist mainly of the tutoring of astronomy projects in primary or secondary classes, and courses for teacher training. On the other side, the Paris Observatory is the head of the doctoral program in Astronomie & Astrophysique in Île-de-France, and proposes graduate studies in connection with the Parisian Universities.

The Paris Observatory plays an important and uniting rôle since it represents one third of all astronomy research in France. Since astronomy is not taught in many French Universities, despite the need for scientific courses for many different audiences, the sphere of influence of the Paris Observatory extends beyond the Île-de-France (the region surrounding Paris). As is it practically impossible to deliver courses everywhere they are needed, and also impossible to develop specific courses for each unique requirement, we decided in 2001 to develop e-learning courses.

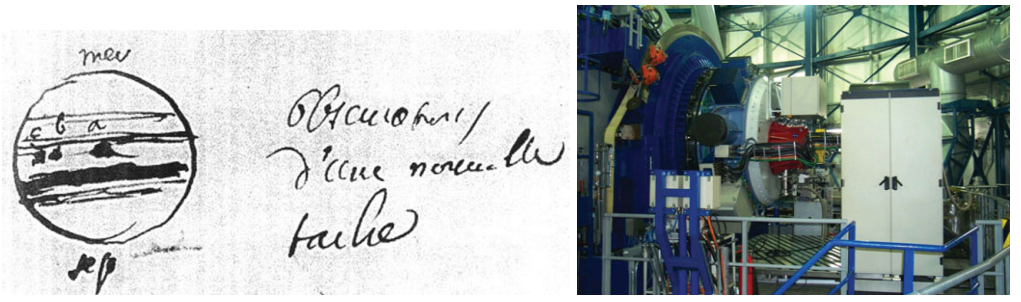

Figure 1. Samples of the large variety of the iconographic material presented in the "Astrophysique sur Mesure" programs. *Left:* New spot discovered on Jupiter by Cassini in March 1684; *Right:* the adaptive optics instrument NAOS at the Nasmyth focus of a VLT telescope.

We present in Section 2 the pedagogical basis of the e-learning project in astronomy, and the multimedia choices and solutions developed for the projects. The pedagogical resources produced between 2001 and 2006 are exposed in Section 3: "Astronomie et Mécanique Céleste" (Astronomy and Celestial Mechanics) and "Fenêtres sur l'Univers" (Windows of the Universe). Section 4 deals with the use of these programs: it presents our e-learners, and the tutoring necessary for an efficient education. Further projects and developments are exposed in Section 5. In Section 6, we present a few remarks summing up our experience in e-learning.

2. E-learning in Astronomy and Astrophysics

During the IAU Symposium 260 on "The Role of Astronomy in Society and Culture", many talks have widely developed the many reasons explaining the large audience of astronomy. Astronomy and astrophysics are linked to numerous scientific areas: physics, chemistry, mathematics, engineering... They give access to science history and epistemology; thus, at the same time, astronomy and astrophysics border philosophy and arts.

When constructing the e-learning projects, we managed to take into account all these aspects. Since we benefit from the rich environment from a large collection of historical resources to the most complex technological developments (Fig. 1), we extensively make use of such materials to actively support the lectures. This helps to give a more complete view of astronomy, without any restrictions.

3. Resources

The "Astrophysique sur Mesure" project started in 2001, via the call for projects "Campus numériques" (Digital Universities), initiated by the Ministry of National Education and the Ministry of Higher education and Research. This funding allows us to setup a specific multimedia engineering unit. The main role of this unit is to provide assistance for the development of digital resources in astronomy.

We chose to develop the e-learning project in the same way we develop large scientific observational projects. This helped us to avoid errors, such as choosing inappropriate multimedia tools.

3.1. *Technical Specifications*

The technical choices were based on XML and the separation of presentation and content. Previous projects have shown that maintenance is very costly when authors use HTML

https://doi.org/10.1017/S1743921311003103 Published online by Cambridge University Press

