Discover the COSMOS: e-Infrastructure for an engaging Science classroom

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Abstract

Discover the COSMOS is a Coordination Action project (2011-2013) funded by the European Commission's Framework Programme 7 and composed of 15 universities, research institutes and centres in eight European countries and the USA. Its aim is to demonstrate innovative ways to engage teachers and students in science through the utilisation of existing e-Infrastructures. This should help to reverse the declining student interest in science and encourage more to follow scientific courses. Situated within current re-schooling initiatives in Europe and beyond, the project aims to help realise the vision for the science classroom of tomorrow by (a) demonstrating effective community building between researchers, teachers and students and empowering the latter to use, share and exploit the collective power of unique scientific resources in meaningful educational activities, that promote inquiry-based learning and appreciation of how science works, (b) demonstrating effective integration of science education with e-infrastructures through a monitored-for-impact use of e-Science activities and (c) documenting the process through the development of a roadmap that will include guidelines for the design and implementation of effective educational and outreach activities.

Tapping into expertise from frontier scientific and educational research in formal and informal science learning, the Discover the COSMOS initiative acts as a vehicle through which Europe's e-infrastructures can be fully exploited by providing powerful tools for the effective introduction of e-Science initiatives in the school science curriculum framed in a pedagogical approach that promotes inquiry-based teaching and learning. In doing so, it creates a rich repertoire of e-Science applications that enable secondary school students to experiment with, appreciate and learn how cutting-edge science works by 'entering' the world of research in Astronomy and Particle Physics. These infrastructures include the Large Hadron Collider (LHC) at CERN and its dedicated experiments ATLAS and CMS, the Gaia global space astrometry misión and the Faulkes and Liverpool Telescopes.

The Discover the COSMOS consortium brings together key players in the field of astronomy and particle physics outreach who have invested major efforts over recent years to introduce frontier research issues school science classrooms in Europe and beyond. The e-Science applications included in the framework of Discover the COSMOS educational activities enhance the effectiveness and quality of the teaching and learning process by employing advanced and highly interactive visualisation technologies that offer a 'feel and interact' user experience, allow for learning 'anytime, anywhere' and provide personalised ubiquitous learning paradigms. They have also been tested in different educational settings (schools, teacher training centres, outreach programmes, workshops, and summer schools) in Europe and beyond and have proven their efficiency and efficacy as inquiry based resources.

1. Introduction

The Discover the COSMOS project addresses the declining interest of students in science [1] and attempts to revitalise their imagination by engaging students in scientific enquiry [2] via e-science activities. The collaboration comprises fifteen universities, research and educational centres in Europe and the USA. It brings together partners with long experience of outreach activity in astronomy and particle physics and in introducing e-science applications into school classrooms. With an emphasis on inquiry based learning, these activities enable students to interact with real data, encourage them to devise their own experimental tests and through these investigations lead them to a deeper understanding of science.

Funded as a Coordination Action project (2011-2013) in the European Commission's Framework Programme 7, the Discover the COSMOS consortium[3] aims to develop the use of existing e-infrastructures to revitalise student interest in science. This paper reviews the e-science tools which have been developed to encourage inquiry based learning and examples are given on how use and exploitation of these tools are establishing a strong European wide community of students, teachers and researchers. The current status of the project is described.

2. Partners and their expertise

The composition of the Discover the COSMOS collaboration is shown in Table 1. Some of the partners (IASA, CERN, TUD, UoB, LBL) have first hand experience of front line research in particle physics with the ATLAS experiment at the CERN Large Hadron Collider (LHC) while other partners (IAP, UoC, UoG, CAM, LJMU, NUCLIO, UCM, LBL) are key players in Astronomy outreach. All these groups have invested major efforts to introduce frontier research into the school classroom.

	Institute	Country
IASA (Coordinator)	Institute of Accelerating Systems and Applications	Greece
CERN	Centre for European Particle Physics	Switzerland
IAP	Institut d'Astrophysique de Paris	France
UoC	University of Coimbra	Portugal
UoG	University of Glamorgan	UK
CAM	Cambridge University	UK
LJMU	Liverpool John Moores University	UK
TUD	Technical University of Dresden	Germany
UoB	University of Birmingham	UK
EA	Ellinogermaniki Agogi	Greece
NUCLIO	Nucleo Interactivo de Astronomia	Portugal
SV	Science View	Greece
BMUKK	Ministry of Education, Arts and Culture	Austria

UCM	Universidad de Complutense de Madrid	Spain
LBL	Lawrence Berkeley National Laboratory	USA

Table 1 Institutes comprising the Discover the COSMOS consortium.