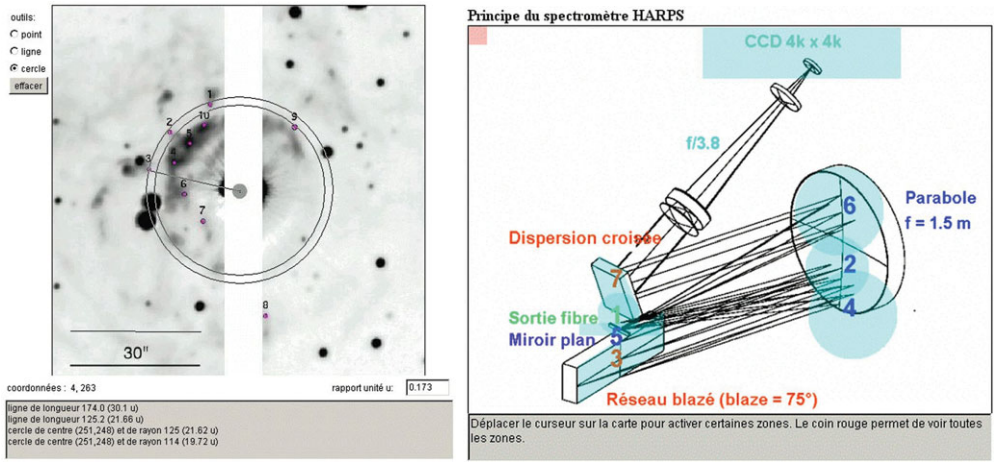

Figure 2. Example of JAVA applets developed by the multimedia unit. *Left:* analyzing an astronomical image (circumstellar environment of the cepheid RS Pup observed by Kervella *et al.* 2008); *Right:* understanding a scheme or an image (optical scheme of the HARPS spectrometer dedicated to very high precision radial velocity measurement, Pepe *et al.* 2003).

to create courses : the mix of content and presentation markup makes separate changes in either of these areas much harder. The use of CSS can help alleviate these problems with the definition of classes for document parts, but XML goes much further. XML allows a complete independence between authored documents and HTML documents served on the web, thus permitting a reorganization of the contents. Using XSLT to transform XML documents into HTML, it is, for instance, possible to insert a table of contents on every page, as well as links to the previous or the next page, without using HTML frames or Javascript.

Another important choice was to let authors of online courses directly edit the contents. The traditional model, where authors create contents with a text processor and engineers create web pages with these contents, make updates difficult. In the rapidly evolving field of astronomy, contents can be outdated within a few years, and we did not have the human resources to keep processing large author contents manually every year.

Based on these choices, we knew that we needed a WYSIWYM (What You See Is What You Mean) XML editor with a simple graphic user interface. Unfortunately, it didn't exist at the time we started the project (and actually, choices are still very limited today): the only good XML editors were commercial and oriented towards computer scientists, not teachers. Since we had the skills to do it, we decided to create our own XML editor, together with our own XML language adapted to e-learning, and associated XSL stylesheets. We made our XML editor (Jaxe - JAva Xml Editor, `http://jaxe.sourceforge.net/`) available for free under an open-source license, so that other universities can use it to create online courses.

In the last 8 years, the contents and presentation of our websites have quickly evolved, in a way that would not have been possible if we had made other technical choices. The XML editor, while requiring an important software development, is now being used in other Universities, and even in private companies in completely different areas. The continued use of XML improves our interoperability with other universities. One of our courses was, for instance, transformed into a website with a very different look and navigation system than the one we use for a project in cooperation with another University: we just had to create a new stylesheet while reusing the same XML documents for

https://doi.org/10.1017/S1743921311003103 Published online by Cambridge University Press

the course contents. Since more and more universities use XML to create new courses (but not always with the same XML language), we have also created XSL stylesheets to transform courses between several XML languages. Transformations like these are only possible when documents separate presentation and content.

3.2. *Pedagogical Choices*

Following general recommendations for e-learning courses, we have chosen to do a presentation in short pages (usually no more than 2 screens).

For "Fenêtres sur l'Univers", we have followed the presentation in 5 sections derived from the program "Université en Ligne" (UEL, `http://www.uel.education.fr/consultation/presentation/index.html`). These sections are: 1) to observe 2) to learn 3) to simulate 4) to practice 5) to evaluate. Presenting first observations is specific to "Fenêtres sur l'Univers": we manage to introduce each new concept by raising a question based on observations. This section allows us to introduce the rich iconographic material available in astronomy. Of course, we use it as an attractive way to awaken the interest of the e-learners. Then, the classical section "To learn" gives the basis for answering the question.