Students appreciate and learn how frontier science works by stepping into research in astronomy and particle physics, via e-infrastructures developed earlier by the collaboration. These are based on the Large Hadron Collider (LHC) at CERN via its experiments ATLAS and CMS, and the Faulkes telescope (part of the "Las Cumbres Observatory Global Telescope Network" in Hawaii and Australia), and the Liverpool robotic telescope on the island La Palma in the Canaries (and potentially to the ESA Gaia Mission). Over many years, the project partners have been developing and testing **HYPATIA**[4], **MINERVA**[5] and **AMELIA**[6], tools which analyse real data from CERN detectors, and **SalsaJ**[7], **LTImage**[8] and **Sun for All**[9] which make real time observations using robotic telescopes and implement experiments in space. Such innovative applications simulate real scientific work and promote many positive educational aspects: problem solving, discovery, learning by doing, experiential learning, critical thinking and creativity.

3. Outline of the project

In a series of 19 **visionary workshops** from November 2011 to June 2012, approximately 400 teachers and educators were able to comment on existing e-infrastructures and to set out their concerns and suggestions. In response to these needs, the Discover the COSMOS partners produced a set of demonstrators/scenarios in astronomy and particle physics - approximately 50 demonstrators in total, each one based on inquiry based learning and translated into all the languages of the consortium. These demonstrators utilise data analysis tools; provide 2D and 3D animations and simulations of physical processes and experiments; allow virtual visits to advanced experimental devices and detectors; introduce educational games and projects presenting the basic concepts of science; show videos and point to live web events. Therefore they are the basis of inquiry based learning.

All these activities are accessible from the Discover the COSMOS portal [10]. The Portal offers to the teaching community the opportunity not only to search for and use interesting applications but also for teachers to share their own material with colleagues by uploading it to the portal. The portal has currently been used by ~1000 teachers who are applying inquiry-based techniques in their everyday teaching.

The second round of activities comprised the **practice reflection workshops** (over 30 in total) that took place from September 2012 to February 2013. Their main goal was to pilot the first wave of demonstrators. Participants were invited to take part in training workshops/seminars, organised not only locally/nationally but also internationally, to build scenarios that address the outcomes of the earlier visionary workshops. After participants gained hands-on experience with a selection of the e-Science tools and resources, they were asked to adapt a resource or tool into their current curriculum. The outcome of the practice reflection workshops was a set of scenarios produced by the participants and ready to be tested in classroom environment. Another pleasing outcome was the collaboration between the participating schools and also between the schools and the researchers supporting the effort.

Finally come the **summative workshops** (one in each country of the consortium) which will take place between April 2013 and August 2013. Their purpose is to recapitulate the experiences and lessons learned during the implementation of the project and to consolidate progress. All those who participated in

the process will be invited to reflect on their experiences and collect together the final outcomes, concerns and suggestions. This will lead to the Discover the COSMOS **roadmap** document, "Effective Ways of Introducing e-Science in Schools".

3 Development of a community

The aim of training and demonstration activities is to encourage interaction among educational groups and provide educators with opportunities to enrich their practices and professional development through cooperation between and within schools, universities and frontier research institutions. Educational and outreach activities are organised at **local, national and international** level: at local and national level, there have been 150 activities in total while at international level 10 activities are planned.

At local level, demonstrations and training workshops were held in schools and teachers' training centres. The aim of these training workshops is to familiarise secondary school teachers with the inquiry-based pedagogical approach to science teaching. The associated e-Science applications provide them with the opportunity to exchange ideas and experiences with experts and teachers' trainers. At national level, training workshops, demonstrations and Masterclasses are held. These activities are supplemented by national contests for both secondary school teachers and students

There are four types of large scale international implementation activities planned to take place over the life of the Discover the COSMOS project: contests for students and teachers; training seminars for teachers including summer and winter COMENIUS schools and the CERN High School Teachers Programme; international masterclasses and e-masterclasses and annual conferences.

3.1 Examples of community building activities

A **teachers' training workshop in Germany** provided lectures from active scientists; measurements on real data from experiments at the LHC; opportunities for discussions with scientists and colleagues; a presentation of the "Netzwerk Teilchenwelt" (German network for students and teachers who engage in particle and astroparticle physics) as well as of the "Discover the Cosmos" framework and finally a presentation of resources usable in the classroom.