For the section "To simulate", we have developed many generic and specific multimedia tools (Figure 2). We may note:

- A Java applet for presenting an image dynamically.
- An applet corresponding to a spreadsheet. Even if basic, this facility is very useful for presenting data, working with it, and drawing a curve from which parameters of a physical law can be inferred.
- An applet presenting an image of a portion of the sky with readable α and δ equatorial coordinates; a similar applet presenting any graph with readable coordinates.
- An applet for extracting information out of an image, such point locations or distances between to points.
- An applet for comparing cases, as a slide show.
- And many more applets devoted to specific subjects, such as black body radiation, Fourier transform spectrometry...

We have sound that such developments require a large amount of effort and close interaction between teachers and engineers.

Since interaction with the e-learners occurs through questions raised by exercises, the section "To practice" presents many exercises with on line solutions. These solutions are not delivered abruptly, but after a few steps aiming to help the e-learners. Multiple-choice questionnaires are also included.

Finally, the section "To evaluate" corresponds to short or long exercises without answers. At this stage, the e-learners can validate their education.

The presentation of "Astrophysique sur Mesure" makes use of the same tools, but in a more informal way. For both programs, we propose frequent updates of the material, in order to keep as close as possible to current research fields. An exercise based on a very recent publication motivates the e-learners efficiently.

3.3. *The Contents of "Astronomie et Mécanique Céleste" and "Fenêtres sur l'Univers"*

After a large effort to gather existing material and to produce new resources in close collaboration with a large number of partners (Universities Paris 6, 7, 11, Orléans, IUFM Midi-Pyrénées), two e-learning courses opened in 2006: "Astronomie et Mécanique Céleste" and "Fenêtres sur l'Univers". Their characteristics are presented in Table 1, and their web sites given in Table 2. Before being open to e-learning, the programmes have

https://doi.org/10.1017/S1743921311003103 Published online by Cambridge University Press

Table 1. Resources

"Astronomie et Mécanique Céleste" (AMC)	"Fenêtres sur l'Univers" (FsU)
Level: high school diploma, or college 1st year	Level: bachelor of science or master of science
L1	L2, L3, M1
Astronomy	Physics for astronomy
1 course	5 courses
1 year	1 or 2 semesters
University certificate	University certificate or ECTS: from 2 to 12 ECTS, depending on the module

ECTS = European credit transfer system.

Table 2. URL

E-learning @ Observatoire de Paris: `http://foad.obspm.fr/`	
"Astronomie et Mécanique Céleste"	
Information	`http://foad.obspm.fr/rubrique102.html`
Free access lecture website	`http://media4.obspm.fr/public/AMC/`
"Fenêtres sur l'Univers"	
Information	`http://foad.obspm.fr/rubrique89.html`
Free access lecture website	`http://media4.obspm.fr/public/FSU/`

Reminder: web sites are in French.

been tested with students at the Paris Observatory; they are still used as a support for classical lectures.

"Astronomie et Mécanique Céleste" presents a wide overview of astronomy dedicated to first year students in science. The program is organized in 6 main chapters: 1) From the Big Bang to Planets 2) Celestial Mechanics, Time and Calendars 3) Sun-Earth-Moon Phenomena (seasons, eclipses, etc) 4) the Sun 5) History of Astronomy 6) Practical Works. Figure 3 shows the homepage of "Astronomie et Mécanique Céleste".

"Fenêtres sur l'Univers" introduces astronomy through 3 chapters based on physical measurements: Time & Distance; Mass; Temperature. These chapters deal with subjects related first to astronomy and to the distance scale, second to dynamics and gravity, and third to the thermodynamics involved in stellar physics. A fourth chapter is dedicated to instrumentation, from the collection of the signal with telescopes to its detection after instrumental processing.

One special feature of "Fenêtres sur l'Univers" is European credits, at the Licence ($\simeq$ Bachelor) or Master level. This allows us to deliver an astronomy course to science students registered at any University where no such equivalent education is provided.

3.4. *Free Access Public Website and Student Website*

The programmes are implemented on the web on two different platforms. The first platform offers the content of all the lectures in free access to all internet users (Table 2). The corresponding website receives more than 50,000 visits per month. This large audience can be explained by the quality of its large and relatively unique content and its free access.

A second platform with restricted access is provided to registered students. It presents the same content as the one in free access, but includes more tools and facilities: a

https://doi.org/10.1017/S1743921311003103 Published online by Cambridge University Press

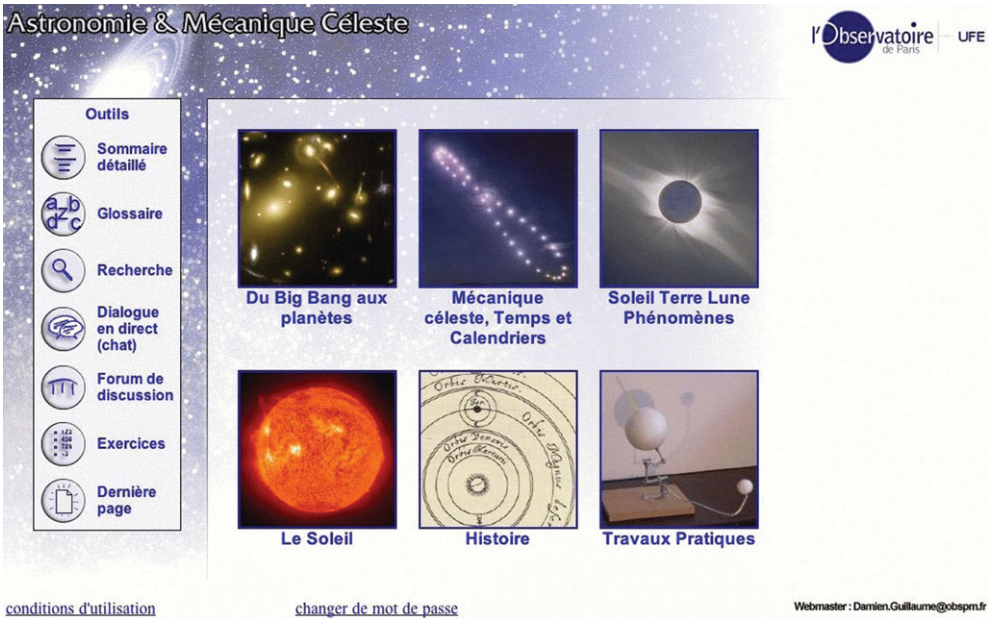

Figure 3. Homepage of the "Astronomie et Mécanique Céleste" programme.

forum for discussion, a research tool and on-line support. Last but not least, the student website provides the link between each learner and his/her tutor. Students and tutors are in regular contact throughout the term by email, and they interact through questions about the lecture and exercises that the students have to solve at the end of each chapter.

Information and conditions for registering are given online (Table 2).

4. Students and Tutoring

4.1. *Students*

Apart from students registered at a University, the major part of the registered learners are doctors, engineers, computer engineers, pilots, science teachers, scientific organizers, scientific journalists, or amateur astronomers. Therefore, "Astrophysique sur Mesure" plays an important role in continuing education. Most of the learners, even a few retired people, are involved in scientific/astronomy activities and wish to refresh their skills in science: "Astrophysique sur Mesure" participates largely in the mission of the Paris Observatory for the diffusion of scientific knowledge and public outreach. A significant fraction of the learners are located abroad: French Guyana, Algeria, Belgium, Cameroon, Italy, Morocco, Portugal, Sweden, Switzerland, Tunisia, USA...

4.2. *Tutoring*

Experience has shown that active on-line tutoring is necessary in order to keep the learners motivated (Sulcic & Sulcic 2007). We have therefore put a large effort into tutoring: instead of devoting many FTE to teach classical astronomy lectures to a happy few, we dedicated them to mentor many e-students. On-line tutors are astronomers or PhD students.

In order to enhance the motivation of the students, we propose a 1-day face-to-face lecture at the beginning of the term. This lecture provides the first contact with the pedagogical distinctive features of e-learning and with the tools of the multimedia

https://doi.org/10.1017/S1743921311003103 Published online by Cambridge University Press

environment. The contact between students and tutors is evidently a major ingredient of this introductory day, since we have verified that an efficient tutoring must be personalized: a 22-year old Masters student and a medical doctor have different motivations for attending the programs, and need different advice.

We meet the learners a 2nd time, for the validation of the certificate. The motivation for a successful examination plays an important role in e-learning. We take time at this occasion to discuss with the learners, in order to benefit from their experience. Their feedbacks are most often very similar: they report that learning on-line is first surprising, then very efficient with the great help of all the multimedia tools and the careful tutoring from their mentor.