Junior and seniors students (16-18 years old) of the high schools of Pelopio and Lalas villages in the region of ancient Olympia in Peloponnese, Greece, listened to lectures about ATLAS, carried out a mini masterclass with the HYPATIA tool, received a preview of the CERN mini exhibition, finishing with a **virtual visit to ATLAS**.

Similarly, students (16-18 years old) from schools from across the Midland region of the UK, met at the University of Birmingham, listened to lectures about the LHC experiments, carried out a masterclass based around the MINERVA tool. There was a question and answer sessions in small groups and finally a **virtual visit to ATLAS**.

The **CERN Mini Expo**, a travelling exhibition that presents a brief overview of CERN and the LHC, has been touring through Europe, stopping at each venue for periods of a few days up to a few weeks. The Discover the COSMOS tools have been demonstrated during the exhibition.

The 1st **Discover the COSMOS Summer School** took place in Crete, Greece in July, 2012. (The 2nd Summer School will take place in Volos, Greece, in August 2013). These schools are organised in the framework of the COMENIUS Programme. Participants familiarise themselves with the large amount of

digital science, develop skills in using these learning technologies and finally use these digital resources to design new pathways in science teaching, following the inquiry-based approach.

The **CERN High School Teachers' (HST) Programme** helps CERN establish closer links with European schools. In 2012 and 2013, participating teachers are invited to become involved in the Discover the COSMOS community by identifying resources they can take back from CERN to their countries and classrooms. An intensive 2-day hands-on workshop takes place towards the end of the HST Programme, where teachers work with members of the Discover the COSMOS team on building such educational scenarios that reflect their vision in connecting in-class teaching of a given subject in particle physics or related field (e.g. Cosmology) with respective educational digital material available through the utilisation of e-Science applications.

4. Current status

The material and tools of the consortium are readily available via its web site [10]. From this central site, details of the e-infrastructures and e-science applications are directly accessible. Also all events are advertised e.g. competitions for students[11] (*name an asteroid newly discovered by the Faulkes Telescope*) and teachers[12,13] (*devise new ideas for using Discover the COSMOS resources in the classroom*), forthcoming summer schools and conferences [14] (July in Volos, Greece). The consortium three-monthly newsletter[15] presents the latest consortium news in a lively format.

Our experience is developing to meet new challenges. The usage of the website[10] is monitored regularly and several hundred hits are registered each week. The site's impact appears rather uniform in Europe and North America, a little variable in Asia and South America but patchy in Africa. Feedback is obtained anonymously after each workshop and results are analysed by our colleagues at BMUKK who have much professional expertise in this area. This process is ongoing and results are not available yet. However the logistics of gathering complete data is not trivial since (in the UK at least) rather few teachers can attend all stages of the workshops, from visionary to summative.

5. Conclusion

Since its beginning in September 2011, the Discover the COSMOS project has exploited existing e-Science tools (many of which had been developed earlier by the consortium) and has produced a large set of e-science demonstrators, described in many languages. Some demonstrators can be used to illustrate the techniques of scientific research and others use particle physics or astronomical data to illustrate basic scientific principles. In each of the partner countries these demonstrators have been used in a series of workshops, initially visionary to map out possible applications in the classroom and then reflective to assess their effectiveness. These national workshops will then merge at the international level to produce a roadmap which will propose how inquiry based learning, founded on e-Science applications, can best develop.

References

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[2] Rocard,M. et al (2007) Science Education now: a Renewed Pedagogy for the Future of Europe, 1-23.

[3] The Discover the COSMOS Project is financed by the European Commission's Framework Programme 7 (FP7) under grant agreement no. 283487.

[4] HYPATIA http://hypytia.phys.uoa.gr

[5] MINERVA http://atlas-minerva.web.cern.ch/atlas-minerva/

[6] AMELIA http://amekia.saveforge.net/index.html

[7] SalsaJ http://www.uk.euhou.net

[8] LTImage http://www.schoolsobservayory.org.uk/astro/tels/ltimage

[9] Sun for all http://www.mat.ac.pt/sun4all/

[10] Discover the COSMOS Home page http://www.discoverthecosmos.eu/

[11] UK Student competition http://discoverthecosmos.eu/news/171

[12] UK teacher competition http://discoverthecosmos.eu/news/172

[13] Worldwide teacher competition http://discoverthecosmos.eu/news/185

[14] Discover the COSMOS conference in Volos, July 2013 http://doscoverthecosmos.eu/news/193

[15] Newsletter http://dIscoverthecosmos.eu/public