Despite the active tutoring, more than 25% of the learners give up the program. The drop-out occurs very early in the training: learners register, pay the fees, but do not start to work. It seems in this case that the initial motivation rapidly disappears in front of web pages. In order to avoid this, we strongly recommend to everyone interested in our online education programmes to carefully explore the free access lecture website before registering.

5. Developments

5.1. *Projects*

The Paris Observatory takes part in two Thematic Digital Universities (Virtual University Environment and Sustainable Development, `http://www.uved.fr/`; On-line University for Science, `http://www.unisciel.fr/00-perso/index.asp`) and contributes to their developments. Giving our resources to these Universities allows us to give to a very larger number of students a coherent, relevant and high-quality set of lectures in astronomy and astrophysics.

The success met with "Astronomie et Mécanique Céleste" and "Fenêtres sur l'Univers" programs opens the way to further developments, for other degrees. A chapter "Mathematics and Astronomy" is in progress. Others contents will also be added, in collaboration with French astronomical institutes, to open "Astrophysique sur Mesure" to others subjects.

The many benefits of providing organized knowledge on a website are sufficient for motivating such developments. One of these byproducts is, for example, the development of high-value resources for Master and Doctorate students. They appreciate to have such resources available at any time.

We currently operate the translation of "Fenêtres sur l'Univers" into Spanish (Ventanas Al Universo), for further collaborations in South America.

5.2. *Continuing Education*

Since e-learning does not fulfil all the needs for continuing education, two courses at the Paris Observatory offer classical face-to-face lectures (`http://duop.obspm.fr/`, `?`): "Explorer et Comprendre l'Univers" (Exploring and Understanding the Universe) and "Structuration de l'Univers" (The Universe Structure).

"Explorer et Comprendre l'Univers" provides lectures from celestial mechanics to cosmology, each week at the Paris Observatory, and especially provides what e-learning cannot achieve: a 1-week lecture dedicated to images and spectra analysis and a 1-week session during the summer to practice observations at the Haute Provence Observatory. In the program "Structuration de l'Univers", lectures are given by the students, who prepare during all year long a dissertation under the supervision of an astronomer.

https://doi.org/10.1017/S1743921311003103 Published online by Cambridge University Press

6. Discussion

Based on our experience, we can propose the following statements:

- E-learning requires large investments at each stage: first, the creation of the platforms requires a large investment from the University (in teachers and engineers FTE, and with an efficient multimedia unit); second, when the site exists, its use requires an intensive tutoring effort; third, maintaining it technically and pedagogically requires also a continuing effort.
- E-learning is complementary to face-to-face lectures; at the Paris Observatory, e-learning allows us to extend our sphere of influence, and to reach learners who have no other opportunity to learn astronomy.
- E-learning appears to be an efficient way to promote and highlight existing resources (digital or non digital). On-line developments appears to be profitable to the 'classical' lectures.
- E-learning motivates the sharing of existing tools and resources (digital or non digital), and motivates the distribution of digital educational resources for free.
- For those who cannot attend a lecture because of distance, time or numerus clausus, e-learning provides efficient education: most of our students in that case are highly motivated, enjoy the courses, work hard on-line and succeed.

Acknowledgements

We would like to thank Françoise Roques, Director of the "Unité Formation Enseignement" of the Paris Observatory (Teaching Unit) who initiated the project in 2001. Her vision of e-learning was decisive to achieve these programs. We are grateful to Monique Vindevoghel, who introduced us in the program "Univsité en Ligne". The realizations would have been impossible without the efficient work achieved by the colleagues involved in the multimedia unit of the Paris Observatory: Gilles Bessou and Marie-France Landréa. BM wishes to thank Michèle Gerbaldi and Gilles Theureau for their active collaboration in the set up of "Fenêtres sur l'Univers". We warmly thank all the contributors and tutors, and Damien Guillaume for the managing of all the projects. We are also grateful to Sarah for the careful reading of the paper.

References

Kervella, P., Mérand, A., Szabados, L., Fouqué, P., Bersier, D., Pompei, E., & Perrin, G. 2008, *A&A* 480, 167

Pepe, F., Bouchy, F., Queloz, D., & Mayor, M. 2003, *Scientific Frontiers in Research on Extrasolar Planets*, 294, 39

Sulčič, V. & Sulčič, I., 2007. *Issues in Informing Science and Information Technology*, 4, 201